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OBSERVATIONS ON THE SPEARFISHES OF THE CENTRAL PACIFIC

By William F. Royce

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ABSTRACT

The taxonomy, distribution, size, food, and spawning habits of spearfishes are considered. Observations on several hundred spearfishes caught in the central equatorial Pacific and in the Hawaiian fishery are presented, together with an extensive review of Japanese and other literature. A morphometric study shows marked variation in all diagnostic characters and allometric growth in many.

Six species are recognized: swordfish (*Xiphias gladius*), shortnose spearfish (*Tetrapturus angustirostris*), sailfish (*Istiophorus orientalis*), black marlin (*Istiompax marlina*), striped marlin (*Makaira audax*), and Pacific blue marlin (*Makaira ampla*).

All six species are shown to be fishes of the high seas of wide distribution in the Pacific, but with different centers of abundance. The swordfish and striped marlin prefer the more temperate waters, the Pacific blue marlin the equatorial region, and the black marlin the coastal areas off Asia, America, and Australia. Maximum known weights of the Pacific forms (in pounds) are as follows: Swordfish—1,061, shortnose spearfish—114, sailfish—132, black marlin—1,560, striped marlin—483, and Pacific blue marlin—1,450. All are broadly carnivorous on fish and cephalopods. The Pacific blue marlin probably spawns throughout most of the year in equatorial waters.

CONTENTS

OBSERVATIONS ON THE SPEARFISHES OF THE CENTRAL PACIFIC

By WILLIAM F. ROYCE, *Fishery Research Biologist*

Since 1950 the Pacific Oceanic Fishery Investigations (POFI), U. S. Fish and Wildlife Service, has been investigating the high-seas fishery resources of the tropical and subtropical Pacific Ocean. These investigations have shown that several kinds of tunas, particularly yellowfin (*Neothunnus macropterus*), skipjack (*Katsuwonus pelamis*), and albacore (*Germo alalunga*), form the most promising fishery resources in this area.[1] Moreover, these tunas are commonly found associated with two other groups of large fishes, the spearfishes, principally the marlins, and certain species of sharks. An understanding of the role of both of the latter groups is important because they compete with the tunas for food, but the marlins, in particular, are objects of great interest in themselves because of their value for sport along the coast of the Americas and for food along the coast of Asia.

Despite the interest in and value of the marlins, these spectacular fish are little known to Americans. Their habits, their wide distribution on the high seas, even the number of their species, have not been known. Much information has appeared in Japanese literature during the last two decades, but little has been written in English, and even if it had been, the uncertainty about the species occurring on both sides of the Pacific might have prevented associating the species of the western Pacific with those found off the Americas.

The spearfish problems discussed in this paper include (1) a study of diagnostic characters and morphological comparisons of the species, (2) a decision as to the correct names, and (3) observations on distribution, abundance, and habits. For the latter we shall use our observations and refer extensively to the Japanese literature. We shall not attempt a monograph, however. Observations on the spearfishes in all parts of the world are being added to the literature so rapidly and so little is known that such a treatment would be premature.

Most of our data have been obtained from spearfishes caught on longline fishing gear from POFI vessels. This gear has been described by Niska (1953) but, briefly, it consists of a series of baited hooks 15 to 30 fathoms apart suspended from a line at depths of about 200 to 400 feet. On all cruises made after July 1952 (table 1) records were kept of the species of spearfishes caught at each station (fig. 1), and in many instances morphometric measurements were made, together with observations on sex, sexual condition, and food in the stomach. Such observations were not as complete as might be desired because the primary assignment on each cruise was to obtain information on the tunas, and observations on the spearfishes were made as time permitted.

TABLE 1.—*The longline fishing cruises of POFI vessels on which spearfish data have been collected, 1952–54*

Vessel and cruise	Cruise period	Locality and west longitude
John R. Manning:		
No. 12	8/16–9/15/52	Equatorial area. 140° and 150°.
No. 13	10/16–12/6/52	Equatorial area. 150° and 170°.
No. 14	1/22–3/25/53	Equatorial area. 140° and 150°.
No. 15	4/28–6/16/53	Equatorial area. 150° and 170°.
No. 16	7/24–9/2/53	Equatorial area around Line Islands. 155° and 160°.
No. 17	10/16–11/8/53	Around Christmas Island.
No. 18	11/21–12/19/53	Equatorial area. 155° and 155° to 159°.
No. 19	1/15–1/17/54, 1/19–2/6/54 Part 1	North of Hawaiian Islands. 160°.
	2/16–3/10/54 Part 2	North of Hawaiian Islands. 155° and 147°.
No. 20	5/11–6/23/54	Equatorial area around Line Islands. 157° to 163°.
Charles H. Gilbert:		
No. 15	2/18–4/26/54	Equatorial area. 110° to 120°, and 155°.
Hugh M. Smith:		
No. 18	10/7–11/22/52	Equatorial area. 120° and 130°.
No. 19	1/8–2/12/53	Equatorial area around Line Islands. 157° to 162°.
Cavalieri	8/13–9/27/52	Equatorial area. 140°.

In the collection of data, assistance was rendered by many members of the POFI staff, including the officers and crews of the vessels who had the problem of handling these large and troublesome

[1] Reports of the tuna studies, together with detailed tables of the catch and fishing localities, may be found in Murphy and Shomura (1953a, 1953b, 1955).

Note—Approved for publication, October 11, 1956. Fishery Bulletin 124.

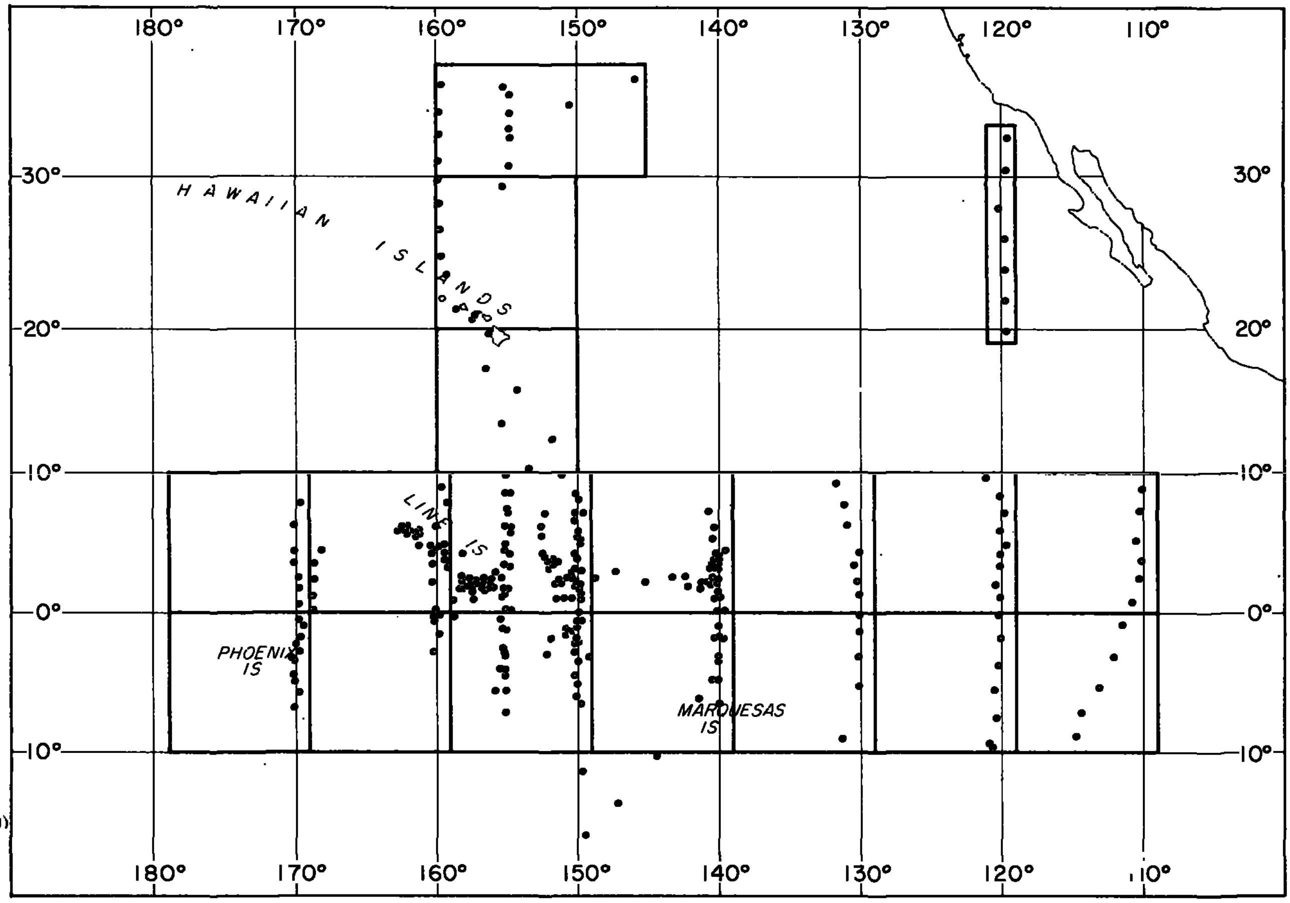

FIGURE 1.—Position of longline fishing stations where spearfish data were obtained.

fish. Many scientific staff members have made observations and those who measured the fish are listed in the appendix. Some people made very special contributions: Vernon Brock, of the Division of Fish and Game, Board of Agriculture and Forestry, of the Territory of Hawaii, in addition to his many helpful suggestions, made available to us observations on the spearfishes recorded by his division, and critically read this manuscript; Wilvan G. Van Campen, Japanese translator for POFI, brought to our attention and translated various Japanese publications on the spearfishes, which added so greatly to our knowledge of this group; and Daniel T. Yamashita and Dorothy D. Stewart most carefully brought together the observations obtained on the longline cruises and assisted notably in the computations. I am also indebted to Carl L. Hubbs, James E. Morrow, Hiroshi Nakamura, Luis R. Rivas, and Robert L. Wisner, for their critical reading of the manuscript.

SPECIES OF SPEARFISHES IN THE CENTRAL PACIFIC

The separation and naming of the species of spearfishes has been a problem of particular difficulty, because the original descriptions of most of the species are so poor and some of the species are so similar and variable that it is impossible to identify them immediately from the original descriptions. It has been necessary for us to start with identifications made by our fishermen, most of whom are experienced longline fishermen and have seen many marlins. We also have had the benefit of the key to Hawaiian fishes by Brock (1950), which was based on observations of the marlins landed in the Hawaiian market.

The fishermen of Hawaii recognize six species of spearfishes to which they have given the English names of black marlin, silver marlin, striped marlin, Indian spearfish, sailfish, and broadbill swordfish. After seeing several hundred specimens which included all of these spearfishes, we concur with the fishermen that these are six clearly distinct and easily recognizable species. All of them are fishes of the high seas, and seem to be the same in Hawaiian waters as along the Pacific Equator, where we have caught them in considerable numbers. They fit so well the descriptions given by Nakamura (1949) that there seems little doubt that they occur also in the western Pacific from Japan to Australia. Furthermore, the description of the marlin fishing off Acapulco, Mexico, given by Gabrielson and LaMonte (1950) indicates that the Acapulco "black" marlin is similar to the Hawaiian "black" marlin and that the "silver" marlin and "striped" marlin of Hawaii also occur in Mexican waters. South of the Equator off Peru, Chile, New Zealand, and Australia, there appear to be two common species of marlin: a "striped" marlin comparable to the "striped" of Hawaii, and a "black" marlin, similar to the one called "silver" in Hawaii and "white" in Japan. A third marlin, similar to the "black" marlin of Hawaii and Japan has been described from New Zealand by Griffin (1927) and from Australia by Whitley (1954), but apparently it is not as common as the other marlins in the Southern Hemisphere. In the discussion to follow, a single common name will be used for each species to avoid confusion.

The following key [2] is based on the subsequent analysis of characters, distribution, and synonomy. Line drawings of spearfishes of different sizes which will aid in identifications are given in figures 2 and 3.

KEY TO THE SPEARFISHES OF THE CENTRAL PACIFIC

1a. Snout broad, flattened and long, pelvic fins absent, one pair of keels on caudal peduncle . . . . Xiphiidae.
BROADBILL SWORDFISH . . . . *Xiphias gladius* Linnaeus.

1b. Snout shorter, nearly circular in cross section, pelvic fins present, two pairs of keels on caudal peduncle . . . . . .
Istiophoridae 2

2a. First dorsal fin very high with middle rays longest, about as long as head.
SAILFISH . . . . *Istiophorus orientalis* (Temminck and Schlegel).

2b. First dorsal fin moderate with anterior rays longest, middle rays much shorter than head 3

3a. Snout short, tip to anterior edge of orbit about equal to length of mandible. Body slender; greatest depth less than 13 percent of fork length. Not striped on sides. Rarely weighs more than 100 pounds.
SHORTNOSE SPEARFISH . . . . *Tetrapturus angustirostris* Tanaka.

3b. Snout longer, tip to anterior edge of orbit more than 1.3 times length of mandible. Body stouter, greatest depth more than 13 percent of fork length. Striped or not on sides. Commonly weighs more than 100 pounds 4

4a. Pectoral fin rigid, cannot be folded flat against side. Height of first dorsal less than 80 percent of greatest body depth, averaging about 60 percent. Pelvic fins 18 to 31 cm., average 26 cm. in fish over 150 pounds. Rarely striped on sides; stripes never conspicuous after death.
BLACK MARLIN [3] . . . . *Istiompax marlina* (Jordan and Hill).

4b. Pectoral fin turns and folds flat against side. Height of first dorsal usually more than 70 percent of greatest body depth. Pelvic fins 22–42 cm., average about 33 cm. in fish over 30 pounds. Stripes on sides usually visible for a few hours after death 5

5a. Height of first dorsal lobe less, usually much less, than greatest body depth. Height of first anal fin more than 76 percent height of first dorsal, average 86 percent. Height of 20th ray of first dorsal 3–9 cm., average 6 cm. above fin sheath in fish more than 2 m. fork length. Body stouter, more cylindrical. Stripes usually present, but seldom conspicuous after death.
PACIFIC BLUE MARLIN [4] . . . . *Makaira ampla* (Poey).

5b. Height of first dorsal lobe more than 90 percent of greatest body depth. Height of first anal fin less than 76 percent of height of first dorsal, average 66 percent. Height of 20th ray of first dorsal 7–14 cm., average 10 cm. above fin sheath in fish more than 2 m. fork length. Body more slender, compressed, and tapered. Stripes usually conspicuous after death.
STRIPED MARLIN . . . . *Makaira audax* (Philippi).

[2] Refer also to the complete discussions referring to specimens weighing less than 50 pounds.

[3] White marlin of Japan, silver marlin of Hawaii, black marlin of South America, Australia, and New Zealand.

[4] Blue marlin of Atlantic Ocean, black marlin of Hawaii and Japan. We follow LaMonte and Marcy (1941) in the use of the name *ampla* and have not attempted to unravel the tangled synonymy of the Atlantic form.

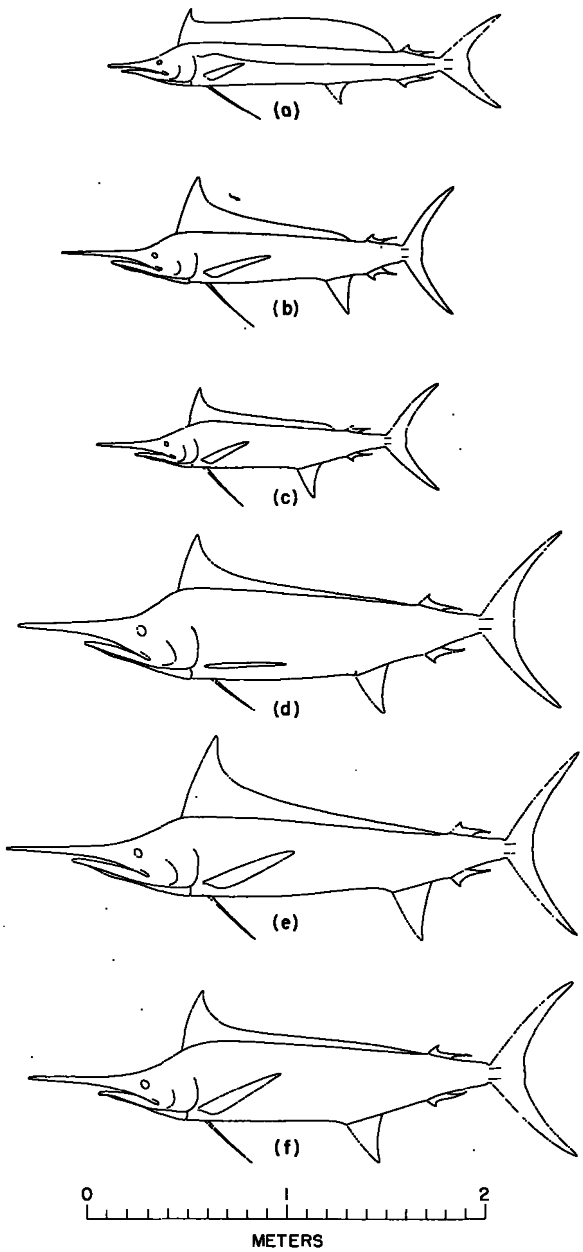

FIGURE 2.—The body proportions at 50 pounds of (a) *Tetrapturus angustirostris*, (b) *Makaira audax*, and (c) *Makaira ampla*; and at 200 pounds of (d) *Istiompax marlina*, (e) *Makaira audax*, and (f) *Makaira ampla*.

ANALYSIS OF DIAGNOSTIC CHARACTERS

It is obvious from an examination of the literature on marlins and from study of a few specimens that a proper designation of the species can be made only after a suitable account of the variation in diagnostic characters. All too frequently casts or photographs of single specimens have been used to describe new species and subspecies. The danger of such a practice has been shown by Conrad and LaMonte (1937) and Gregory and Conrad (1939), who measured numerous specimens of three species from restricted localities and found marked variation in body proportions in each species. Furthermore, since Shapiro (1938) and Morrow (1952a) demonstrated marked changes in certain proportions due to allometric growth, it is dangerous to use ratios to describe the size of body parts.

Of the spearfishes, the marlins are the species of most concern, and the numerous authors who have considered them have tried to recognize their differences with a great variety of external characters. These characters have included the proportions of the head with its unique sword, body proportions, length or height of certain fins, character of the lateral line, color patterns, and in a few instances, the number of rays in certain fins. Also, it has been observed repeatedly that the pectoral fin of certain marlins cannot be folded against the body, whereas the pectorals of other marlins fold readily. The work of Nakamura (1938) has shown that considerable differences in bone structure account for this variation in flexibility.

SOURCE OF THE DATA

There is now available a considerable amount of material for morphological comparison which includes the 12 sets of measurements of *Istiompax marlina* and the 30 of *Makaira audax* from New Zealand and Australian waters recorded by Gregory and Conrad (1939); also the 23 sets of measurements of the Atlantic blue marlin, *Makaira ampla*, obtained at Bimini, Bahama Islands, in July 1937 and reported by Conrad and LaMonte (1937). Morrow (1952a) gave a few measurements for 49 *audax* from New Zealand. From our POFI collection, we have measurements of 11 *marlina*, 68 *ampla*, 25 *audax*, 6 *Istiophorus orientalis*, and 8 *Tetrapturus angustirostris* (appendix tables 1–A to I–E, p. 541). Almost all of these spearfishes are from the central equatorial Pacific waters. In addition, Vernon Brock of the Hawaiian Division of Fish and Game (DFG) has made available to us certain measurements from 5 *marlina*, 27 *ampla*, 30 *audax*, and 2 *angustirostris* (appendix tables 2–A to 2–D, p. 548), obtained from

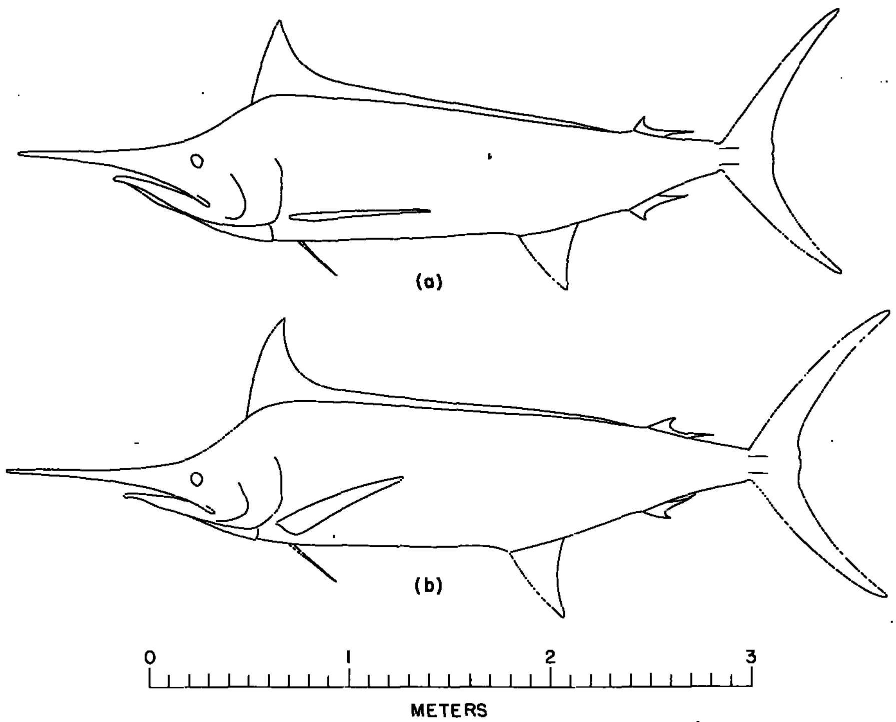

FIGURE 3.—The body proportions at 800 pounds of (a) *Istiompax marlina* and (b) *Makaira ampla*.

fish landed at the Honolulu market and which, undoubtedly, were caught within 200 miles of the Hawaiian Islands.

From many of the POFI specimens we obtained notes on food and sexual condition, which are summarized in the discussions under the species. Also, for several specimens not listed in the appendix, length and weight data were obtained which have been used together with listed observations to compute the length-weight relation.

Considerable material on the weight of spearfishes landed at the Honolulu auction market has also been made available by the Hawaiian Division of Fish and Game. This consists of weights of individual fish identified and recorded by dealers who allowed their records to be copied. These data show the range of sizes, seasonal trends, and modal sizes landed in Honolulu. These weights are slightly less than live weights, however, because the swords, pectorals in *marlina*, and sometimes the lobes of the tail are removed before delivery to the market. Also large fish are frequently cut in two or more pieces so that they have lost body fluids.

All measurements taken by POFI and by the Hawaiian Division of Fish and Game have been obtained with sliding calipers read to the nearest millimeter. All measurements are the shortest straight line between the points specified. No attempt was made to obtain offset measurements parallel to the midline of the body. The fish to be measured were laid on their sides in as natural a position as possible with the jaws shut and with the snout propped up so that the sword was an extension of the midline of the body.

The POFI measurements were taken by people accustomed to measuring tunas according to the methods of Marr and Schaefer (1949). Where applicable, the same methods were followed in measuring the spearfishes, but certain morphological differences required special definition. The orbit was measured instead of the iris and it was measured parallel to the midline of the body. The depth of the head was measured from the supraoccipital (which may be felt easily) to the throat on a line perpendicular to the midline of the body. The heights of the first anal and first dorsal fins were measured from the top of the fin sheath, and the posterior end of the fin was considered to be the end of the fin groove. The length of the mandible was measured from the tip to the posterior end of the mandibular bone at the joint, which can be found easily by moving the jaw. The body width was usually measured when the fish was balanced on its belly but occasionally when the fish was on its side.

Having in mind the difficulty in sexing *Xiphias gladius* reported by LaMonte and Marcy (1941), we expected that the marlins also might be troublesome. We have, however, encountered large numbers of marlins in which the eggs or milt were unmistakable, and on examination of the mature gonads of these fish we found differences that make it possible to determine the sex with assurance. The most obvious difference is the presence of a firm, connective-tissue sheath around the ovary that is lacking in the testis. The inactive testes superficially resemble the fatty tissue of mammals. They are usually approximately cylindrical, but when bent can be seen to be distinctly lobed and without a sheath. On the other hand, the inactive ovaries are also roughly cylindrical but have a definite sheath and no evidence of lobes. When an ovary is cut, the interior is usually orange in color and appears distinctly granular to the naked eye due to ova in early stages of development. We have noticed no external sexual differences, except that in *marlina* and *ampla* all specimens of more than 322 pounds have been females.

DETERMINATION OF ALLOMETRIC GROWTH

In view of the known allometric growth [5] in some parts of marlins it is desirable to examine each diagnostic measurement to determine if allometry exists. If so, it will be feasible to compare samples only at specified body sizes, which usually is done from regression equations. If the growth is isometric we can use ratios. In addition, it will be shown that the size of certain parts is completely unrelated to the size of fish (within the range of fish sizes studied) and that it is possible to compare samples by use of the simple length frequency and mean size.

A determination of allometric growth sufficiently accurate for our purposes can be had from a plot of each character on graph paper. When the points are in place, it is a simple matter to fit by eye a trend line (curved if need be) and then draw two other lines from the origin representing constant ratios near the upper and lower boundaries of the distribution. It is convenient if the boundary lines are drawn to represent even percentages of the abscissal character. Now, if growth is isometric the trend line will be straight, pass through the origin, and approximately bisect the angle of the outer lines. If growth is not isometric, the trend line will curve or cross one or both of the outer lines and it is possible to judge approximately how much the ratio changes over the range of the data. In the marlin data, we found it easy to judge when the trend line changed over the range of the data more than about one-third of the difference between the boundary lines. When the change was greater we used straight-line regression analysis. When the trend line was curved we omitted part of the data and used only that from the straight portion.

Such approximations are adequate for our purposes for two reasons: (1) We are concerned here principally with differences among species and not the minutiae of racial or subspecific differences, and (2) some of the marlin measurements show curvilinear relationships which our samples are not adequate to describe precisely and which cannot be dealt with easily through the logarithmic growth equation.

An example of the method is the plotting of the length of the pectoral fin against the fork length, using the data from the POFI collections (fig. 4). Use of this character is appropriate because Morrow (1952a) found a slight, although not statistically significant, negative allometry in this character. We notice in our plot which includes small specimens of *audax* and *ampla* that the growth is probably curvilinear in both of these species. But if we omit the specimens of less than 200 cm. fork length, the evidence of allometric growth is very small indeed. There is a suggestion that the length of the pectoral in *audax* increases or shows a slight positive allometry (contrary to Morrow's finding), whereas in *ampla* and *marlina* the allometry appears to be trivial. However, if we omit the small specimens, the trend in any one species changes only

[5] We follow what we believe to be the intent of Huxley and Teissier (1936), who proposed that allometry be used in place of other terms to denote growth of a part at a rate different from that of the whole. This they defined to be the case where the relative growth could be expressed by a formula of the type $y=bx^a$ with $a\neq 1$, in which y is the part, x the standard or whole, and a and b are constants. When $a=1$, growth would be considered to be isometric.

We have used a growth equation of the type $y=a+bx$, and have considered growth to be allometric when $a\neq 0$, and the ratio of part to whole changes with size of the whole. When $a=0$, the ratio is constant and the growth is considered to be isometric. This is consistent with the proposal of Huxley and Teissier because, if $a\neq 0$ and the line is extrapolated from the data to the zero point, a curve results, and if the formula $y=bx^a$ is applied, then $a\neq 1$.

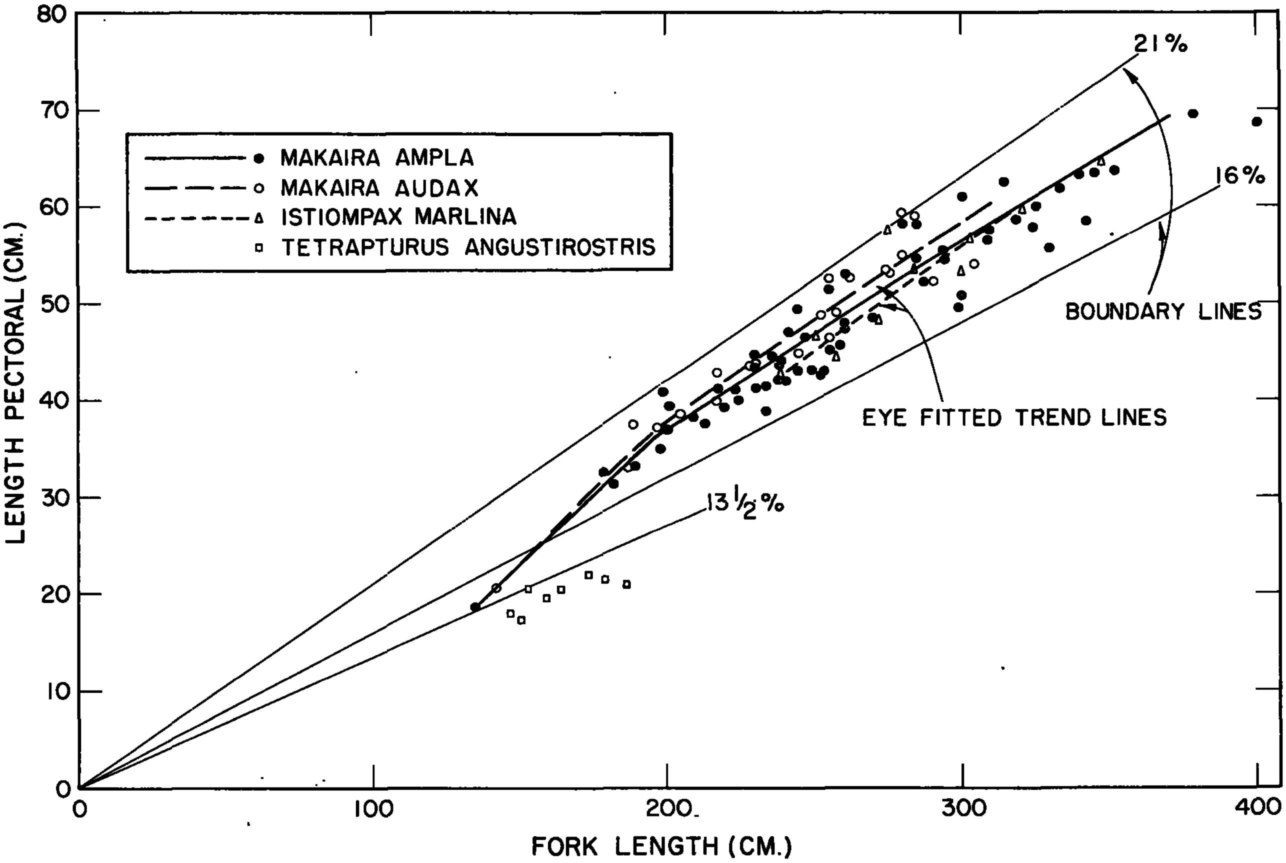

FIGURE 4.—Relation of length of pectoral fin to fork length. (Measurements by POFI have been supplemented by measurements of the Hawaiian Division of Fish and Game (DFG) on specimens between 150 and 200 centimeter fork length.)

about one-fourth of the spread of the distribution. Therefore, we consider that it is satisfactory to compare pectoral fins by using the ratio, or percentage, of fin length to fork length for specimens of more than 200 cm. fork length. (Figure 4 demonstrates, however, that this character is of no value for separation of species.)

An example, in which a considerable amount of allometry is to be found, is that of the greatest depth of body plotted against fork length, again from the data collected by POFI (fig. 5). There is quite obviously a considerable positive allometry in *audax* and *ampla*—which is as expected from the observations that these species tend to become more humpbacked in the larger individuals. We, therefore, conclude that if we use the relative depth of the body we must use regression analysis. Straight-line regressions are satisfactory, for there is no visible curvilinearity within the range of our data. Another obvious conclusion is that other measurements may be compared to the depth of the body in a simple ratio only if they happen to grow proportionately to it.

Using the graphic technique, we have decided that the following body-part relationships are sufficiently isometric over the range of our samples to permit the use of simple ratios for comparing species: (1) Tip of the snout to the anterior edge of the orbit in relation to the length of the head; (2) height of the anterior lobe of the first dorsal to fork length; (3) length of pectoral to fork length; (4) caudal spread to fork length; and (5) height of the anterior lobe of the first anal to the height of the anterior lobe of the first dorsal. It is necessary to use regression analysis for the relation between the greatest depth of the body and the fork length, the head length and the fork length, the height of the anterior lobe of the first dorsal and the greatest body depth, and

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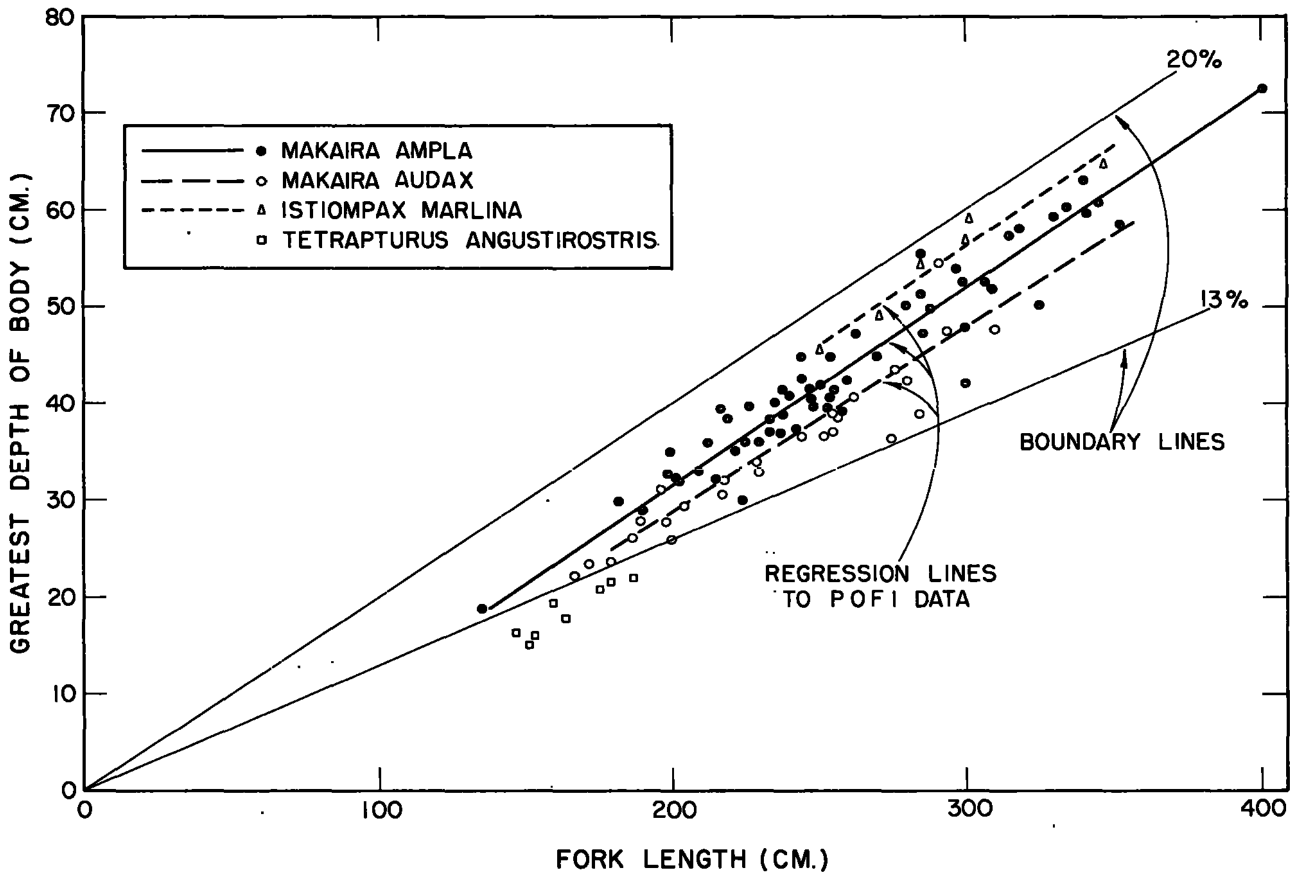

FIGURE 5.—Relation of greatest depth of body to fork length. (Measurements by POFI supplemented by measurements of the Hawaiian Division of Fish and Game (DFG) on specimens between 150 and 200 centimeter fork length.)

the length of the mandible and the length of the snout, measuring the snout from its tip to the anterior edge of the orbit.

Another method must be used to compare the lengths of the pelvic fins (fig. 6). We find no relation between the length of the pelvic fin and the length of the fish, even in the case of the POFI data on *ampla* with specimens ranging from 28 to 1,002 pounds. Thus, our samples may be compared simply by the mean lengths of the pelvic fin.

Finally, in a comparison of the length of the 20th ray (about the middle) of the first dorsal fin (fig. 7) to the length of the fish there is clear evidence of negative growth. This ray is the longest in small (25-pound) specimens of *audax*, but it becomes not merely relatively but actually shorter as the fish increases in size. A similar but not so pronounced a trend is evident in *ampla*. We have compared samples with regard to this character by averaging the length of the 20th rays in fish over 200 cm. fork length, since the curves (fig. 7) level off above this size.

COMPARISON OF DATA

The type of growth will determine how the data may be compared. In the case both of isometric growth, where we have used ratios, and of characters not related to total length, which can be compared on the basis of mean lengths, we shall use the graphical method described by Hubbs and Hubbs (1953). This consists of plotting the mean, one standard deviation on either side of the mean, and the range of the observations. We will not use the additional feature of plotting two standard errors on either side of the mean because we shall not be concerned with tests of significance.

On the other hand, the characters exhibiting allometric growth will require the use of regression analysis as discussed by Marr (1955). From the regression equations we will compute the mean size of a character for given sizes of fish and the

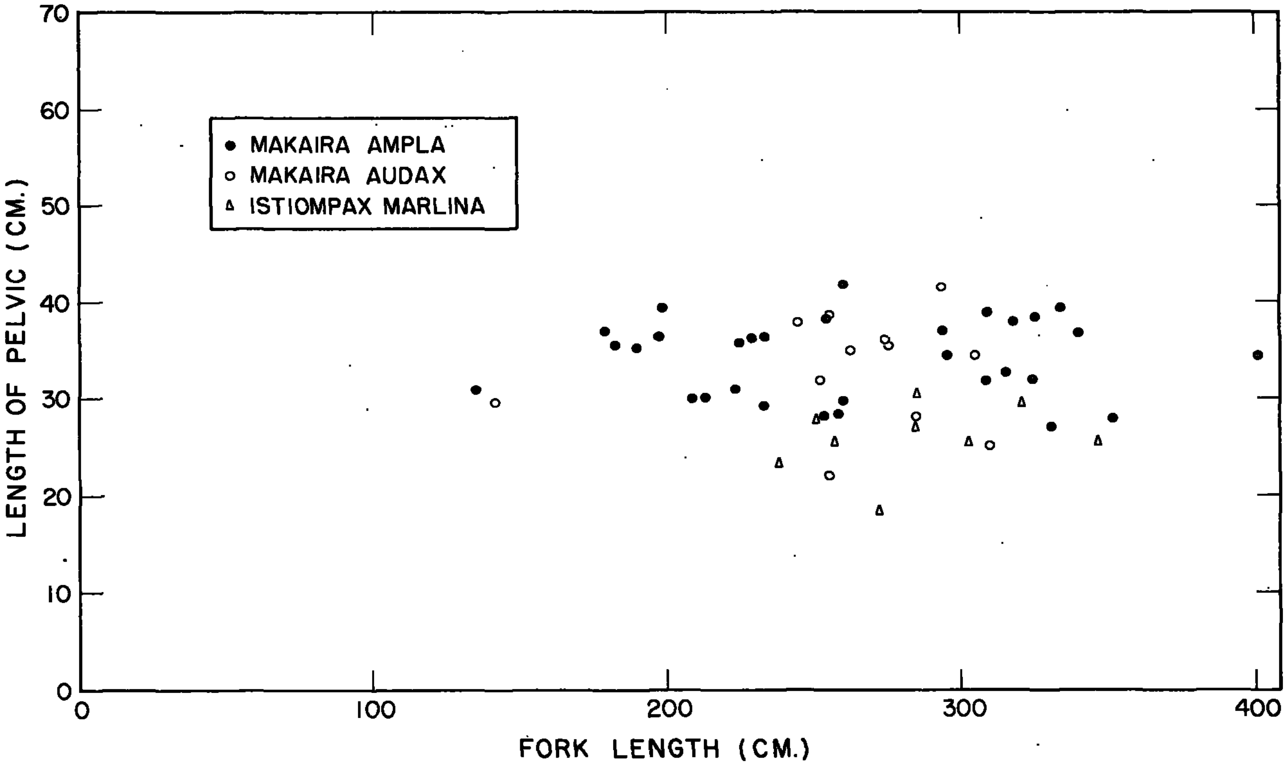

FIGURE 6.—Relation of length of pelvic fin to fork length. (Measurements by POFI.)

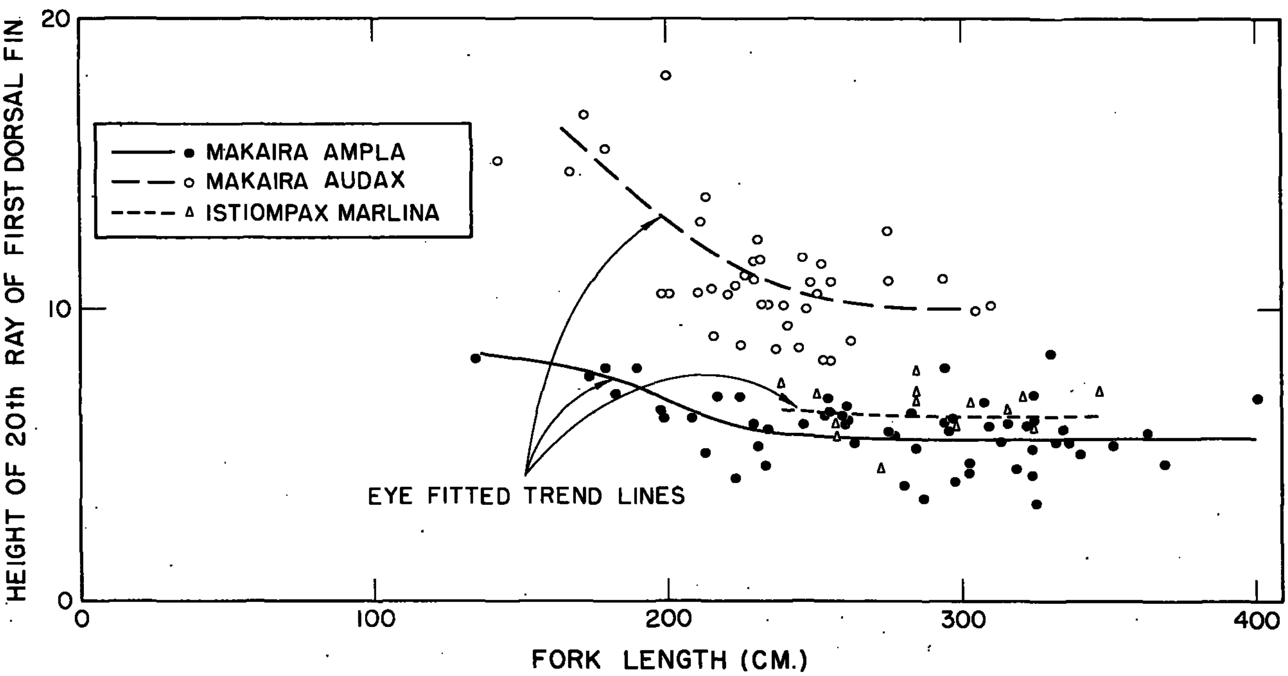

FIGURE 7.—Relation of length of 20th ray of first dorsal fin to fork length. (Measurements by POFI and DFG.)

standard deviation from regression. These will be substituted for the mean and standard deviation in the graphical method of Hubbs and Hubbs. (The range around a point on the regression line is usually not available.) Unfortunately, some samples are so small and the allometric growth so marked that it is necessary to consider some characters at only a single size and others merely from the plotted points on the graph.

CONVERSION OF LENGTHS

Nearly all of the measurements must be considered in relation to other measurements. The best standard is usually length of the fish, but here a difficulty arises. Conrad and LaMonte (1937), Gregory and Conrad (1939), and Morrow (1952a) used body length, measured from the snout to the base of the tail (standard length). Brock, who measured the fish in the Hawaiian market where the snouts are almost always cut off, measured the body length from the naris to the fork of the tail. Measurement from the posterior edge of the orbit to the fork of the tail has been commonly used by Japanese scientists. Thus, a preliminary requirement for examining the characters is to be able to convert from one length to another. We have done this by regression analysis for the three species of marlins, *audax*, *marlina*, and *ampla*, on the basis of POFI measurements. In each case we converted the measurement given to fork length, which is defined as the straight-line distance from the tip of the snout to the tip of the center rays of the tail. These conversions have been made from regression equations (appendix tables 3–A to 3–E, p. 550) on the assumption that straight-line relationships exist between the length measurements. Plots of all measurements for each species have substantiated this assumption.

CHARACTERS

Weight

The general tendency for certain species of the marlins to look heavier than others suggested that it might be possible to separate the species on the basis of the length-weight relation. Nichols and LaMonte (1941) attempted this for the Pacific marlins and they stated that for a given length their striped marlin (*audax*) tended to weigh the least, their silver marlin (*marlina*) more, and their black marlin (*ampla*) most. When the relation is plotted (fig. 8) for the POFI measurements from the central Pacific,[6] it is obvious that *audax* weighs less than the other two which are much alike, and that the length-weight relation might indeed be useful for distinguishing individuals of less than 150 pounds. At lengths of about 300 cm. and weights of around 300 pounds, however, there is a great deal of overlap, as the weight of *audax* for a given length then approaches that of *marlina* and *ampla*. In the larger sizes, all three species are so alike that it is impossible to distinguish individuals on the basis of the length-weight relation.

A comparison of POFI data with DFG material and the published data (Gregory and Conrad, 1939; Conrad and LaMonte, 1937; Morrow 1952a) in figure 9 shows that *audax* from all areas is lighter at a given length than the other two species. There is, however, a slightly greater overlap between species at the 300-cm. size, especially for the POFI material in which the specimens of *audax* were slightly heavier at a given length than were those from the other areas.

Greatest body depth

When this measurement is plotted against fork length a marked positive allometry is obvious (fig. 5). Both figures 2 and 10, in which all samples are compared for given lengths, show that *marlina* is deepest bodied, *ampla* intermediate, and *audax* the most slender, but there is considerable overlap between the species. The species *marlina* and *audax* usually can be separated on the basis of body depth, but *ampla* cannot clearly be distinguished from either. Thus, the character is of little value for taxonomic purposes. Within each species there is quite close agreement of the means; and the relative position of the means is almost the same as the mean weights of figure 9, which indicates that the local populations that are heavier for a given length are also deeper bodied.

Head length

Head length has not been used to separate the species of marlins, but Gregory and Conrad (1939, fig. 1) showed that *ampla* has a mean head length of 36 percent of the body length, whereas this ratio in *audax* is about 39 and in *marlina* about 38. Such a difference suggests some possibility of separating the species with this character, and also because most head parts are compared with head length, it is desirable to examine our data for allometric

[6] The data used for this graph include a few specimens not listed in the appendix.

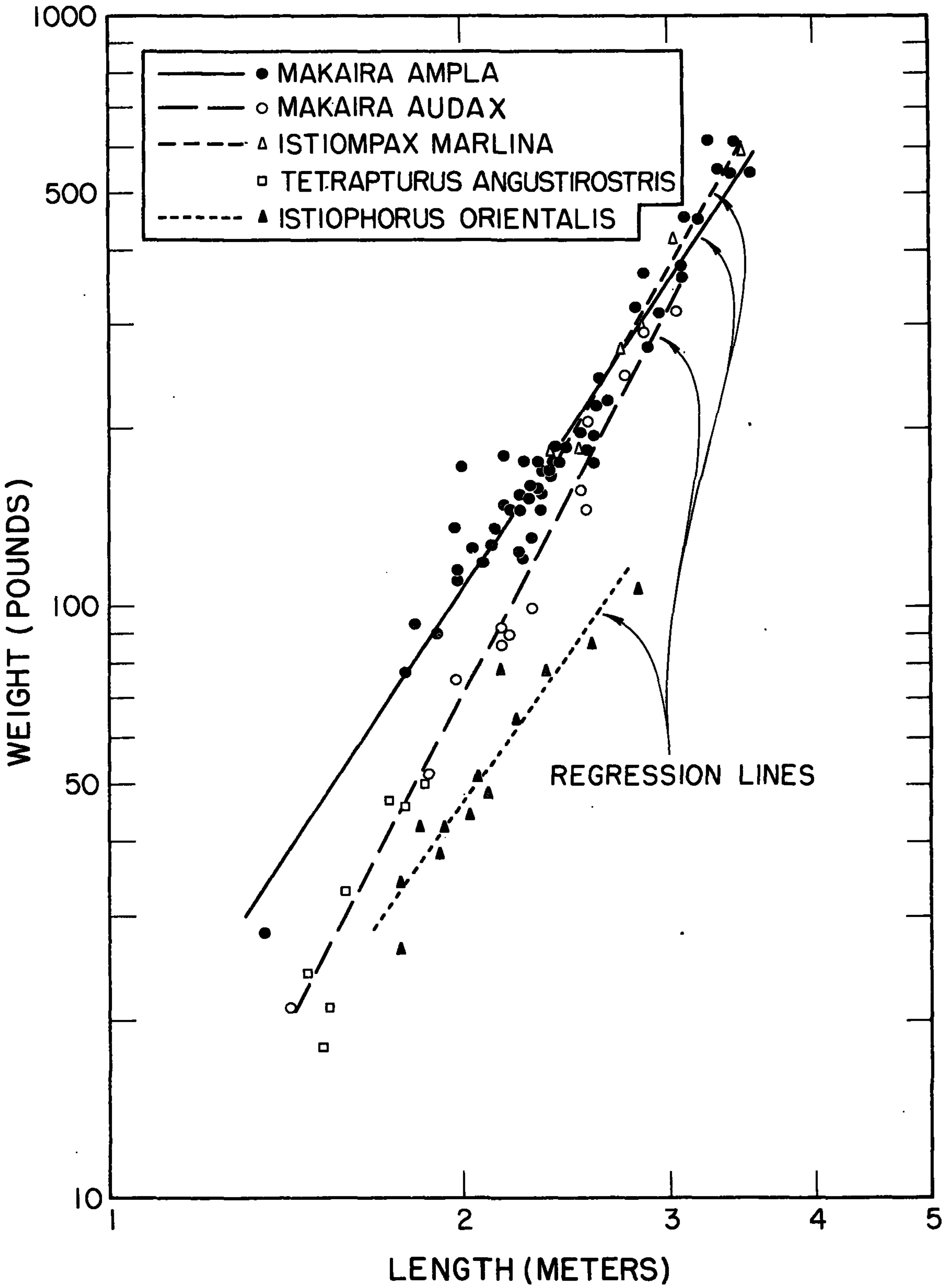

FIGURE 8.—Length-weight relations. No regression line has been computed for the few observations on *T. angustirostris*. (Measurements by POFI.)

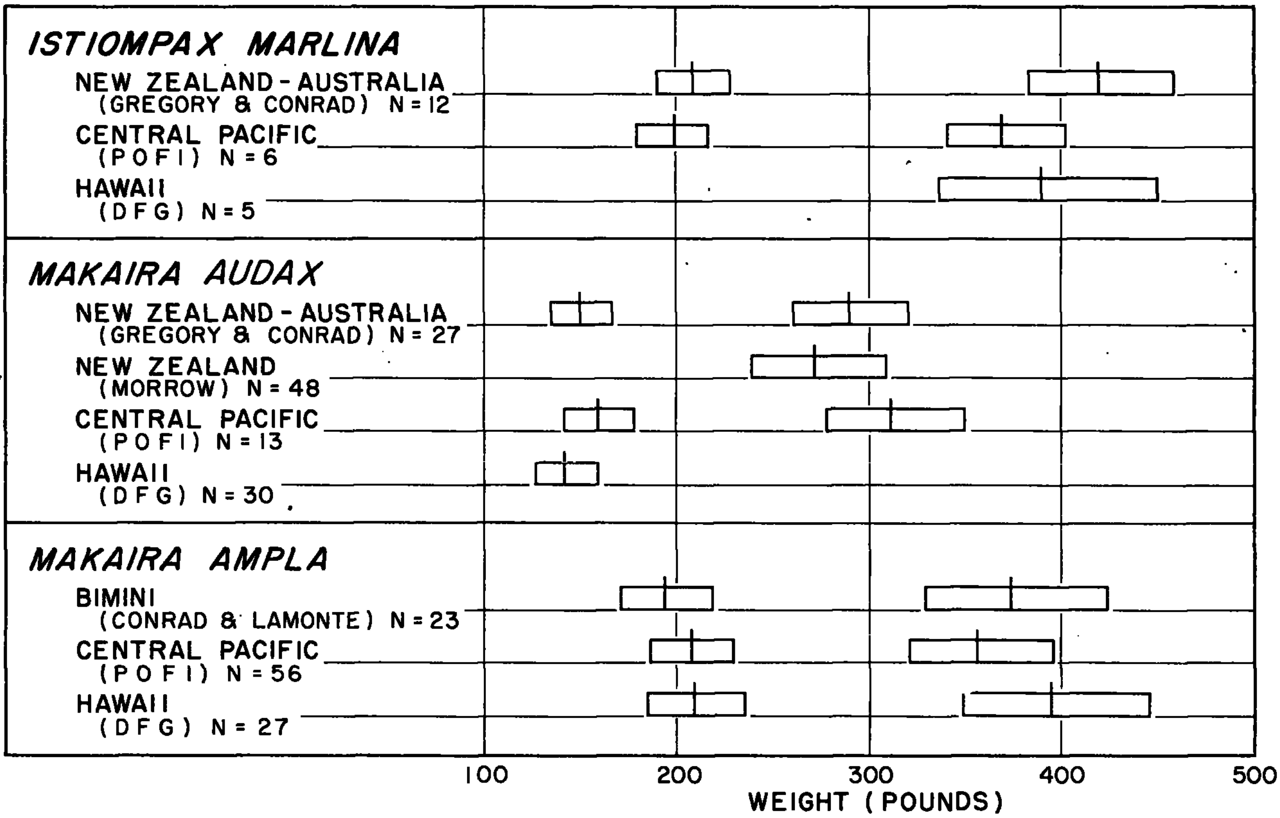

FIGURE 9.—Mean and standard deviation from regression of the weight of marlins at 250 cm. (left) and 300 cm. (right) fork lengths. (Names in parentheses indicate source of data in the literature.)

growth. In the POFI data, head length plotted against fork length shows slight positive allometry in *ampla* and slight negative allometry in *audax*. The condition in *marlina* is intermediate, but too few measurements are available to be conclusive. Therefore, regression methods are indicated for all species.

When we compare the POFI data with those published by Gregory and Conrad (1939) and Conrad and LaMonte (1937), we find good agreement between samples of the same species except that *marlina* from the central Pacific have somewhat longer heads than from the New Zealand-Australia sample (fig. 11). However, the number of samples is so small and the overlap is so great that we consider this difference to be only racial. The differences between species, too, are so slight that the character is almost useless for diagnostic purposes.

Length of snout

Length of snout from front of orbit was used by Jordan and Evermann (1926) as well as by Nichols and LaMonte (1941) in an attempt to separate these species of fish, no doubt because of the general impression that *marlina* has the shorter and stouter spear and *audax* and *ampla* the longer and slenderer ones. When snout length was compared with head length we found no evidence of allometric growth; hence, we can compare snout lengths by simple ratio. When this is done (fig. 12) for the published data and the POFI data we find that appearances as to snout length are misleading, for all samples of all three species show remarkably similar ratios with the overlap among species and between samples almost complete in all cases. Spear stoutness was not investigated because of the small amount of data. Also, measuring the breadth and width at the tip of the mandible, as we did, is not satisfactory because of the allometric growth of the mandible in *ampla* (see next section).

Length of mandible

When this character is plotted from our POFI measurements (fig. 13), we find a strikingly

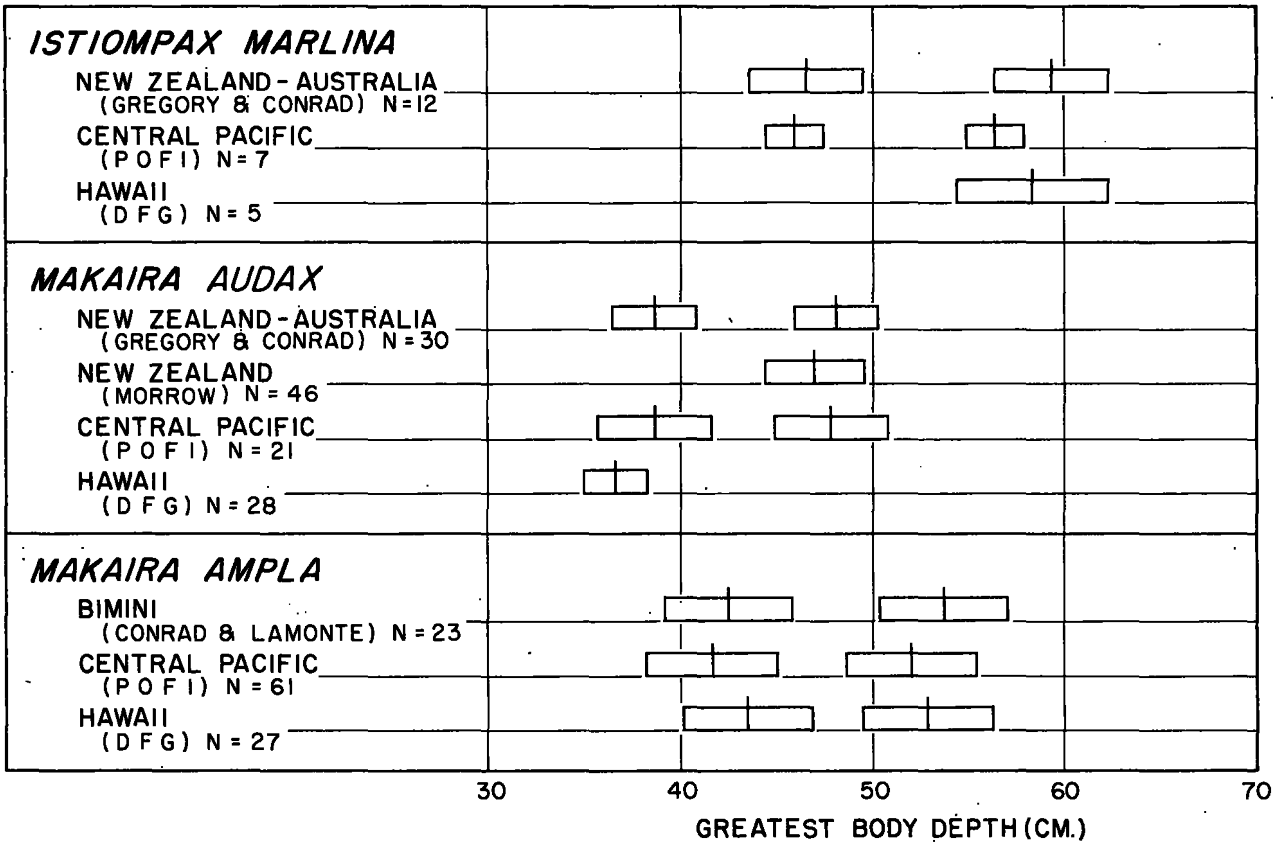

FIGURE 10.—Mean and standard deviation from regression of the greatest body depth of marlins at 250 cm. (left) and 300 cm. (right) fork lengths.

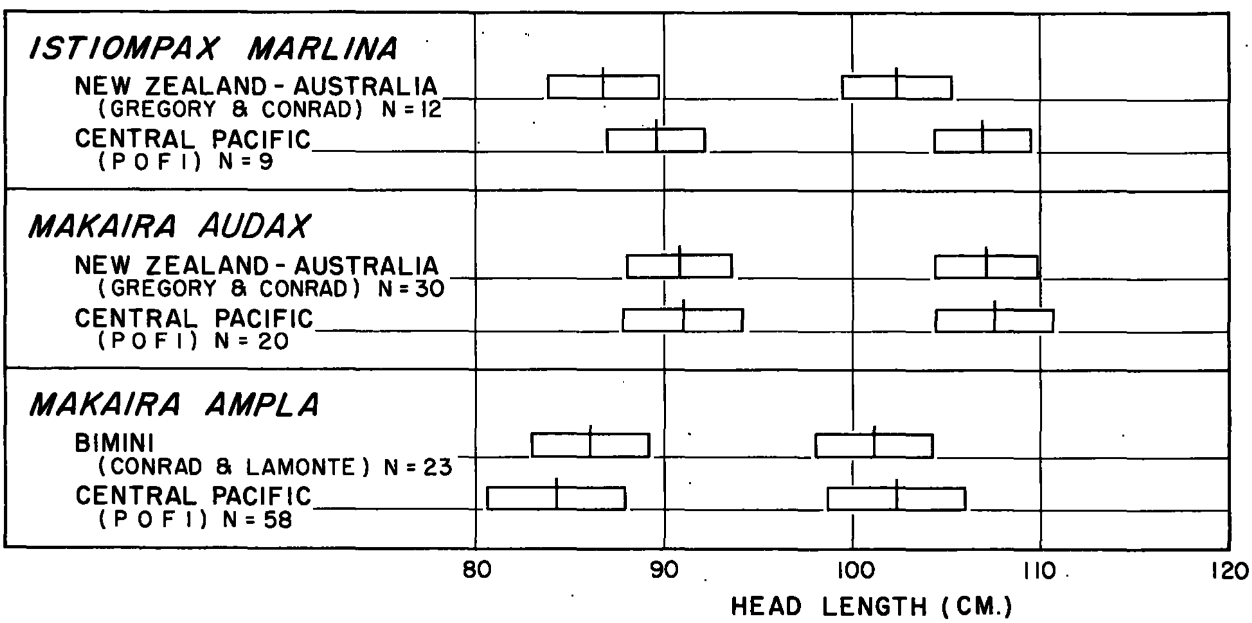

FIGURE 11.—Mean and standard deviation from regression of the head length of marlins at fork lengths of 250 cm. (left) and 300 cm. (right).

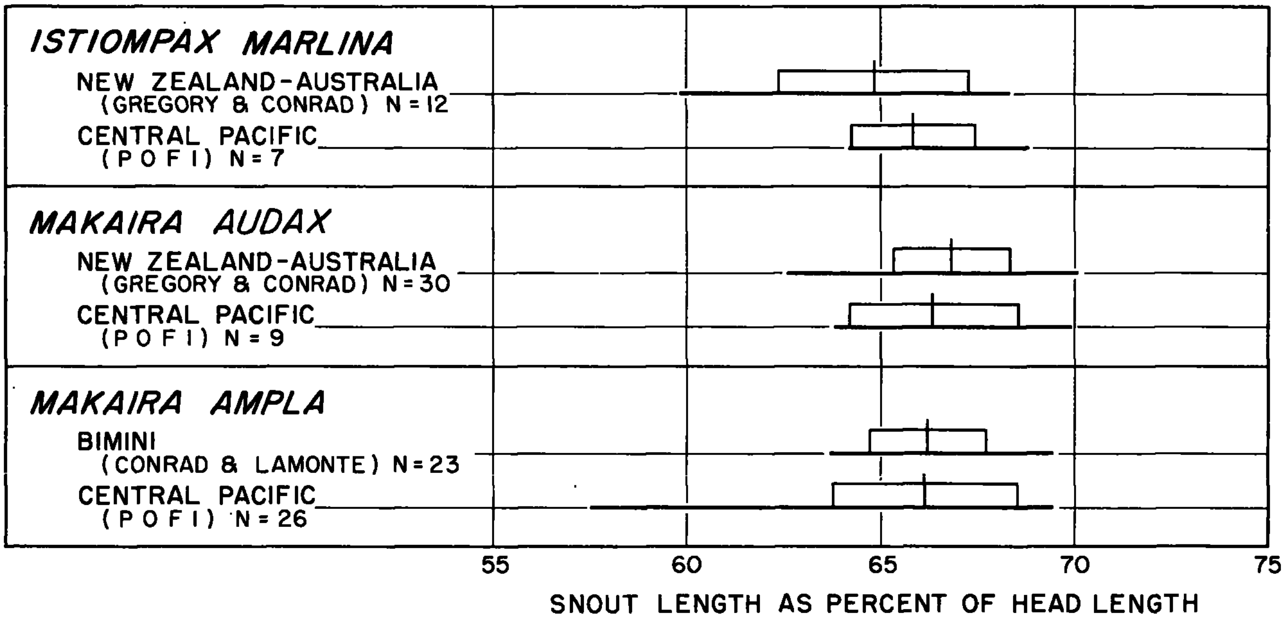

FIGURE 12.—Mean, standard deviation, and range of ratio of snout length to head length.

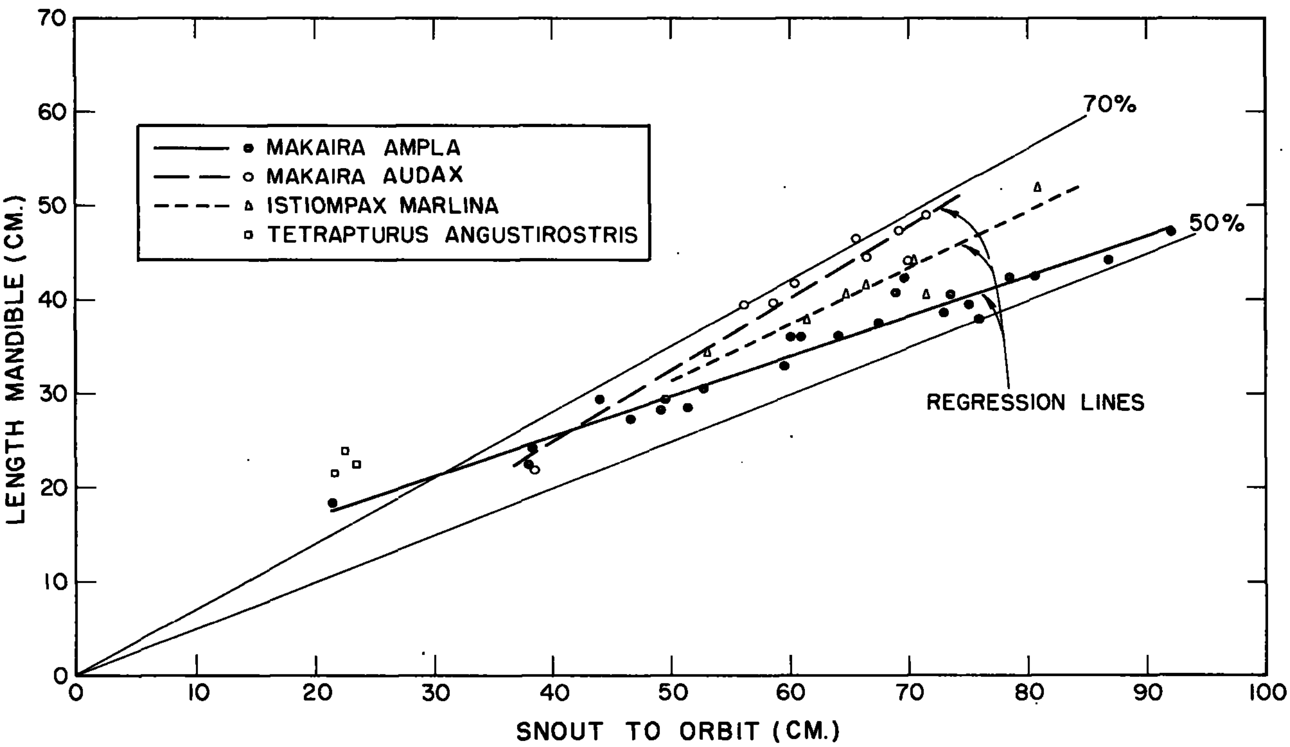

FIGURE 13.—Relation of length of mandible (to the joint) to snout from tip to orbit. (Measurements by POFI.)

different type of growth in *ampla* than in the other two species. The mandible of *ampla* tends to become markedly shorter in relation to the snout as the fish grows, whereas in the other two species the growth is nearly isometric.

A similar relation is apparent when regression lines are fitted to the published data (fig. 14) of Gregory and Conrad (1939) and Conrad and LaMonte (1937). Their data cover a much smaller range than the POFI data but the same

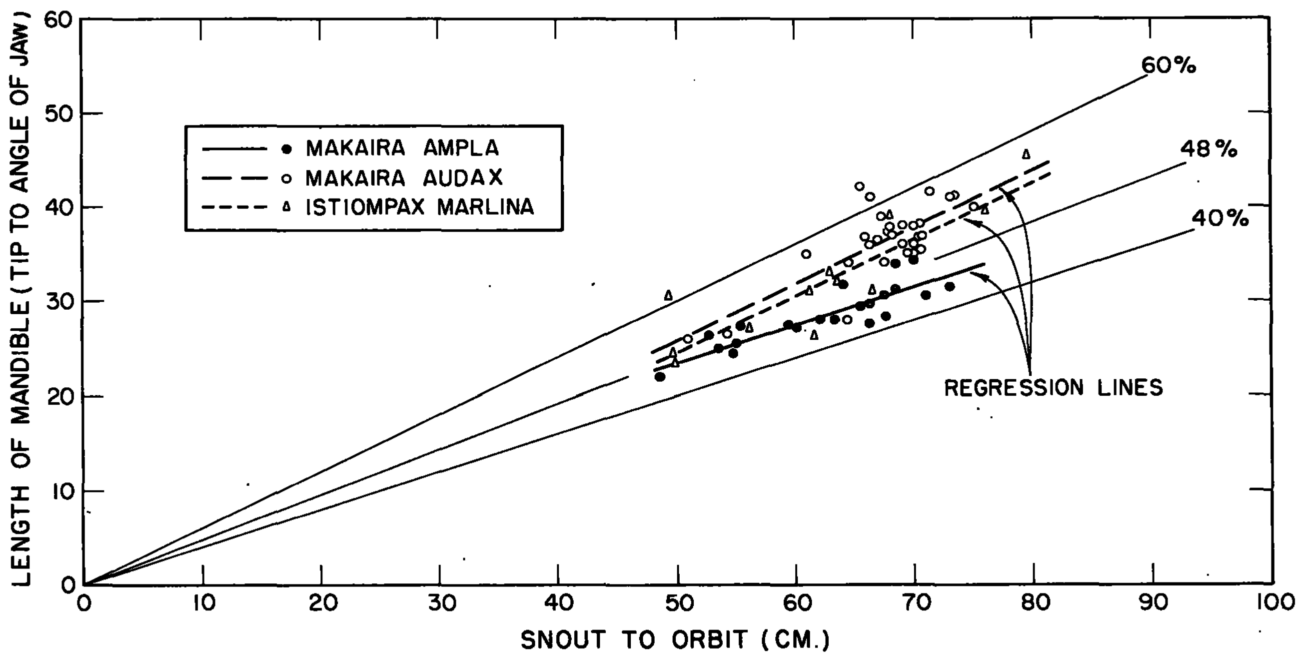

FIGURE 14.—Relation of length of mandible (tip to angle of jaw) to snout from tip to orbit. (Measurements from Gregory and Conrad, 1939, and Conrad and LaMonte, 1937.)

divergence among species is apparant; *audax* and *marlina* show slightly positive allometric growth of the mandible in relation to the snout, whereas *ampla* shows a slightly negative allometric growth. Unfortunately, the POFI measurements of the mandible (to the joint) are not comparable to the measurement used by these authors, so comparisons between areas are not possible.

Obviously, here is a character that is useless for separating the species among the intermediate sizes, but the divergence among the very large specimens suggests that, in them, it may be useful for distinguishing *ampla* from *marlina*. The length of the mandible to the angle of the jaw, as measured by Gregory and Conrad and by Conrad and LaMonte, is preferred to the measurement used by POFI; also, it may be measured with considerable precision from photographs. The plots of the published data suggest that specimens of more than about 600 pounds in which the mandible is more than 48 percent of the snout (that is, goes into the snout less than 2.1 times) will be *marlina*, whereas those in which the length of the mandible is less than 48 percent of the snout should probably be considered to be *ampla*. If we apply this criterion to the type photograph of *marlina* (Jordan and Evermann, 1926: pl. 17; which weighed only 509 pounds), and to all of Farrington's (1953) photographs of black marlin of more than 600 pounds in which the characters can be measured, we find that the length of the mandible is contained in the snout 1.5 to 1.9 times, with an average of 1.76. On the other hand, in the photographs of *ampla* of more than 400 pounds, shown by Farrington (1937), the length of the mandible is contained in the snout from 1.9 to 2.4 times, with an average of 2.09. Here is a character that may well be useful in distinguishing *ampla* from *marlina*, when the unequivocal character of the pectoral fin has not been recorded; but additional measurements of large specimens are needed to establish the difference.

Clearly, too, this difference in the lower jaw is the reason for the apparent differences that have been observed in the snout. When the lower jaw is very short, as in large *ampla*, the snout seems extremely long and slender, whereas the snout seems shorter when the lower jaw is long, as in *marlina*.

Length of pelvic fin

In our previous discussion of allometric growth, we pointed out that there was almost no change in the length of the pelvic fin with size of the fish in any of the three species examined by POFI. Consequently, we may compare these on

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the basis of the average length of the fin and disregard the size of the fish.

We find good agreement between the samples of the same species, but *marlina* has markedly shorter fins on the average than either *audax* or *ampla* (fig. 15). Of the 19 measurements available for *marlina*, the average is approximately 26 cm. and only 1 measurement is more than 30 cm. This is in contrast with the other two species in which the pelvic fins average about 33 cm. and in which we find only 19 out of the 95 measurements less than 30 cm. In most of the samples, the range extends farther from the mean on the lower side than on the upper and we suspect that some of the smaller measurements may be due to broken fins. If a careful watch is kept for broken fins, this character may then be useful to separate *marlina* from the other two species when other characters are not available. Any marlins with pelvic fins longer than 30 cm. are probably not *marlina*.

Length of pectoral fin

Length of pectoral fin also was discussed in the section on allometric growth and it was pointed out that while small specimens appeared to have slightly smaller pectoral fins in relation to fork length, specimens of more than 200 cm. fork length had pectoral fins which grew almost isometrically.

When pectoral fins are compared (fig. 16), it is apparent that they show almost as much variation within species as between species and that the character is useless for distinguishing one species from the other. The means vary from only 18.2 percent in *ampla* from Hawaii to 19.4 in *audax* from New Zealand and Australia.

Height of first dorsal fin

Height of the first dorsal fin appears to be one of the best means of distinguishing the three species of marlins. Nichols and LaMonte (1941) compared the anterior lobe with head length, Jordan and Evermann (1926) usually compared it with the length of the pectoral fin, and Nakamura (1949) with the greatest depth of the body. When we plotted height of the first dorsal in relation to fork length, we found a negligible amount of allometric growth and, hence, we can use it as a ratio. The comparison of all samples (fig. 17) shows that *marlina* has the lowest fin, *ampla* intermediate, and *audax* the highest. The averages are approximately 12, 13.5, and 17 percent, respectively; however, the separation between species is not complete, as there is considerable overlap between *audax* and *ampla* and between *ampla* and *marlina*. The samples show close agreement within species except for *marlina*, in which there is a suggestion of a clinal difference. The specimens from New Zealand and Australia have the highest first

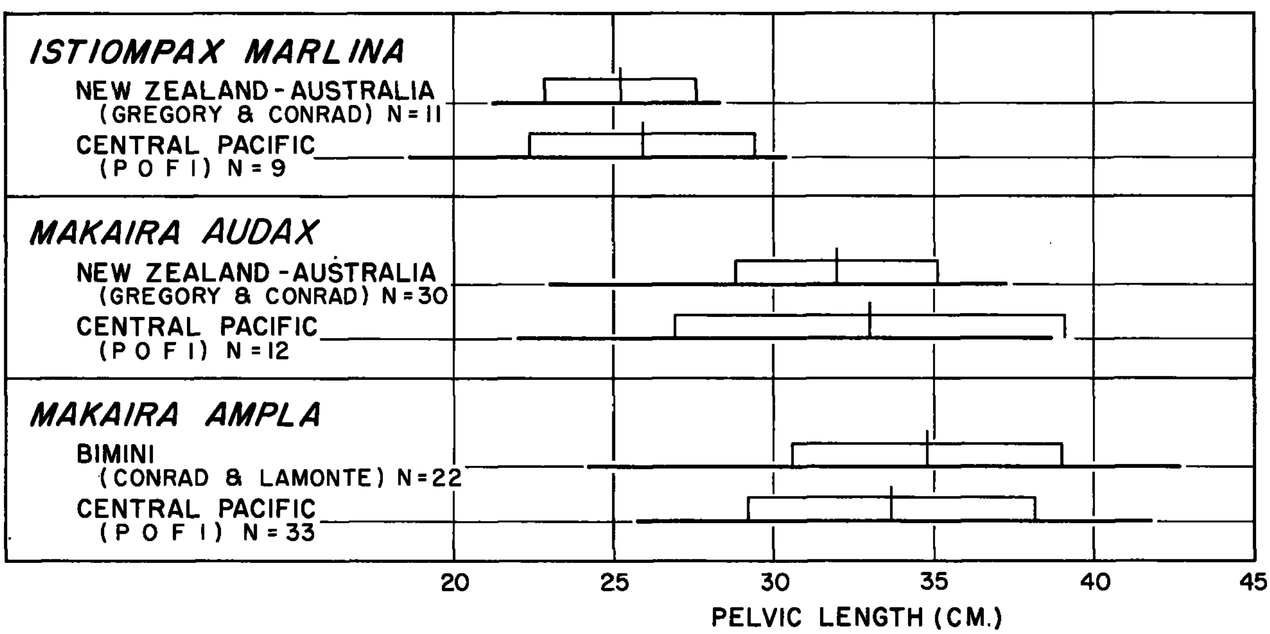

FIGURE 15.—Mean, standard deviation, and range of the length of the pelvic fin.

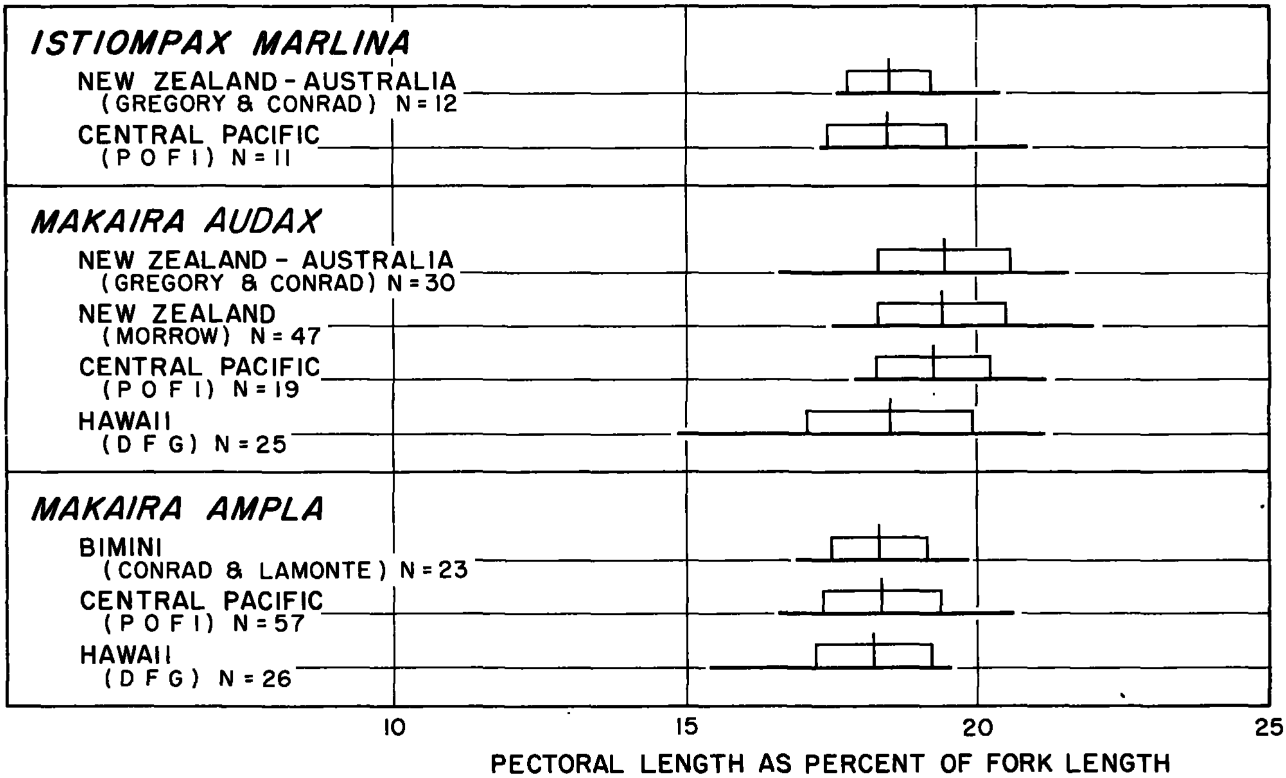

FIGURE 16.—Mean, standard deviation, and range of the ratio of length of pectoral fin to fork length in fish of more than 200 cm. fork length.

dorsal fins, those from the equatorial Pacific lower fins, and those from Hawaii the lowest.

When height of the first dorsal fin is compared with the greatest depth of the body we find a marked allometric relationship (fig. 18). We found no *ampla* in which the height of the first dorsal was greater than the greatest body depth and only one *audax* in which the height of the first dorsal was less than 90 percent of the greatest body depth. The trend lines are such, however, that it is evident that in very small *ampla* the first dorsal may exceed the greatest body depth and in very large *audax* may be less than 90 percent. In any event, there is a considerable overlap of specimens in which the anterior lobe is between 90 and 100 percent of the greatest body depth.

The difficulty presented by allometric growth and most of the overlap between *ampla* and *audax* is eliminated if, instead of comparing the height of the first dorsal with the greatest depth of the body, we compare it with the height of the first anal (fig. 19). Plots of this relationship indicated no allometric growth and hence the comparison by ratios is valid. This comparison shows that the anal fin in *audax* averages 66 percent of the height of the first dorsal, whereas in *ampla* it averages 86 percent. If we accept 76 percent as a dividing line between the species, we find only a single overlapping specimen of *audax* with a greater value. *Istiompax marlina* is intermediate with an average of approximately 80 percent, and overlaps both of the other species.

Despite the nearly isometric growth of the anterior lobe, the middle of the first dorsal (as indicated by the length of the 20th ray) in *audax* shows not merely negative allometry but actual negative growth, with those fish of less than 200 cm. fork length having a longer 20th ray than the larger individuals. There is a suggestion that the same condition pertains to *ampla*, but the data are too few to verify it. At any rate, the length of this ray changes little in fish of more than 200 cm. and, hence, we compare the samples on the basis of the actual average length of the ray (fig. 20). Here we find the shortest 20th rays in *ampla* and *marlina* and much the longest in *audax*. This character appears to be a fairly

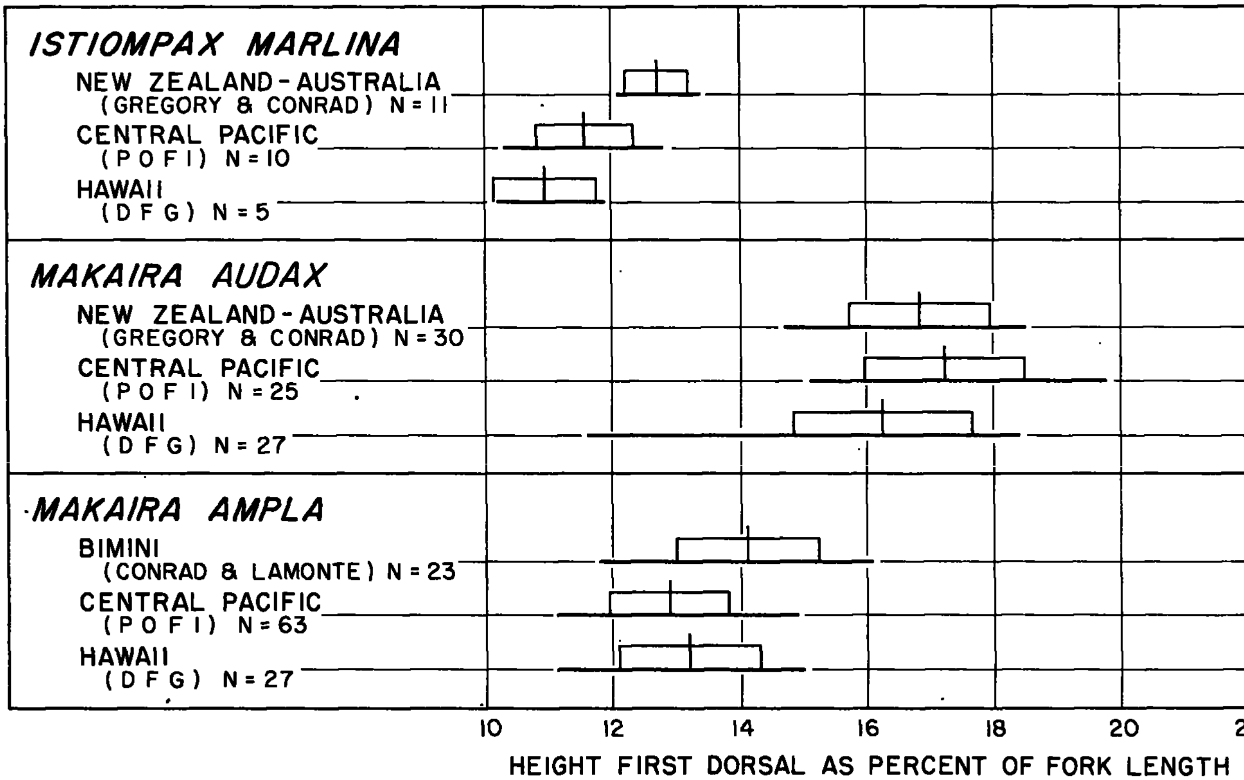

FIGURE 17.—Mean, standard deviation, and range of the ratio of height of anterior lobe of first dorsal to fork length.

good one for distinguishing *audax* from each of the other two species, because with a dividing point of 8 cm. only 1 out of 35 *audax* had a shorter 20th ray and only 5 out of 62 *ampla* had a longer 20th ray. None of the 13 *marlina* had a 20th ray longer than 8 cm.

Caudal spread

When plotted, the caudal spread showed no evidence of allometric growth and, hence, has been compared on the basis of its ratio to fork length (fig. 21). It may be seen that *audax* tends to have the slightly smallest tail, *marlina* intermediate, and *ampla* the largest, but there is so much overlap that the character is useless for distinguishing the species.

There is a persistent tendency for the specimens measured by POFI in each species to have slightly broader caudals than those measured by Gregory and Conrad (1939) and Conrad and LaMonte (1937). All of the POFI measurements, except the one largest *ampla*, were obtained on board ship at sea from fish that had never been lifted by the tail. Consequently, the fin rays had not been compressed and the measurement of the spread might be expected to be slightly greater than if the fish had been handled or hung up by the tail. We suspect that some or all of the fish measured by the authors cited might have been lifted by the tail; consequently, we attach no significance to the slight differences.

Lateral line

Nakamura (1949) has pointed out that *audax* and *marlina* have simple lateral lines, whereas *ampla* has a complex lateral line. We concur in the presence of a complex lateral line in a preserved specimen (specimen No. 1 in appendix table 1–E, p. 545) of *ampla* in which the lateral line is conspicuous. In all fresh material we have examined at sea and in the Honolulu market, we have found the lateral line extremely difficult to locate and to determine whether or not it is complex. We question the usefulness of this character in the field.

Flexibility of the pectoral fin

Many people who have seen *marlina* have reported that the pectoral fin cannot be folded back against the body. Those who have not examined the fish quite naturally have wondered if this

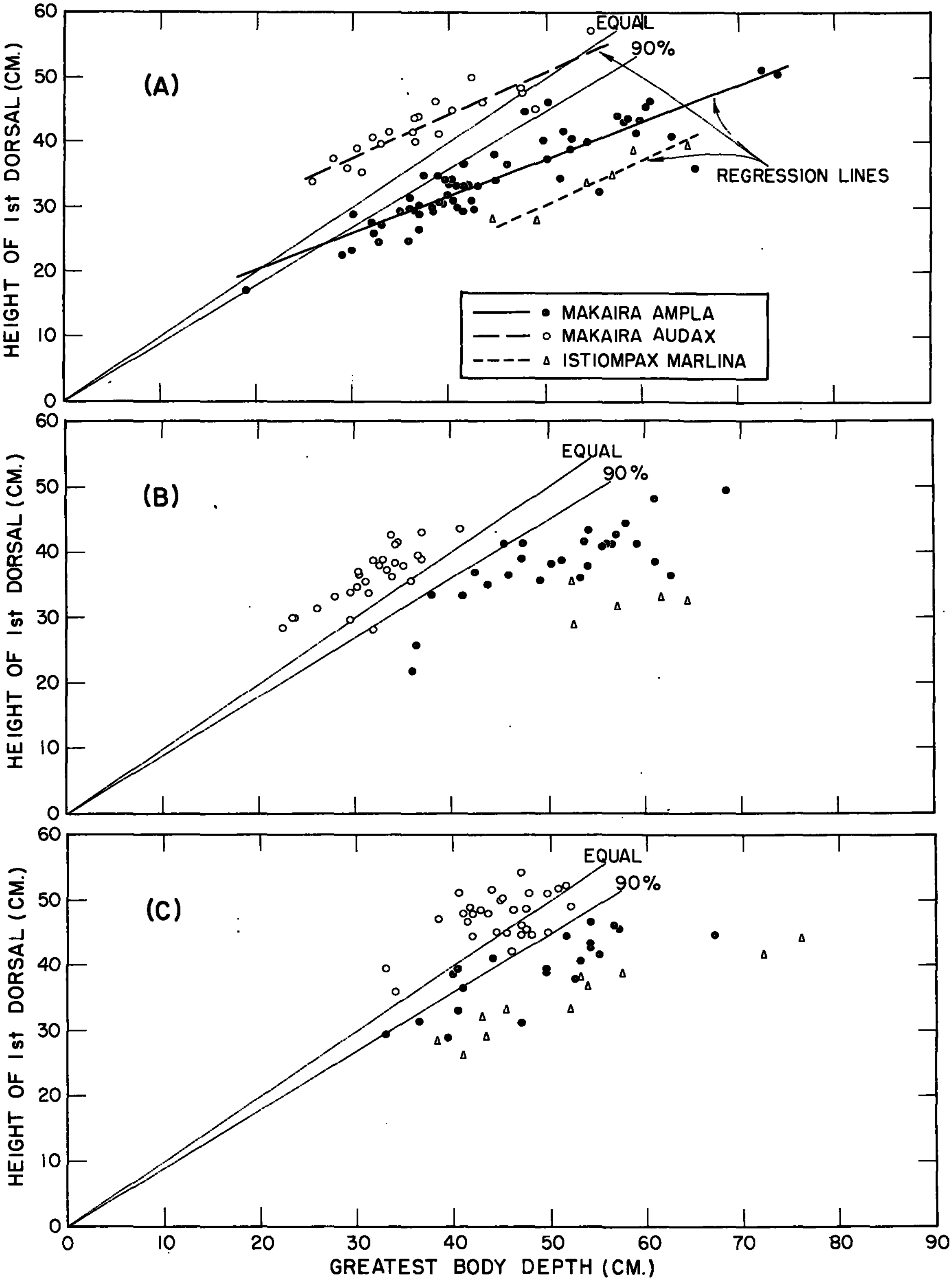

FIGURE 18.—Relation of height of first dorsal fin to greatest body depth. A. Measurements by POFI; B. Measurements by DFG; C. Measurements from Conrad and LaMonte (1937) and Gregory and Conrad (1939). Regression lines have been computed for the POFI data.

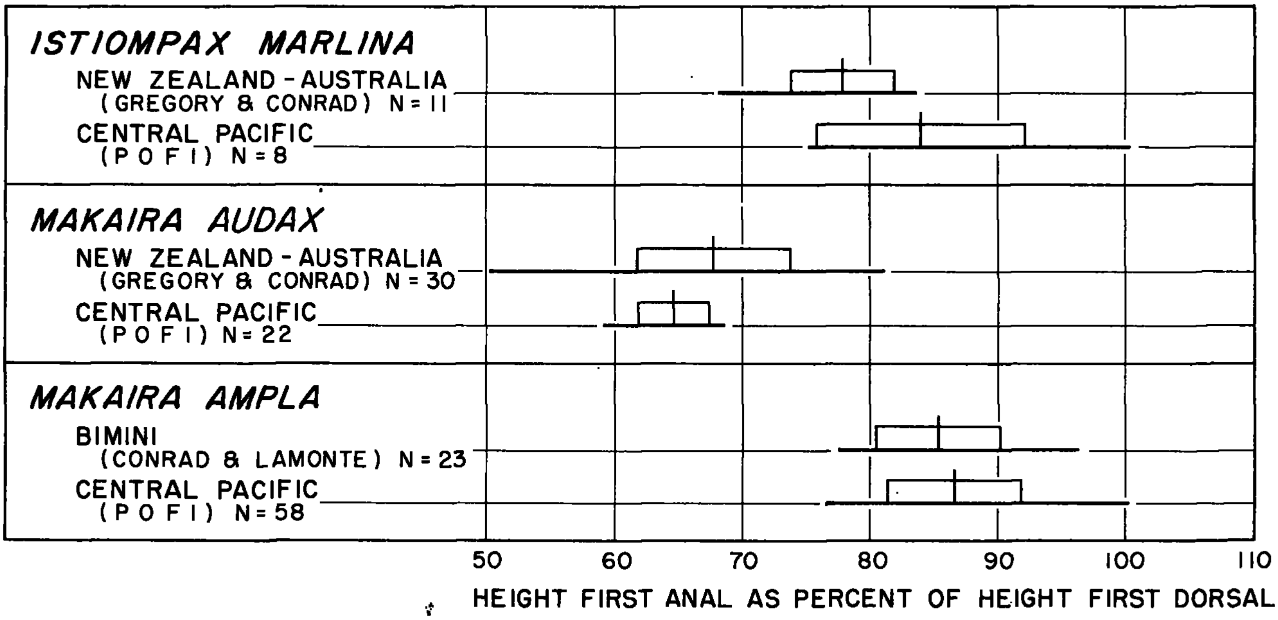

FIGURE 19.—Mean, standard deviation, and range of the ratio of height of anterior lobe of first anal to height of anterior lobe of first dorsal.

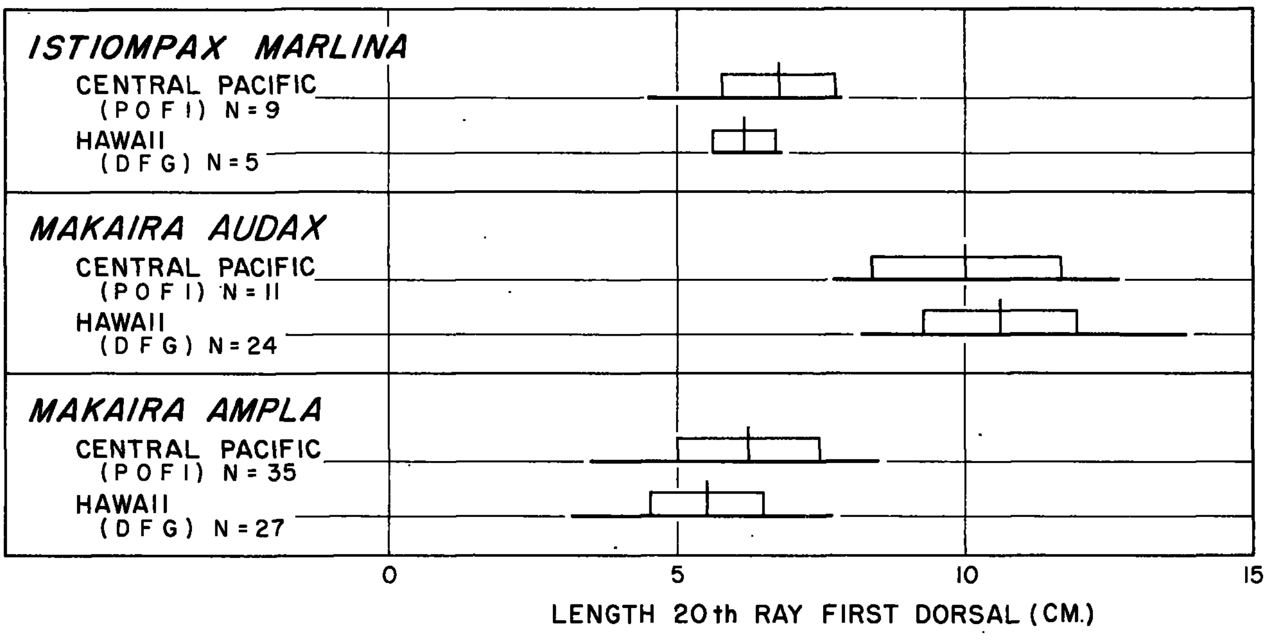

FIGURE 20.—Mean, standard deviation, and range of the length of 20th ray of first dorsal fin in specimens of more than 200 cm. fork length.

condition could arise from rigor mortis or from accidental locking of the joint and thus would not really be a distinctive species character at all. The anatomical work of Nakamura (1938) has established that this fin condition results from osteological structure and not from accidental locking of the fin. Furthermore, after having an opportunity to compare *marlina* with specimens of *ampla* and *audax* in rigor we do not question the usefulness of the character. The stiff fin of *marlina* can be moved through a limited range but positively cannot be rotated or folded back along the side without breaking. It does, however, move easily in its limited range when not

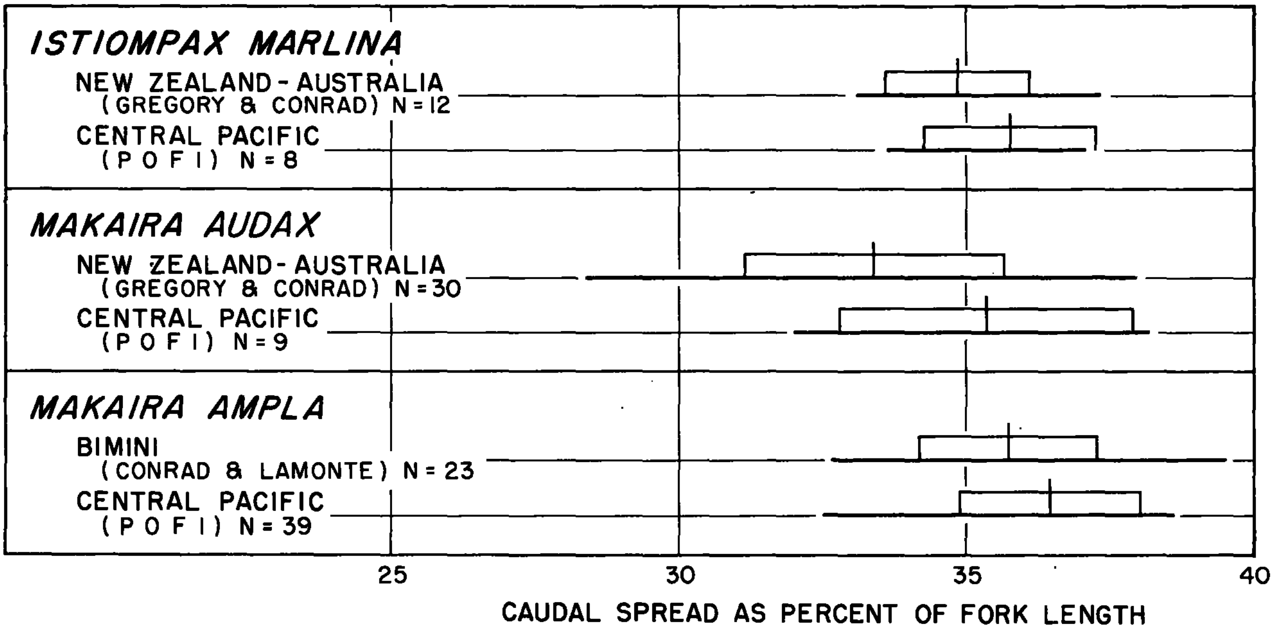

FIGURE 21.—Mean, standard deviation, and range of the ratio of caudal spread to fork length.

in rigor. On the other hand, the pectoral fins of marlins in rigor move stiffly at all times, but we have not yet encountered an *ampla* or *audax*, even though in rigor mortis, whose pectoral fin could not be folded back against the body without breaking.

Miscellaneous characters

We have not used a number of other characters because they are too variable, too similar among species, or our data too few. The depth of the head in *marlina* appears to be greater than in the other species, but when measured from the supraoccipital to the isthmus we found this character to be highly variable. Perhaps this is because it is so difficult to standardize the position of the branchiostegal rays after death. Also, the body of both *marlina* and *audax* appears to be definitely more tapered than that of *ampla*. We attempted to measure this by obtaining a depth at the vent to compare with the greatest body depth but had too few measurements to establish any relation. Then the sword in *marlina* appears definitely heavier and more robust than that of the other two species; but when the breadth is measured at the tip of the mandible we find a great deal of overlap, probably because, as pointed out earlier, the mandible becomes shorter in relation to the sword in *ampla*, whereas in *audax* and *marlina* it grows nearly isometrically. (It would be better to measure the width and depth of the mandible at the midpoint.) On another occasion, when we had an opportunity to examine a specimen of *marlina* alongside an *ampla* of about the same weight, we noticed that the distance between the ventral groove and the insertion of the anal fin in *marlina* was considerably greater than in *ampla*. However, a few more measurements of this character suggest that it also is extremely variable.

The principal criteria used by Jordan and Evermann (1926) to separate the nominal species properly referable to the genus *Tetrapturus* are the presence or absence of short, stiff spines between the two dorsal fins or between the two anal fins and the width of the interspaces. We doubt the value of these characters in distinguishing the species, because in the few shortnose spearfishes examined we found the interspace between the two dorsals to be highly variable and in one specimen even lacking. We have found no free spines in our specimens of *Tetrapturus*, but have noticed them occasionally in *ampla*, and have even found them in separate fin slots. In most spearfishes the posterior spines of the first dorsal fin become very small, and whether they are separate is not easily determined unless they happen to be in separate fin slots. We consider the interspace between the anals and dorsals and the number of free spines to be of very doubtful value as taxonomic characters.

OBSERVATIONS ON SPEARFISHES OF THE CENTRAL PACIFIC

Having decided which characters are of diagnostic value, it is now possible to consider our observations on the spearfishes of the central Pacific together with the considerable literature on the group from the several parts of this ocean. This we have done in the following discussion, with the assumption that many of the minor differences reported in body proportions will prove to be individual variation, or at most, varietal differences.

During this study we were fortunate to have ready access to Japanese literature through our translator, W. G. Van Campen. He located many papers including several which were published entirely in Japanese. Many of these papers were translated and others were summarized. Further, we corresponded extensively with Japanese workers on the spearfishes and feel that we quite completely covered the recent Japanese literature on the spearfishes.

Xiphias gladius Linnaeus

Swordfish, Broadbill

Tsun, Shūtome, or Mekajiki (Japan)

Our catches of the swordfish have been so small that we can add little of significance; however, it seems worthwhile to discuss it here and give a few brief notes from recent Japanese publications.

The truly pelagic nature of the swordfish is indicated in Kikawa's (1954) review of the Japanese fishery. He reported that at the beginning of the season in late summer the highest catch rates are to be found northeast of Japan, north of

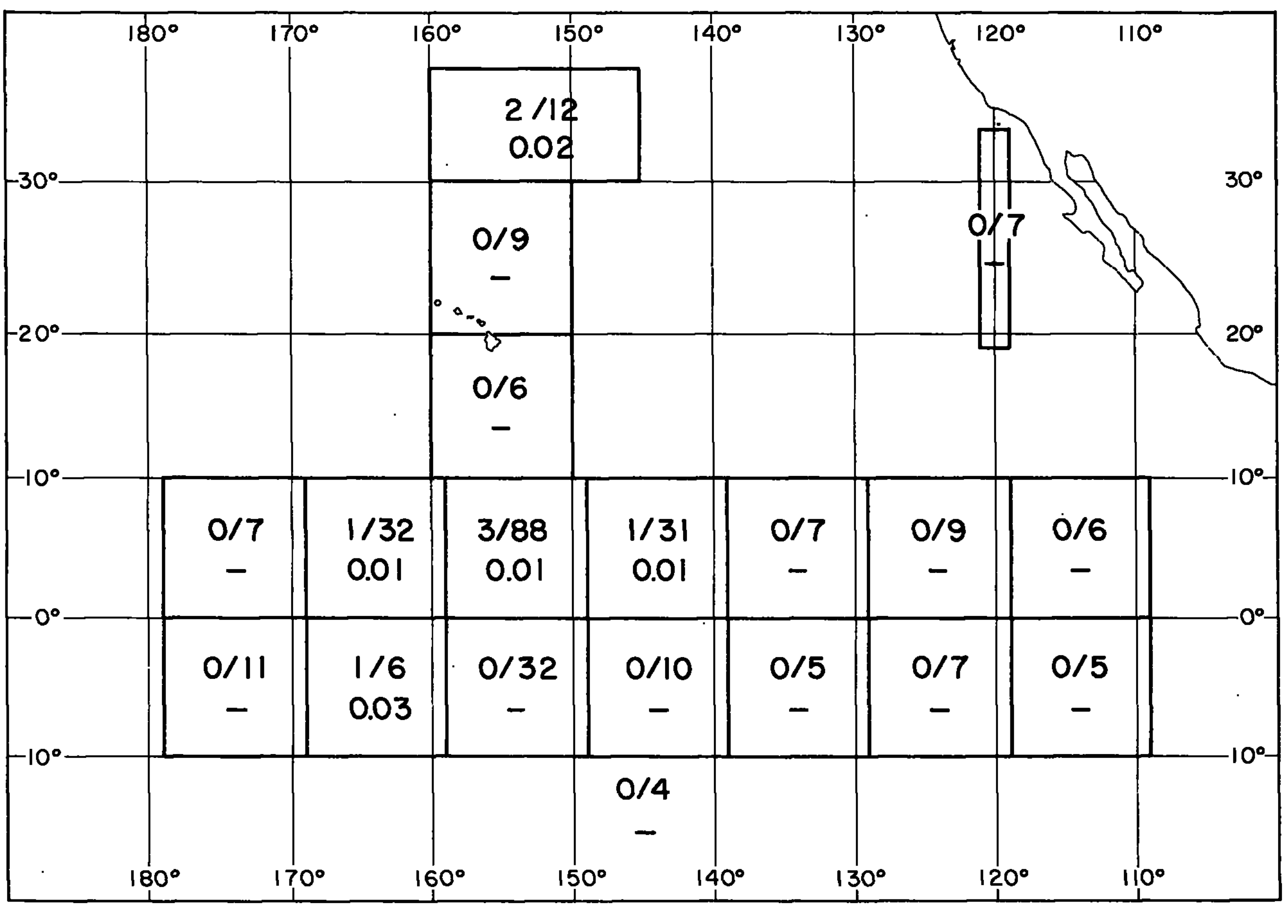

FIGURE 22.—Distribution of POFI catches of swordfish, *Xiphias gladius*. Fractions indicate stations at which catches were reported out of the total fished; decimals indicate average catch per 100 hooks per day.

40° N. latitude, and between 150° and 170° E. longitude. Fishing is carried on at this time north to 45° but, with the advent of winter weather, the fishery moves south to the vicinity of 30° where good fishing is found in December and January. In addition to this offshore fishery there are inshore fisheries around southern Japan and the Bonin Islands, some of which are productive the year round.

The swordfish is generally considered to be an inhabitant of warm seas throughout the world, but its distribution in the western Pacific suggests that the adults prefer the cooler waters. Kikawa (1954) noted that they are only sporadically captured in tropic seas, and this is in agreement with POFI experience (fig. 22) and with the results of the Japanese tuna mothership expeditions to the Caroline Islands area in 1950–51. In the latter, Van Campen (1952) reported that the average catch rate of swordfish for all expeditions was less than .01 per 100 hooks, whereas catch rates off northeastern Japan average nearly 1.0 per 100 hooks (Kikawa 1954).

Nakamura et al. (1951) think that the tropics are the spawning grounds of the swordfish, and noted therefrom the capture of juveniles less than 30 mm. in length and numerous larvae in the stomachs of other fish. They also reported that the longline catches in the equatorial area are predominantly fish from 50 to 100 cm. in length (orbit to fork of tail). In addition, all of the fish in the northern fishery have undeveloped gonads. The presence of small fish in the equatorial area is substantiated by the reports from the Japanese mothership expeditions to the Caroline Islands where, according to Ego and Otsu (1952), the weight of the swordfish captured during each of the first six expeditions ranged from 58 to 102 pounds.

Such catches of large and small swordfish are in accord with the limited POFI experience, for the largest of the three taken in tropical waters on which size data are available was only 80 pounds. The other two were very small, each only 92 cm. long. We also have notes on two small swordfish taken from the stomachs of *Makaira ampla:* one of 35 cm. taken on May 18, 1954, at 6°02′ N., 162°28′ W. and another of 38 cm. taken on May 28, 1954, at 6°02′ N., 159°34′ W. On the other hand, the two specimens taken north of Hawaii were each large, more than 300 cm. total length.

Swordfish landed in the Honolulu market (table 2) ranged from 75 to 1,061 pounds, according to the records collected during 1949 and 1950 by the Hawaiian Division of Fish and Game. There was no pronounced mode in this weight distribution.

Additional insight into the habits of the swordfish is available from Kikawa's (1954) account of the methods used in the Japanese fishery. Most of the swordfish are taken by vessels specializing in the fishery that use longline gear similar to tuna gear. The principal difference is in the mode of operation, for these swordfish vessels fish at night when the catch rate is approximately twice what it is in the daytime. Such a difference in the habits of the broadbill makes it difficult to compare these catches with the abundance in other parts of the Pacific, where swordfish are taken by tuna vessels that fish entirely during the day.

TABLE 2.—*Weight frequency of swordfish,* Xiphias gladius, *landed at the Honolulu market during 1949 and 1950*

[Data collected by the Hawaiian Division of Fish and Game]

Weight group (pounds)	Number weighed in—		Total
	1949	1950	
60–69			
70–79	1		1
80–89			
90–99	2		2
100–109	2		2
110–119	2		2
120–129	2	1	3
130–139	4		4
140–149	3		3
150–159	1		1
160–169	1		1
170–179			
180–189	1	1	2
190–199	2		2
200–219	2	3	5
220–239	1		1
240–259	2		2
260–279		2	2
280–299	1		1
300–319	2	3	5
320–339	4		4
340–359	1	1	2
360–379	3		3
380–399	1	1	2
400–419		1	1
420–439			
440–459			
460–479	2	1	3
480–499	1	1	2
500–549	2	2	4
550–599	1	2	3
600–649	5	1	6
650–699	3	1	4
700–749	1		1
750–799	2		2
>800	2	2	4
Number			80
Maximum weight (pounds)	863	1,061	

Tetrapturus angustirostris Tanaka

Shortnose Spearfish

Fūraikajiki (Japan); Indian Spearfish (Hawaii)

Distinguishing characteristics

This little spearfish is characterized by a snout that extends only slightly beyond the lower jaw, a long, slender, compressed body, the greatest depth of which is less than 13 percent of the fork length, relatively short pectoral fins that are less than 14 percent of the fork length, and an easily visible, single lateral line. It lacks the stripes of most of the other species.

Unfortunately, we lack data on a sufficient number of specimens of less than 30 pounds of the other species to separate them clearly from *Tetrapturus*. In very small *Makaira ampla* the snout is scarcely longer than the mandible, but the body is heavier, rounder, and the middle of the first dorsal fin is probably less than two-thirds of the height of the anterior lobe. In small *M. audax*, the middle of the first dorsal fin approaches the height of the anterior lobe as it does in *Tetrapturus*, but *audax* may be distinguished by the presence of stripes and a snout markedly longer than the mandible. We have seen no very small specimens of *Istiompax marlina*, but presumably they may be distinguished unequivocally by the stiff pectoral fin, which in *Tetrapturus* is flexible.

The close resemblance of the shortnose spearfish to the young of the other marlins has led some to suspect (LaMonte and Marcy 1941:21) that it is merely a juvenile form. This view, however, was effectively disproved by the work of Nakamura (1937) who figured the eggs, ovaries, and testes and described one ripe female taken in November which was 152 cm. in fork length and 27 pounds in weight. This fish was taken along with several others with enlarged ovaries. A female with running-ripe ovaries (specimen No. 5 in appendix table 1–A, p. 541) that we captured on March 18, 1954, was 164 cm. fork length. It was not weighed but the weights of other specimens of similar length suggest that its weight should have been about 40 pounds. Such sizes are far below the sizes at which the other species commonly occur and appear to mature.

Jordan and Evermann (1926) listed four Pacific and one Indian Ocean species of this genus, but it appears probable that there is but a single species in this whole area. Two of the species, *ectenes* and *brevirostris*, obviously do not belong to the genus *Tetrapturus*. Two other species, *illingworthi* and *kraussi*, were described as new from Hawaii and were separated from the Japanese species *angustirostris* because the latter was described as having a dorsal lobe longer than the pectoral. In the 9 specimens from the central Pacific on which we have these measurements we find 8 in which the dorsal lobe is very slightly longer than the pectoral, and 1 (from Hawaii) in which the opposite is true but the variation in these two characters is such that this comparison of fins is not a good specific character. These authors also distinguished *illingworthi* and *kraussi* on the basis of the separation of the dorsal fins—a character we find highly variable in our specimens. We, therefore, place both species in synonymy with *angustirostris*.

There appears to be no valid reason to retain the genus *Pseudohistiophorus* as proposed by De Buen (1950:170–171). He established this genus because the previous attempts to place heterogeneous species in *Tetrapturus* suggested to him that *Tetrapturus* was the synonym of *Makaira*. We cannot accept this view because the redescription of *Tetrapturus belone* Rafinesque given by Cuvier and Valenciennes (1831:205—the earliest description available to us) is excellent and obviously represents a species extremely close to, if not identical with, our Pacific species.

If *Tetrapturus* should prove to be monotypic, the species name *belone* described from a Mediterranean specimen would have priority. Jordan and Evermann (1926) separated it on the basis of the short, stiff spines in the interspace between the dorsal and anal fins. We have seen none of these spines in the Pacific form, but in some specimens of *M. ampla* we have noticed that the first dorsal fin may continue almost to the second dorsal or may be broken up into separate spines, sometimes even in separate fin slots. This appears to be a matter of individual variation, and further examination of the species from several areas is needed to determine whether this is a constant character.

Color

Immediately after death *T. angustirostris* is a brilliant, deep metallic blue on the back and first dorsal with silvery gray on the sides and white on the belly. In about an hour this rapidly fades to a dark, slate gray on the back and to black on the first dorsal. We have seen no evidence of stripes and, according to Nakamura (1949), it never has them.

Distribution in the Pacific

According to Nakamura (1951), this pelagic species does not enter coastal or enclosed seas. Off Japan it occurs south of 35° N. latitude and rather densely in the waters east of Formosa and the Philippines from November to January. Nowhere is it abundant enough to be of importance to the fishery. In our POFI fishing we have taken only the 8 specimens recorded in appendix table 1–A; their distribution is indicated in figure 23. In the Hawaiian fishery it is one of the miscellaneous spearfishes that comprises only a small fraction of the total spearfish catch. On the first six Japanese mothership expeditions to the vicinity of the Caroline Islands (Ego and Otsu, 1952) it was combined with the sailfish in the statistics, and on each of these trips the catch of the two species together averaged only from .02 to .07 per 100 hooks.

Size

This is the smallest of the spearfishes and, according to Nakamura (1949), attains a weight of only 44 pounds, but the POFI specimens which we have weighed from the central Pacific ranged from 18 to 51 pounds. Based on the data obtained from the Honolulu market by the Hawaiian Division of Fish and Game (table 3), the maximum weight found in 177 specimens was 114 pounds. However, the modal size was approximately 38 pounds.

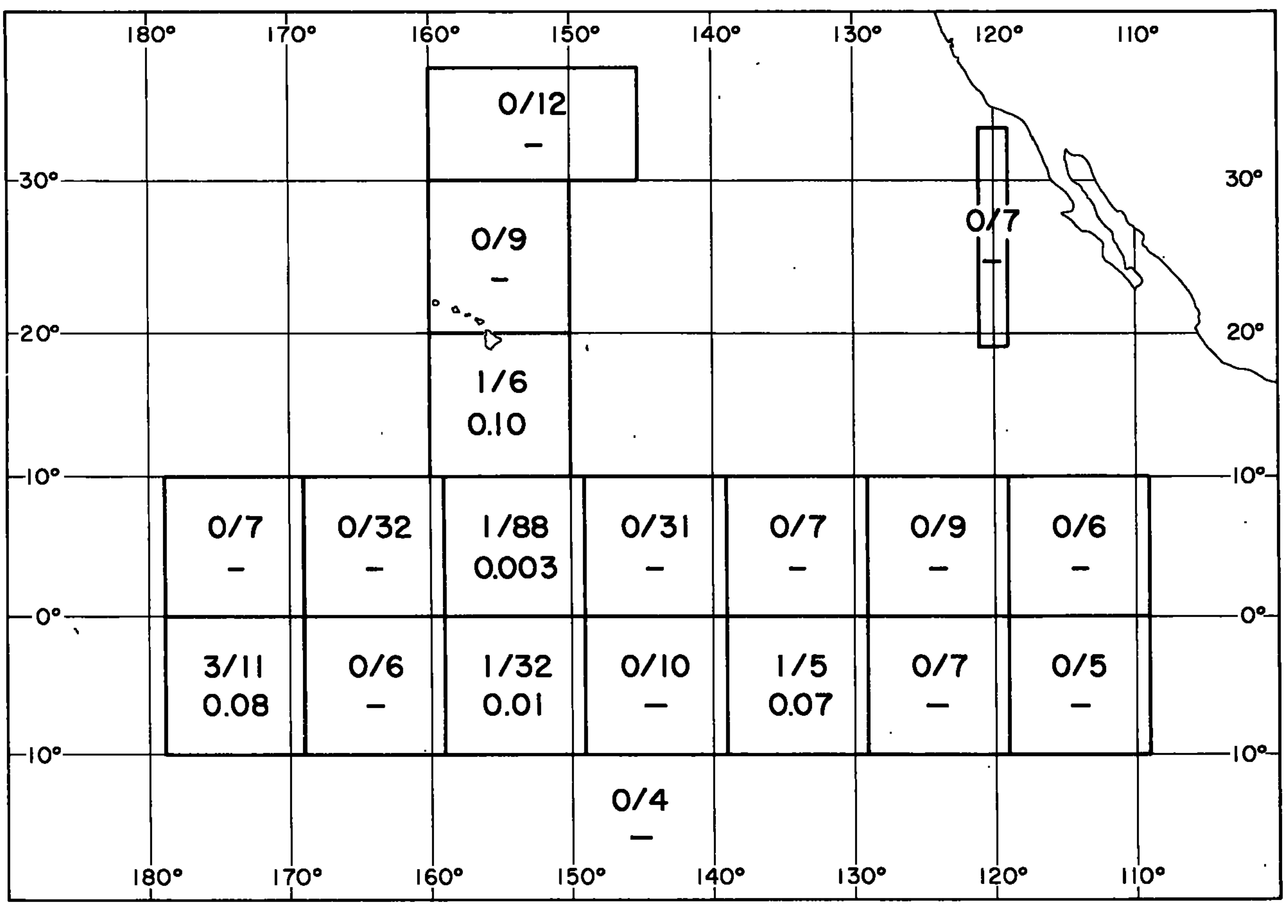

FIGURE 23.—Distribution of POFI catches of shortnose spearfish, *Tetrapturus angustirostris*. Fractions indicate stations at which catches were reported out of the total fished; decimals indicate average catch per 100 hooks per day.

TABLE 3.—*Weight frequency of shortnose spearfish,* Tetrapturus angustirostris, *from the Honolulu market in 1951*

[Data collected by the Hawaiian Division of Fish and Game]

Weight group (pounds)	Number of fish	Weight group (pounds)	Number of fish
15–19		70–74	6
20–24	6	75–79	4
25–29	11	80–84	2
30–34	23	85–89	1
35–39	32	90–94	
40–44	25	95–99	
45–49	23	>100	2
50–54	10		
55–59	14	Number	177
60–64	15	Maximum weight (pounds)	114
65–69	3		

Food

We have notes on the contents of 6 stomachs of which 2 were empty and the other 4 contained squid. Three stomachs contained fish of which only bramids were identified.

Synonymy and references

Tetrapturus angustirostris, Tanaka, 1914:324 (Japan); Nakamura, 1937 (Formosa); Nakamura, 1938:24 (Formosa); LaMonte and Marcy, 1941:2 (Japan); Nakamura, 1942 (Formosa); Hirasaka and Nakamura, 1947:11 (Formosa); Nakamura, 1949:56 (Japan); Rosa, 1950:159 (Japan); Nakamura, 1951:35 (northwestern Pacific).

Tetrapturus illingworthi, Jordan and Evermann, 1926:32, pl. 8 (Hawaii); LaMonte and Marcy, 1941:2; Brock, 1950 (Hawaii); Rosa, 1950:161 (Hawaii).

Tetrapturus kraussi, Jordan and Evermann, 1926:33, pl. 9 (Hawaii).

Tetrapturus brevirostris, De Beaufort and Chapman, 1951:238 (850-mm. specimen); Fowler, 1928:136 (Hawaii).

Not *Histiophorus brevirostris,* Playfair and Günther, 1866:53, 145 (Indian Ocean).

Not *Tetrapturus ectenes,* Jordan and Evermann, 1926:34, pl. 11, fig. 2 (Hawaii).

Istiophorus orientalis (Temminck and Schlegel)

Sailfish

Bashōkajiki (Japan)

Distinguishing characteristics

This genus is effectively distinguished from all other spearfishes by its very high first dorsal fin. It also has a slenderer, more greatly compressed body and much longer pelvic fins.

Problems of identification arise within the genus because so many species have been described. Those listed by Jordan and Evermann (1926) are differentiated mostly on the basis of the interspace between the dorsal fins, whether or not that space has spines, the shape of the first dorsal, the color, the length of the pectoral, the length of the spear, or the relative size of the second dorsal and second anal fins. We have seen only a few sailfish, but most of these characters are so variable in the other spearfishes that they have little value for identifying species.

There seems little doubt that the species occurring in the central Pacific should be *orientalis,* which most authors have used. On the basis of a cast in the Bishop Museum,[7] Jordan and Ball, *in* Jordan and Evermann (1926), also describe *eriquius* from Hawaii in which the first dorsal fin is subtruncated behind with only 34 dorsal spines. The photo in Jordan and Evermann (p. 101) suggests that the posterior part of the dorsal fin was missing from the cast. Further, there are no reports from Hawaiian fishermen of two species of sailfish. We, therefore, regard *eriquius* as a synonym of *orientalis.*

Distribution in the Pacific

Nakamura (1949) gave the distribution of the sailfish as extending from the northeastern coast of Japan south and noted that it is comparatively abundant in the Kinan Sea area. He also stated that this species often enters coastal waters. It is, however, widespread in the tropical Pacific. It was taken in small quantities by the Japanese mothership expeditions near the Caroline Islands in 1951 and 1952 (Ego and Otsu, 1952), and 20 specimens were taken during the POFI longline fishing, as indicated in figure 24. Some of the POFI specimens were taken many hundreds of miles from the nearest land.

Spawning

Spawning sailfish were taken on July 10 and 12 off Hainan Island, according to Nakamura (1940), along with several juveniles of less than 10 mm. He also reported that a spawning female caught on the hook was followed by a companion fish, presumably a male. He (1949) noted that they spawn in Formosan waters from April to August. We can add nothing to the information on spawning because none of the POFI specimens examined had ripening gonads.

[7] Not included in the current list of specimens in the museum.

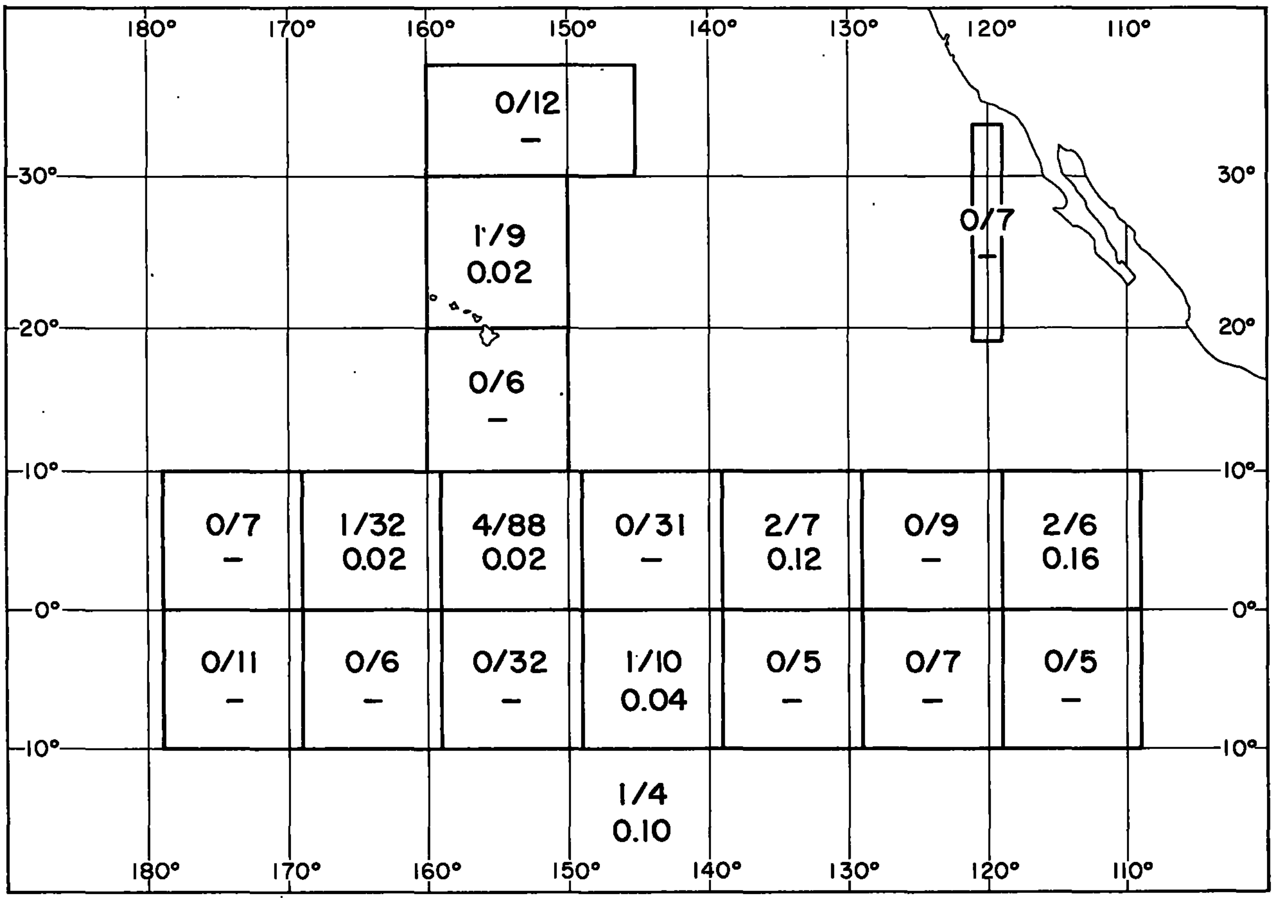

FIGURE 24.—Distribution of POFI catches of sailfish, *Istiophorus orientalis*. Fractions indicate stations at which catches were reported out of the total fished; decimals indicate average catch per 100 hooks per day.

Size

Specimens which we have weighed in the POFI catches ranged from 26 to 106 pounds. Weights of 11 Honolulu market specimens recorded in July and August 1950 by the Hawaiian Division of Fish and Game ranged from 25 to 114 pounds with all but 1 weighing less than 45 pounds. Nakamura (1949) stated that sailfish attain a weight of 132 pounds.

Food

Probably these fish are broadly carnivorous like the other spearfishes but perhaps it is significant that 8 of the 9 stomachs examined contained squid, which usually was the predominant food. The other food items included octopus, nautilus, *Alepisaurus*, one bramid, and one pilot fish.

Synonymy and references

Istiophorus (*Histiophorus*) *orientalis*, Temminck and Schlegel, *in* Siebold, 1844:103, pl. 55 (Japan); Jordan and Evermann, 1926:46, pl. 15, fig. 1 (Japan); Fowler, 1928:136 (Hawaii); Nakamura, 1938:25 (Formosa); Nakamura, 1940 (South China Sea); LaMonte and Marcy, 1941:2 (Hawaii, Japan); Nakamura, 1942 (Formosa); Hirasaka and Nakamura 1947:12, pl. 1, fig. 2 (Formosa); Fowler, 1949:74 (Tahiti); Nakamura, 1949:58 (from northeastern Japan south); Brock, 1950:146 (Hawaii); Rosa, 1950:151 (western Pacific from Indonesia to Vladivostok, Hawaii); De Beaufort and Chapman, 1951:241 (Singapore, Java, Japan, Siam, Hawaii); Yabe, 1953 (Japan); Murphy and Otsu, 1954 (Caroline Islands).

Istiophorus eriquius, Jordan and Ball, *in* Jordan and Evermann, 1926:48, pl. 15, fig. 2.

Istiophorus brookei, Fowler, 1934:400 (Tahiti).

Bashōkajiki, sailfish, Nakamura, 1944b.

Istiompax marlina (Jordan and Hill)

Black Marlin

Shirokajiki "White Marlin" (Japan); Silver Marlin (Hawaii)

Distinguishing characteristics

Nakamura (1938) has described the anatomical differences between *marlina* on the one hand and *Makaira audax* and *M. ampla* on the other, which differences were subsequently used by Hirasaka and Nakamura (1947) to propose the genus *Marlina*. The principal differences are that (1) the shoulder girdle in *marlina* is considerably broader than in the other species, and the articulation with the pectoral fin restricts its movement; (2) the pelvic girdle in *marlina* has the two sides fused together and difficult to separate, whereas in the other two species the two sides of the girdle are separated by a broad space and they can be easily separated; and (3) the air bladder in *marlina* consists of several layers of small chambers, whereas it has only a single layer of chambers in *ampla* and *audax*.

We believe the differences noted here warrant the retention of *marlina* in a separate genus; however, the generic name *Marlina* cannot be applied to this genus. In the first place, its use is prevented by Zane Grey's introduction of the name *Marlina mitsukurii* in 1928. Since he used the name solely in this combination and prior to 1928 when such a proposal was permitted, *mitsukurii* is the haplotype of *Marlina* Grey. In the second place, Whitley (1931:18) proposed the genus *Istiompax* for *I. australis*, new species, recognized as a synonym of *Makiara marlina* Jordan and Hill. Therefore, the generic name *Istiompax* has precedence over *Marlina* Hirasaka and Nakamura (*non* Grey).

The most distinctive external characters of *marlina*, in addition to the rigid pectoral, are the short ventral fins which range in length from 18 to 31 cm., with an average of 26 in our specimens, and the very low first dorsal, which in its anterior lobe averages about 60 percent of the greatest body depth, but may range from 50 to 80 percent. Many other subtle differences aid in recognizing *marlina* at a glance. The body seems compressed more than in *ampla*, and it appears markedly heavier in the pectoral region than either *audax* or *ampla* because of the larger hump on the back. Although *marlina* has been reported by Nakamura to differ from *ampla* by having a single, simple lateral line, the lateral line is a poor field character because it is difficult to see in fresh specimens.

Marlina and *ampla* are the only marlins that appear to surpass 1,000 pounds in weight. When near this size, *marlina* is readily distinguishable because the lower jaw from tip to corner of the mouth is at least half the length of the snout from tip to orbit. In *ampla* the lower jaw recedes with growth, and in very large specimens the snout has the appearance of being much longer and more slender than in *marlina*.

The name *marlina* may lack priority if adequate descriptions of marlins from the type localities of *Tetrapturus herscheli* Gray (South Africa), or *Histiophorus brevirostris* Playfair (Zanzibar) become available. Gray's (1838) description of *herscheli* agrees well with *marlina* in most characters. In sizes estimated from his figure (pl. X), the relation of the height of the anterior lobe of the first dorsal to the fork length (13 percent), the height of the first anal to the height of the first dorsal (77 percent), the length of the ventral fins (23 cm.), all agree with our measurements of *marlina*. The height of the 20th ray of the first dorsal (9 cm.) is slightly greater in *herscheli* than *marlina* but the difference is not unreasonable if we assume that the fin slot in *herscheli* may have shrunk during preservation. The relation of the height of the first dorsal to body depth in *herscheli* is not like *marlina*, but the drawing is from a stuffed specimen which may have been distorted. Playfair's (1866) description of *brevirostris* could also have been taken from a slender *marlina*. The height of first dorsal, color, and length of pelvic fin, all fit *marlina* but the body depth is comparable to that of *audax*. We do not suggest changing the name *marlina*, however, until better evidence is available.

Color

The name "white marlin," a literal translation of the Japanese, shirokajiki, probably arises from the appearance of the fish—sometimes a milky white when freshly hooked. We have been amazed at the whiteness of some of these huge fish as they swam near the boat before they had fought hard on the line. When near death and immediately after death the milkiness is replaced by shades of metallic bluish gray (hence the name silver) ranging from deep color on the back to almost white on the belly. Usually at this time there is smooth gradation in color from the back to the belly, though in a few specimens a sharp line separates side and belly color. A few hours after death the color of the back deepens to a dark lead gray, when it is reasonable to call these fish black marlins.

In Japanese, Hawaiian, and central equatorial Pacific waters the absence of stripes usually distinguishes *marlina* from *audax* and *ampla*, but Nakamura (1938) stated that stripes may sometimes be detected after death and complete removal of the slime. We have seen only one specimen with faint stripes immediately after death. Whitley (1954) described a stiff-finned marlin that had pale blue bars when first caught, and J. E. Morrow, in a personal communication, stated that *marlina* are commonly striped in Peruvian waters when alive. We suspect that the stripes and the white color in life may be more noticeable among the smaller sizes.

Distribution in the Pacific

In the literature reviewed by Rosa (1950), *marlina* has been reported in the eastern Pacific from California to Peru, in New Zealand, Australia, Hawaii, and Tahiti. Nakamura (1949) reports that it occurs widely in the warm seas of the Pacific and Indian Oceans and north off the coast of Japan to about 41° N. latitude. No verification has been obtained for rumors of the occurrence of "black marlin" in California, though both *marlina* and *ampla* appear to occur occasionally off western Mexico (Carl L. Hubbs and Robert L. Wisner, personal communication).

In certain of these peripheral areas *marlina* is apparently one of the abundant marlins, certainly in the sport-fishing centers off Peru, New Zealand, and Australia. Nakamura (1951) believes that the center of its distribution is in the extreme western Pacific and in the adjacent waters of the South China Sea, Sulu Sea, and Celebes Sea. He (1942) calls it the most abundant marlin off Formosa and (1951) reported the catch by species in Formosa for 1943 which, in numbers of fish taken, ranks sailfish, *marlina*, *ampla*, and *audax* in decreasing order. He (1951) also reported that *marlina* is the most abundant spearfish off Okinawa. Off Hawaii and in the equatorial Pacific from south of Baja California to the Caroline Islands it is much less abundant than *ampla*. The scattered POFI catches (fig. 25) occurred mostly in the vicinity of the Line Islands and north of the Marquesas, but nowhere was *marlina* numerous. In the Hawaiian fishery *marlina* is so scarce that Otsu (1954) lumped it in the catch data with sailfish, shortnose spearfish, and broadbill swordfish, which together comprised less than a tenth of the total spearfish landings in an average year. The nine Japanese mothership expeditions to the vicinity of the Caroline Islands in 1950 and 1951 (Van Campen 1952) had a combined catch rate of less than .01 fish per 100 hooks for *marlina*, which may be contrasted with the catch rate of .53 for *ampla*. Despite this general scarcity, *marlina* has been taken in sufficient numbers in the open Pacific to establish the strong probability that its distribution is continuous from America to Asia but that the concentrations are peripheral off the coasts of the Americas, Asia, and Australia.

The intervening distances, together with anatomical evidence, suggest that these concentrations may be isolated enough for local varieties to be evolving. A difference in color between *marlina* from the central Pacific and from Peruvian areas has been noted. Furthermore, the difference in head length, length of pelvic, and height of the anterior lobe of the first dorsal is somewhat greater between samples of *marlina* than between samples of the other species. Indeed, the overlap in the height of the anterior lobe of the first dorsal (fig. 17) between the samples of *marlina* from Hawaii, New Zealand, and Australia is beyond the commonly accepted level of subspecific differentiation. However, the samples are small and a sample from the equatorial Pacific is intermediate in this dimension, so we shall consider the differences as merely varietal.

Size

This is one of the largest species of bony fishes. Nakamura (1949) stated that *marlina* attains a body length of 350 cm. and a weight of 570 kg. (1,250 lb.). The world's record angling catch taken off Peru on August 4, 1953, weighed 1,560 pounds (Farrington 1953). The previous record, 1,352 pounds, was caught only 6 days earlier. Farrington also reports that the first 25 "black marlin" caught by angling off Peru averaged 817 pounds with many weighing more than 1,000 pounds. It apparently reaches similar sizes off

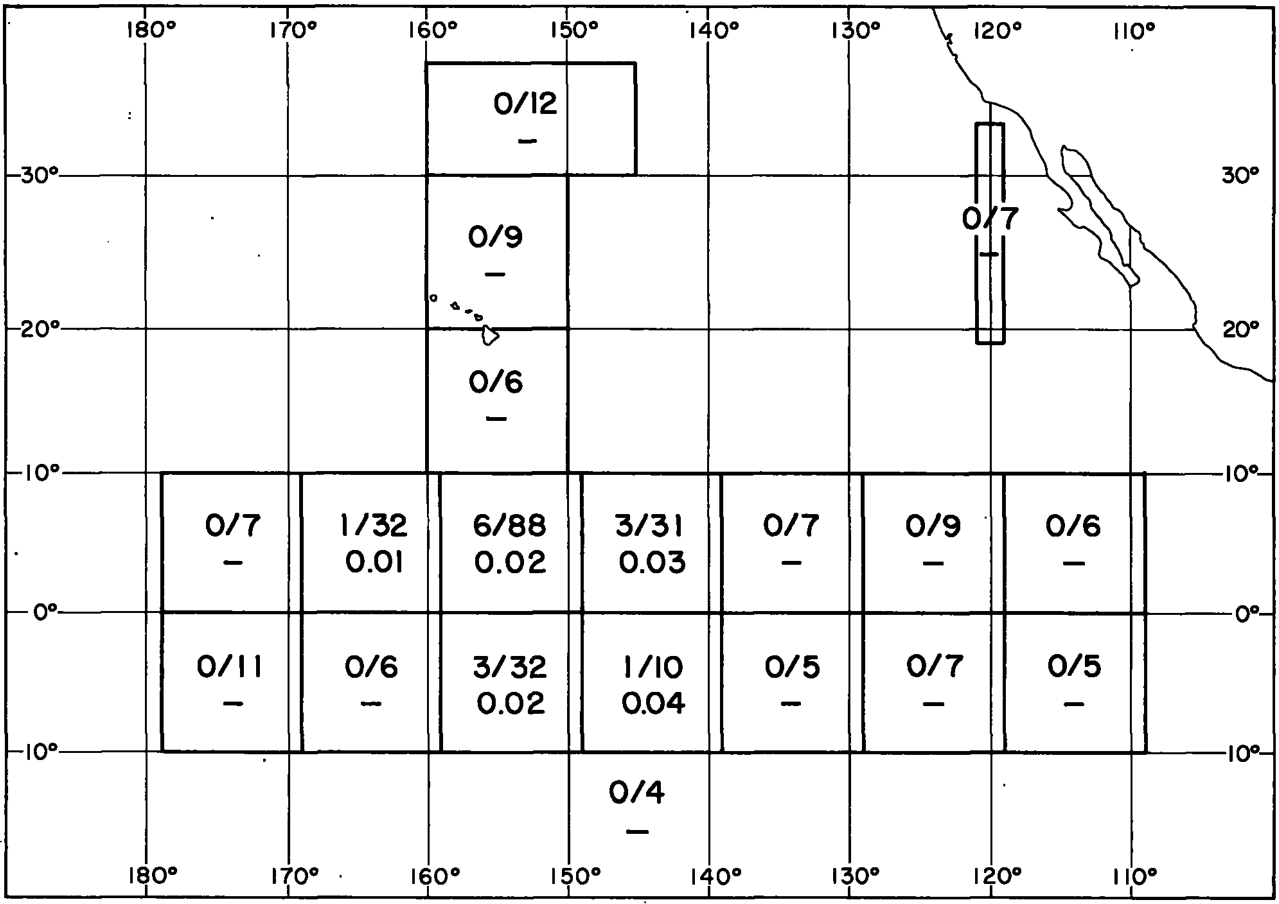

FIGURE 25.—Distribution of POFI catches of black marlin, *Istiompax marlina*. Fractions indicate stations at which catches were reported out of the total fished; decimals indicate average catch per 100 hooks per day.

Australia where one weighing 1,226 pounds was stranded in April 1938, according to Gregory and Conrad (1939), and also off Hawaii where the largest of 77 weighed in the market was 1,100 pounds (table 4).

Such record fish are always females; the largest males have been much smaller. Nakamura (1951) reports a maximum weight for the males of 287 pounds. The largest male in the POFI collection of six in which the sex was determined was 270 pounds and in those reported by Gregory and Conrad from off New Zealand and Australia was 322 pounds.

Data on the size composition of a large catch are given for the Formosan fishery by Nakamura (1944a). He reports that in the 1943 landings at Takao, only 104 *marlina* of 2,542 weighed were more than 440 pounds and the modal size was 90 to 110 pounds. At Suō, of 4,448 weighed, 74 were more than 440 pounds; and there was a broad mode at 110 to 200 pounds with a secondary mode at 250 to 270 pounds, in February and March. At Takao, the largest percentage of *marlina*

TABLE 4.—*Weight frequency of* Istiompax marlina *landed at Hawaiian markets in 1950 and 1951*

[Data from the Hawaiian Division of Fish and Game]

Weight group (pounds)	Total	Weight group (pounds)	Total
60-79		440-459	3
80-99	5	460-479	
100-119	7	480-499	1
120-139	8	500-549	5
140-159	12	550-599	3
160-179	5	600-649	
180-199	4	650-699	
200-219	2	700-749	
220-239	1	750-799	1
240-259	2	800-849	3
260-279	2	850-899	1
280-299		900-949	
300-319		950-999	
320-339	2	>1,000	2
340-359	3		
360-379	1	Number	77
380-399	3		
400-419		Maximum weight (pounds)	1,100
420-439	1		

weighing less than 110 pounds was landed in October and November. In the Hawaiian market data (table 4) one modal group from 100 to 150 pounds occurs, but too few data are available to show other modes.

Food

No specific food studies of *marlina* have appeared but Nakamura (1949) in his general discussion of the food of marlins indicates that they feed on live food but will take dead bait or artificial lures and do not seek food on the bottom. June (1951) has recorded the gluttony of one specimen which contained a 158-pound bigeye tuna.[8] Of our 10 specimens on which we have food notes, 3 contained remains of the sunfish, *Mola*, and 2 contained tunas, 1 a 30-cm. *Katsuwonus* (1 lb.), and 1 a 94-cm. *Germo* (40 lb.). Another contained vertebrae and fin rays which were evidently from a fairly large fish, since the vertebrae were 5 cm. long in the centrum and the fin rays were about 20 cm. in length. This marlin is probably as broadly carnivorous as the other species of marlins which eat a great variety of fish and squid. Certainly, if they can capture tunas few other animals would be fast enough to escape them.

Spawning

Nakamura (1949) stated that he had no concrete data on the spawning habits of *marlina* but suspected from some data on the condition of the gonads and the relative abundance of males and females that it spawns off Formosa around August to October. None of the POFI specimens had ripening gonads.

Seasonal occurrence

The season for *marlina* in Formosa is from October through April, according to Nakamura (1938, table 9; 1951, table 43) who gave catch statistics for the Suō fish market. Off Cabo Blanco, Peru, the sport fishermen have taken it throughout the year, according to a personal communication from J. E. Morrow. Apparently, there has not been enough fishing in the other parts of the Pacific where *marlina* is plentiful to clearly establish the best seasons.

[8] After this manuscript was written, two similar records were obtained. Joseph E. King of the POFI staff reported that on April 4, 1955, a *marlina* 402 cm. fork length was taken on a longline at 1°49′ N. latitude and 157°38′ W. longitude. It contained a yellowfin tuna 154 cm. fork length which was estimated from length-weight curves to weigh 157 pounds. The *marlina* apparently had taken the dead herring bait after eating the tuna because the tuna showed no signs of being hooked nor did it have bait in its stomach. The *marlina* was hooked normally in the jaw. The tuna had two holes through its body similar in size to the marlin's spear. E. S. Iversen, formerly of the POFI staff, reported that a *marlina* 303 cm. fork length was taken on April 8, 1955, at 4°31′ N. latitude and 160°30′ W. longitude, that contained a yellowfin estimated to weigh 70 pounds.

Synonymy and references

Makaira marlina, Jordan and Hill, *in* Jordan and Evermann, 1926:59, pl. 17 (Pacific coast of Mexico); Grey, 1928:47 (New Zealand); Walford, 1937:48 (Baja California, Pacific coast of Panama); Nakamura, 1938:29 (Formosa); Nakamura, 1942 (Formosa); Farrington, 1949:151 (New Zealand, Australia, Pacific coast of Panama and Mexico); Brock, 1950:146 (Hawaii); June, 1951:287 (Hawaii); Nakamura, 1951:37 (western Pacific); Murphy and Otsu, 1954 (Caroline Islands).

Marlina marlina, Hirasaka and Nakamura, 1947:15, pl. 3, fig. 1 (Formosa); Nakamura, 1949:63 (western Pacific, Indian Ocean).

Makaira ampla marlina, Nichols and LaMonte, 1941:8, fig. 1 (west coast of the Americas, New Zealand, Australia); LaMonte and Marcy, 1941:2 (Peru, New Zealand, Australia, Hawaii, west coast of Mexico, California).

Makaira nigricans marlina, Nichols and LaMonte, 1935b:328; Gregory and Conrad, 1939:443 (New Zealand, Australia); Gabrielson and LaMonte, 1950:27 (Australia, New Zealand, Tahiti, Peru, Pacific coast of Panama and Mexico); Rosa, 1950:143 (California to Peru, New Zealand, Australia, Tahiti); Morrow, 1954:819 (East Africa).

Makaira ampla tahitiensis, Nichols and LaMonte, 1941:8, fig. 3 (Tahiti, Hawaii); LaMonte and Marcy, 1941:2 (Tahiti, Hawaii).

Makaira nigricans tahitiensis, Nichols and LaMonte, 1935a:1, fig. 1 (Tahiti); Nichols and LaMonte, 1935b:328; Gabrielson and LaMonte, 1950:28 (Tahiti, Hawaii, Pacific coast of Mexico); 1950:144 (Pacific coast of Mexico, Hawaii, Tahiti).

Makaira mazara, LaMonte, 1955:336, pl. 9 (in part).

Makaira mazara tahitiensis, LaMonte, 1955:342, pl. 10 (in part).

Istiompax australis, Whitley, 1931:18 (Australia).

Istiompax dombraini, Whitley, 1954:60 (Australia); 1955:295 and fig. 293.

Histiophorus gladius, Ramsay, 1881:295 (Australia).

Makaira australis, Fowler, 1934:400, 402 (Australia, Tahiti).

Makaira indica, Fowler, 1949:74 (Hawaii, Galapagos, Tahiti).

Shirokajiki, white marlin, Nakamura, 1944a (Formosa); Van Campen, 1952:7 (Caroline Islands).

Black marlin, Farrington, 1953 (Chile, Peru, Ecuador, Pacific coast of Panama and Mexico).

Silver marlin, Farrington, 1949:152 (Hawaii, Tahiti) (in part).

Probable synonyms

Tetrapturus herscheli, Gray, 1838:313, pl. X (South Africa).

Histiophorus brevirostris, Playfair and Günther, 1866:53, 145 (Zanzibar); Day, 1878:199, fig. 3, pl. 47 (India).

Tetrapturus brevirostris, Rosa, 1950:160 (South Africa, Zanzibar, India, Indo-Pacific area); De Beaufort and

Chapman, 1951:238 (Java, Zanzibar, Seychelles, Muscat, coast of New South Wales, Hawaii), 3,900-mm. specimen.

Makaira herscheli, Smith, 1950:315, fig. 875 (South Africa); Rosa, 1950:139 (South Africa); Smith, 1956a:26, pls. 1 and 2 (South Africa).

The *Tetrapturus australis*, Anon., *in* Whitley, 1955:292.

Makaira audax (Philippi)

Striped Marlin

Makajiki "True Marlin" or Akakajiki "Red Marlin" (Japan)

Distinguishing characteristics

This marlin in the familiar sizes of 100 to 200 pounds is readily distinguishable from either *marlina* or *ampla* by its higher first dorsal fin and slenderer, more compressed body. The first dorsal is higher in the anterior lobe, where its height is usually more than the greatest body depth, as well as in the middle where the rays range from 8 to 15 cm. with an average length of 10 cm. The vertical bars on the sides, which are probably always present and usually prominent, provide the obvious vernacular name.

The considerable allometric growth, however, has led to the confusion of very large and very small specimens with other species. The very large specimens tend to become thicker and broader through the pectoral region and the height of the anterior lobe of the first dorsal may be as little as 90 percent of the greatest body depth. They may closely resemble the slenderer specimens of *ampla* which sometimes have prominent stripes. This has caused anglers in Hawaii and perhaps elsewhere to identify 400- to 700-pound specimens of *ampla* as *audax*.

Among the very small *audax*, the high middle dorsal fin has led to the description of the species *formosana* and *grammatica*, and even of *Tetrapturus ectenes*. The pronounced negative growth of the mid-dorsal fin as shown in figure 7 provides evidence that these high-finned forms are merely young *audax*, and not a distinct species. All those we have seen can be separated from *Tetrapturus* by the stripes and the snout which is about twice as long as the mandible. Occasionally, however, the high median dorsal rays are retained in medium-sized adults off California and off Mexico (Carl L. Hubbs and Robert L. Wisner, personal communication).

Color

Audax is generally deep metallic blue above with white belly and prominent vertical stripes on the sides when captured. The blues fade after death and in a few hours the predominant color is a dark blue gray or lead gray broken by faded but persistent stripes. The number of stripes in POFI specimens varied from 10 to 21, but frequently the count was uncertain because of the tendency for alternate stripes to be faint.

The Japanese name akakajiki "red marlin" arises from the pink flesh, according to Nakamura (1951), who stated that it is especially valued for sashimi, or raw fish, because of its fine appearance and flavor. In the specimens from equatorial waters we have noticed that some are pink fleshed, others are not. We have no explanation for the difference.

Distribution in the Pacific

The striped marlin has been taken by the Japanese longline fleet (Ueyanagi 1954b) almost everywhere they have fished. This includes the equatorial waters, east from Borneo to about 155° W. longitude, along the coasts of Java and Sumatra in the Indian Ocean, off northeastern New Guinea, along the coast of Asia north to the East China Sea and along the outer coast of Japan north as far as 44° N. latitude. In addition, POFI vessels have taken it through most of the equatorial area east to 110° W. longitude, and north of Hawaii to nearly 35° N. latitude (fig. 26). It has previously been reported off the coast of the Americas from southern California to northern Chile and off New Zealand and Australia (Rosa 1950).

The concentrations suggest that *audax* prefers the more temperate waters, however. The best grounds for the Japanese longline fleet have been sketched by Ueyanagi (1954b) who showed two areas east of Formosa roughly between 20° and 30° N. latitude, one of them from 128° to 135° E. longitude, the other from 140° to 170° E. longitude. Both of these areas are best from March to June. A little later in the season from August to November the best grounds are east of Japan, roughly from 34° to 40° N. latitude, 145° to 175° E. longitude. Other, lesser concentrations are located immediately off the coast of Japan, just south of Korea, in the Celebes Sea, and at times in the South China Sea. *Audax* is regularly taken but not abundantly in the winter albacore fishery east of Japan from about 28° to 35° N. latitude. It is scarce along the Pacific Equator near the Carolines and the Marshall Islands where the Japanese mothership expeditions took *audax* at an average rate of less than .01 per 100 hooks (Van Campen 1952). It is a little more abundant to the east of 150° W. longitude where POFI catches averaged as high as .30 per 100 hooks (fig. 26).

The relation of the marlins to the ocean currents was discussed by Nakamura (1954a). He noted that in the principal marlin grounds in the western Pacific between 14° and 30° N. latitude, most of the *audax* are caught north of the region of subtropical convergence, whereas to the south *ampla* predominates. There is not, however, a complete separation of the species.

Off Hawaii, *audax* is the most abundant marlin. Otsu (1954) showed that the average monthly landings for the years 1948 to 1952 contained more *audax* from December through June and more *ampla* from July through November. The average annual landings by weight of *audax* were a little less than *ampla*, but *audax* averaged only about 70 pounds compared with 200 to 300 for *ampla* (tables 5 and 6), so the numbers of *audax* landed were much the greater.

Food

In the other species of marlins, the scattered observations suggest that they are broadly carnivorous, but in *audax* the specific food studies show it clearly. Morrow (1952b) examined 53 stomachs taken off New Zealand and found the principal food items to be *Scomberesox* and *Arripis*. Hubbs and Wisner (1953), who examined 32 stomachs from marlin caught near San Diego, Calif., in 1951, found the principal food items to

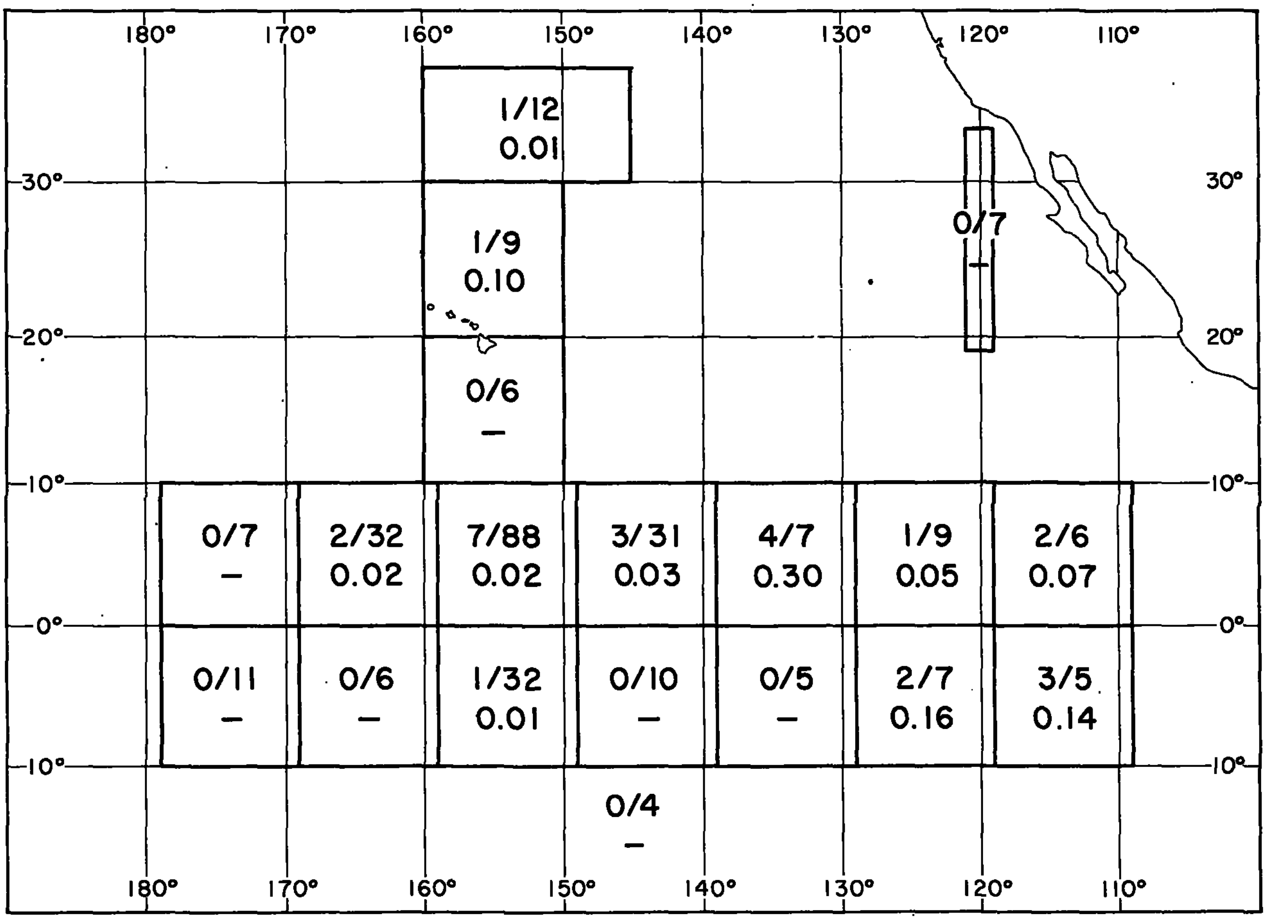

FIGURE 26.—Distribution of POFI catches of striped marlin, *Makaira audax*. Fractions indicate stations at which catches were reported out of the total fished; decimals indicate average catch per 100 hooks per day.

be the saury, *Cololabis*, and the northern anchovy, *Engraulis*. In both of these studies minor quantities of cephalopods were found. Yabuta (1953), who reported on 64 striped marlin taken off the Bonin Islands, gives a long list of items which includes *Gempylus* in 75 percent of the stomachs, *Pseudoscopelus* in 41 percent, *Alepisaurus* in 41 percent, *Ostracion* in 30 percent, crustacea in 30 percent, and cephalopods in 67 percent of the stomachs. Among the numerous minor food items were *Katsuwonus*, 14 percent, and even the broadbill swordfish *Xiphias gladius* in 1 stomach. Of the 19 stomachs from equatorial waters taken by POFI (appendix table 5, p. 554), 13 contained material which included several tunalike fishes, some identifiable as *Auxis*, and miscellaneous remains of other fish, shrimp, and squid.

Size

The maximum size of the striped marlin is a matter of some uncertainty because it seems to have been confused with *ampla*. Farrington (1949) noted that the world's record, taken off California, was 692 pounds; the next largest, taken off Chile, weighed 483 pounds. He states, "It seems strange that no one has ever taken a striped marlin between these weights." The larger record seems to us unreasonably large when compared with the maxima found in other parts of the Pacific. Griffin (1927) reports a male (?) of 381 pounds from off New Zealand, and Grey (1928) caught 21 off New Zealand that ranged up to 350 pounds. Gregory and Conrad (1939) took 27 off New Zealand and Australia weighing up to 336 pounds, and Morrow (1952a) presented the data on 48 fish weighing up to 336 pounds.

In the North Pacific, the striped marlin seems to reach an even smaller maximum size. Nakamura (1944b) in a weight frequency study of 1,387 specimens from off Formosa had class sizes ranging up to 130 kg. (290 pounds), although in his 1949 paper he reported that this marlin reached a maximum of 220 pounds. The latter weight seems improbably low, because in the specimens taken along the Pacific Equator by POFI one of 314 pounds was weighed, and in the Hawaiian market (table 5) occasional specimens weighing nearly 300 pounds and one rather questionable record of 434 pounds have been listed. Ueyanagi (1954b) gives a maximum class size of 200 cm. orbit to fork, which is approximately 190 pounds. The largest specimen caught in 1955 off La Jolla, Calif., weighed 406.5 pounds (Carl L. Hubbs and Robert L. Wisner, personal communication). All of this information suggests that the maximum size of the striped marlin is less than 500 pounds.

In the longline fishery off Japan, the modal size of *audax* is rarely greater than 100 pounds, according to Ueyanagi (1954a). He also showed the variation in size composition by latitude from the Equator to 30° N. In each latitudinal zone there is a major mode around 75 to 80 pounds, but between 10° and 20° N. another major mode is centered at 105 cm., or 24 pounds. Such a

TABLE 5.—*Weight frequency of striped marlin,* Makaira audax, *from the Honolulu market, January 1949–February 1952*

[Data from the Hawaiian Division of Fish and Game]

Weight group (pounds)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Year 1949:												
10–19				3	1					11	40	9
20–29	22	48	4	5	8	10	3		1	1	24	146
30–39	113	615	94	24	38	54	16	1	2	5	9	28
40–49	27	146	136	134	65	21	7	2		4	6	12
50–59	3	27	28	180	152	10	2	4	2	12	13	9
60–69	5	28	14	32	33	8	1	2	5	29	26	17
70–79	17	90	40	14	10	7	3	1	4	32	46	62
80–89	36	157	84	21	4	19	3		1	32	54	59
90–99	24	141	78	47	28	44	21	1	2	20	20	53
100–109	10	89	102	52	28	69	26		1	12	14	27
110–119	10	24	37	36	27	49	16		1	10	8	11
120–129	1	13	10	17	27	23	7	1		5	5	3
130–139		2	10	13	15	17	4	1	1	4	6	6
140–149		3	2	6	11	6	1		1	3	1	5
150–159		3	4	7	11	5	2			2		2
160–169		1	2	5	8	3	1		1	2		
170–179			1	2	4		1				1	
180–189				2	3	3	2	2			1	
190–199				2	2					1		
>200			1	3	5	3		1		1	2	1
Number	268	1,387	647	605	480	351	116	16	22	186	276	450
Maximum weight (pounds)			308	235	227	227		203		215	205	434

TABLE 5.—*Weight frequency of striped marlin,* Makaira audax, *from the Honolulu market, January 1949–February 1952*—Continued

[Data from the Hawaiian Division of Fish and Game]

Weight group (pounds)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Year 1950:												
10–19		2	4			4				2	10	5
20–29	45	70	21	2	18	56	10	3	1	4	97	22
30–39	34	186	228	25	31	63	42	15	2	4	10	50
40–49	11	81	217	74	22	9	12	17	2	3	5	1
50–59	6	10	46	45	13	6		6		5	7	4
60–69	13	28	37	17	15	20	2	2	3	25	30	28
70–79	30	88	105	34	15	34	8	1	13	51	82	102
80–89	32	149	138	73	44	126	28	4	7	50	138	172
90–99	31	123	125	99	67	188	49	1	2	33	141	160
100–109	35	69	77	53	62	137	37	3	4	14	88	107
110–119	8	30	36	21	29	101	28	3		15	53	61
120–129	6	11	11	17	15	47	21			4	17	30
130–139	4	4	8	6	14	13	9	3		2	9	8
140–149	1	5	3	3	12	14	2	2			2	4
150–159				4	5	6	1			1	2	3
160–169		1	1	2	6	7						
170–179			1	1	2	2	1		1			
180–189				2	2	2	3			1		
190–199					2	1			1			
>200		1		1	1	1	3	2		1		
Number	256	858	1,058	479	375	837	256	62	36	215	691	757
Maximum weight (pounds)		310		297	239	211	229	226		233		
Year 1951:												
10–19		1								1	3	
20–29	6	5		1	8	2	1			6	6	4
30–39	10	7	59	17	8	15	6	1	1	1	3	8
40–49	4	6	94	42	6	5	5	1	1	1		1
50–59		3	22	32	10	5	6	3	3	3	4	
60–69	4	13	10	7	6	3	2	9	1	7	13	8
70–79	16	30	46	18	19	8	5	6	3	16	29	28
80–89	31	51	88	52	59	34	7	3	3	11	37	27
90–99	24	61	102	51	71	77	17		3	15	29	25
100–109	17	34	63	43	83	122	26	3		9	12	9
110–119	9	15	32	23	42	78	14	2	1	6	6	6
120–129	4	10	10	14	58	44	7			2	11	1
130–139	1	3	5	7	37	21	12	3	1	9	1	6
140–149			4	3	18	22	4	1		1	3	2
150–159		2	1	10	19	6	1			2		1
160–169			1	5	7	6					2	
170–179			1		4	4						2
180–189			1	1	2			1				
190–199				2	1	1				1	1	
>200				1	3	1	1	1		3	1	1
Number	126	241	539	329	461	454	114	34	17	93	161	129
Maximum weight (pounds)				200	216	231	210	219		304	226	214
Year 1952:												
10–19												
20–29	7	1										
30–39	22	13										
40–49	10	15										
50–59	1	6										
60–69	6	10										
70–79	19	53										
80–89	30	84										
90–99	23	45										
100–109	10	25										
110–119	5	6										
120–129	1	1										
130–139	2	2										
140–149	1	1										
150–159	1	3										
160–169		1										
170–179												
180–189												
190–199												
>200												
Number	138	266										
Maximum weight (pounds)												

latitudinal distribution appears to exist in the central Pacific, for the POFI catches in the equatorial area included only a few striped marlin of less than 100 pounds, whereas in the Honolulu market (table 5) about half of the fish weighed less than 60 pounds each. In the latter case, the distribution is very definitely and characteristically bimodal in most months of the year. In the winter months, the position of the modes corresponds quite closely to those given by Ueyanagi for the 10° to 20° latitudinal zone.

If we follow the progression of the modes from month to month in table 5, two rather striking things may be noted. First, after the period of low catches in August and September, the fishery resumes on striped marlin of very different weight composition than existed in early summer. Secondly, between about November and April the smaller mode progresses with reasonable smoothness from about 30 to 50 pounds, and from about October to July the larger mode progresses, again with reasonable smoothness, from about 80 to 105 pounds. If we assume that the fishery has been fishing the same stock of fish through these months it would appear that such a progression might be due to growth and, hence, an annual increment of about 30 pounds can be estimated.

Spawning

In the South China Sea near Formosa, spawning seems to be at its peak from April to May according to Nakamura (1949). He also stated that *audax* is known to spawn near the Ogasawara Islands around May and June.

That spawning occurs at this season is suggested by the scanty POFI observations from the central equatorial Pacific. Two males with milt in the testes were taken during March, and two females with enlarged ovaries were taken in February and March.

Synonymy and references

Histiophorus audax, Philippi, 1887:35–38, pl. 8, figs. 2 and 3 (Chile).

Istiophorus audax, Fowler, 1944:499 (Tarapacá, Iquique, Valdivia).

Marlina audax, Smith, 1956a:30 (South Africa).

Makaira audax, Smith, 1956b:758 (South Africa).

Tetrapturus mitsukurii, Jordan and Snyder, 1901:303, pl. 16, fig. 5 (Japan): Fowler, 1928:136 (Hawaii, tropical Pacific).

Makaira mitsukurii, Jordan and Evermann, 1926:61, pl. 18 (Japan, Hawaii, California); Griffin, 1927:143, pl. 14 (New Zealand); Walford, 1937:47 (California, Pacific coast of Mexico); Nakamura, 1938:27 (Formosa); Gregory and Conrad, 1939: 443 (New Zealand, Australia); Nichols and LaMonte, 1941:8, fig. 2; LaMonte and Marcy, 1941:2 (Japan, Hawaii, California, Chile, New Zealand, Australia); Nakamura, 1942 (Formosa); Farrington, 1949:150 (Chile, Peru, Ecuador, Pacific coast of Panama and Mexico, California, Hawaii, New Zealand, Australia, Marianas, Japan); Brock, 1950:147 (Hawaii); Gabrielson and LaMonte, 1950:28 (California, west coast of Mexico and Panama, Ecuador, Peru, Chile [S. to Caldera], Australia, New Zealand, Hawaii); Rosa, 1950:132 (Americas from California to Caldera, Chile, New Zealand, Australia, Philippines, Japan, Hawaii); Nakamura, 1951:36 (warm seas of western Pacific); Morrow, 1952a:53 (New Zealand); Morrow, 1952b:143 (New Zealand); Murphy and Otsu, 1954 (Caroline Islands); Morrow, 1954:819 (East Africa); LaMonte, 1955:333, pl. 7, pl. 8 (2), and 346, pl. 12 (2) thought to be a young one.

Marlina mitsukurii, Grey, 1928:47 (New Zealand).

Makaira grammatica, Jordan and Evermann, 1926:55, pl. 16 (Hawaii).

Makaira holei, Jordan and Evermann, 1926:63, pl. 19, fig. 1 (Pacific coast of Mexico).

Makaira zelandica, Jordan and Evermann, 1926:65, pl. 19, fig. 2 (New Zealand).

Tetrapturus ectenes, Jordan and Evermann, 1926:34, pl. 11, fig. 2 (Hawaii).

Kajikia mitsukurii. Hirasaka and Nakamura, 1947:14, pl. 2, fig. 1 (Formosa); Nakamura, 1949:60 (south from northeastern Honshu, Japan); Nakamura, Yabuta, and Ueyanagi, 1953 (Japan); Ueyanagi, 1954a (northwestern Pacific from Equator to 42° N.); Ueyanagi, 1954b (Western Pacific from Japan to Australia, Indian Ocean off Sumatra).

Kajikia formosana, Hirasaka and Nakamura, 1947:13 (Formosa); Nakamura, 1949:61 (Philippine Sea to Japan).

Kajiki, makajiki, akakajiki, striped marlin, Nakamura, 1944b (Formosa); Van Campen, 1952 (Caroline Islands); Yabuta, 1953 (Bonin Islands); Nakamura, 1954b (northwestern Pacific, 14° to 30° N. latitude); Farrington, 1953 (Chile, Peru, Ecuador, Pacific coast of Mexico, California, Hawaii, New Zealand, Australia).

Probable synonym

Istiophorus ludibundus, Whitley, 1933:83 (New South Wales).

Makaira ampla (Poey)

Blue Marlin

Black Marlin (Hawaii); Kurokajiki (Japan)

Distinguishing characteristics

This is the giant marlin with the flexible pectoral fin that can be folded flat against the body, with the more nearly cylindrical body and, in very large sizes, with the relatively long snout. There is less of a hump on the back than in *marlina*, more than in *audax*. The anterior lobe of the first dorsal is higher than in *marlina*, but lower than in *audax*. The anterior lobe of the first anal fin, on the contrary, is higher in *ampla* than in either *audax* or *marlina* and the relation between the first anal and first dorsal is the best character we have found for distinguishing *ampla* from *audax*. In *ampla*, the height of the first anal averaged 86 percent of the height of the first dorsal with a range of 76 to 100 percent; in *audax*, the range was from 50 to 76 percent with an average of 66 percent. The center of the first dorsal fin is low and in our specimens there is a suggestion of an actual decrease in the average length of the 20th ray with the growth of the fish up to 200 cm.; but in the specimens of more than 200 cm. fork length the length of the 20th ray is nearly constant. The average length of the ray in *ampla* is approximately 6 cm. with the range in our specimens from 3 to 9 cm.; in *audax*, which has a similar growth pattern, the range is from 8 to 14 cm. with an average of 10 cm. The length of the pelvic fin is comparable to that of *audax* and longer than that of *marlina*, averaging about 34 cm. in our specimens with no change in size according to length of fish.

This species appears to be unique among the marlins in the growth relation of mandible and snout (fig. 13).[9] In *audax* and *marlina* the snout and mandible grow approximately isometrically, whereas in *ampla* the mandibular growth definitely is negatively allometric. As a result the snout appears long in very large individuals.

The lumping of the Atlantic and Pacific forms of this marlin in the single species *ampla* will no doubt be contested by people who automatically consider that such geographic separation indicates distinct species. However, in none of the characters considered in the preceding pages do we find a difference that even approaches the subspecific level. Until morphological differences can be found it seems preferable to consider both forms as belonging to the same species.

Color

In the living specimens of *ampla* that we have seen in the Pacific, the predominant color of the upper parts is a brilliant, deep metallic blue which fades rapidly after death to a lead-gray color mixed with browns wherever the fish has been rubbed or scraped. Stripes usually are present on the sides immediately after death but are rarely conspicuous, and generally some are so faint that it is difficult to count them. They may be absent or remain conspicuous after death and cannot be relied on to distinguish the fish from either *marlina* or *audax*.

Distribution in the Pacific

This is the predominant marlin of the central tropical Pacific, having been taken in all of the tropical areas fished by POFI, from 110° W. longitude to 180° longitude, with catch rates up to 0.35 per 100 hooks (fig. 27). West, along the Equator in the Marshall and Caroline Islands area, the Japanese mothership expeditions of 1950 and 1951 found it even more abundant, for they had an average catch rate of 0.53 per 100 hooks. Off Formosa it is taken in lesser quantities than *marlina* and *orientalis* (Nakamura 1951, table 114). Northward from the Equator its abundance declines with latitude and, according to Nakamura (1951, fig. 31), for the zone from 143° to 150° E. longitude just off the coast of Japan *ampla* becomes less abundant than *audax* at about 15° N. latitude, but moderate quantities are caught as far north as 40°. It has been reported recently off Australia by Whitley (1954). LaMonte (*in* Gabrielson and LaMonte 1950, p. 515) showed a photograph of a black marlin from off Acapulco which almost certainly is of this species because the fin is folded against the side, and the body shape, height of first dorsal, and the very short mandible are typical of *ampla*.

The localities where *ampla* has been taken by the Japanese longline fishery are shown in the atlas prepared by the Nankai Regional Research Laboratory (Yabuta 1954). Catches are reported from the South China Sea off Hainan Island, from the Celebes Sea just east of the Philippines off northern New Guinea, and then almost continously along the Equator east to 155° W. longitude. The best catches were made during the summer months at 10° to 15° N. latitude north of the Caroline Islands. A few were taken during winter months in the albacore fishery along 30° N. latitude, east of Japan as far as 175° W. longitude, north of Midway. They also were taken at fishing stations in December and January in the Indian Ocean along the coasts of Java, Sumatra, and in the vicinity of the Nicobar Islands. Special concentrations were found during February 1952 off northwest Australia at about 15° S. latitude, 118° E. longitude, and in the vicinity of the Solomon Islands. In the Hawaiian longline fishery, *ampla*

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[9] Dr. Hiroshi Nakamura, in a personal communication, pointed out that allometric growth of the snout occurs in *Istiophorus orientalis*. At about 140 mm. the snout is extraordinarily long in relation to body length and, as the fish grows, the length of snout in relation to body length decreases.

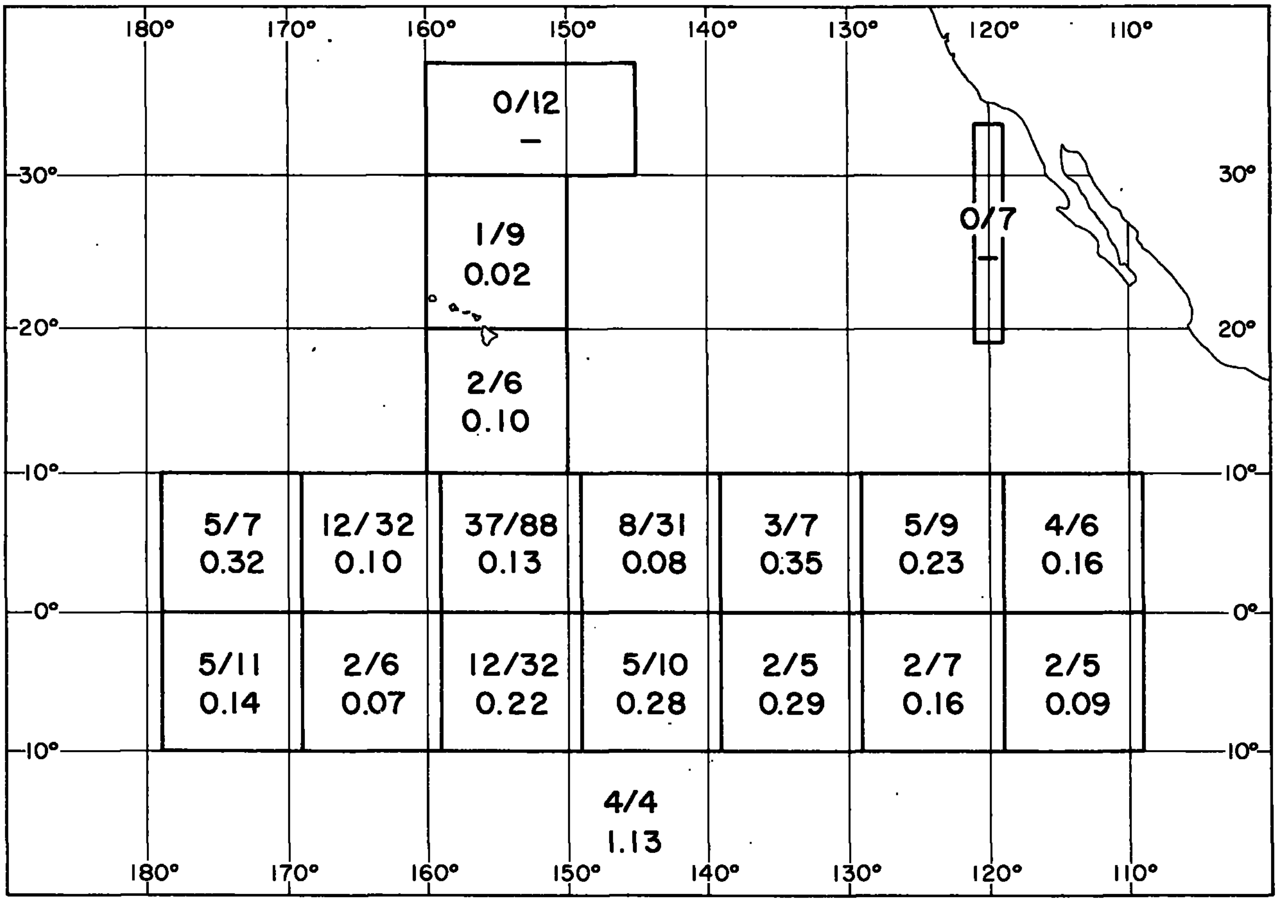

FIGURE 27.—Distribution of POFI catches of the blue marlin, *Makaira ampla*. Fractions indicate stations at which catches were reported out of the total fished; decimals indicate average catch per 100 hooks per day.

is the most abundant spearfish by weight, and the annual landings ranged from a low of 512,000 pounds to a high of 679,000 pounds during the period 1948 to 1952 (Otsu 1954).

Food

All reports indicate that this species is broadly carnivorous on fish and cephalopods of the open ocean. Nakamura (1942) tabulated the food contents of 163 stomachs from fish taken in the east Philippine Sea. Of these, 53 stomachs contained squid, 11 *Leiognathus*, 12 *Balistes*, 11 *Auxis*, and lesser amounts of some 9 other genera of fish. One contained a species of shrimp. In the POFI catches, 36 stomachs contained food, of which 34 contained fish and 16 cephalopods. The commonest fishes in the stomachs were the tunalike fishes, particularly *Katsuwonus* in the larger individuals. Most of the cephalopods were squid. In two additional stomachs from POFI catches the complete contents were not noted but speciems of *Xiphias gladius* were preserved for later examination (see p. 519).

Seasonal occurrence

Yabuta (1954) presented data which show that the catch rate varies little thoughout the year in the tropical seas in the vicinity of the Caroline and Marshall Islands. Murphy and Otsu (1954) noted that the catches of *ampla* by the nine Japanese mother-ship expeditions in this same area showed a minor peak in February and another in October 1951, but that the catch rate during the summer months of 1951 was only about half that during the summer months of 1950.

North of the Carolines, however, there is evidence of a seasonal migration and the peak abundance which occurs in May at 12° to 16° N. latitude, moves farther north with the season until the peak is at 24° to 28° N. in September. Farther east off the Marshall Islands the principal fishery is from 8° to 12° N., and here the seasonal abundance gradually increases until July, then slowly declines. Off Formosa, Nakamura (1942) reported that *ampla* is plentiful on the Pacific side during the summer, and he (1949) stated that they are extremely rare in the Kuroshio Current region from October to April. Off Hawaii, Otsu (1954) showed that *ampla* reaches the peak of abundance and is the principal spearfish in the catch from July through November, whereas during the other months of the year *audax* is the principal species in terms of pounds landed. Thus, north of the equatorial area the seasonal occurrence suggests a summer movement of *ampla* northward followed by a return south in the late autumn.

Size

The reports from the Japanese and Hawaiian fisheries indicate that *ampla* rivals and may even surpass *marlina* in maximum size reached. Nakamura (1949) reported that *ampla* attains 1,100 pounds, but a weight of 1,450 pounds has been recorded from the Hawaiian fishery (table 6), and fishermen recall weighing specimens of more than 1,600 pounds.[10] The POFI specimens include one of 1,002 pounds from Hawaii and another nearly as large from the equatorial area, which was partly eaten by sharks (Nos. 67 and 68 in appendix table 1–E, p. 548).

As in *marlina*, the large *ampla* are always females. The largest male weighed by POFI was 218 pounds. Ueyanagi (1953) and Nakamura et al. (1953) both reported that males do not exceed 200 cm. (orbit to fork), which is equivalent to about 255 pounds. Yabuta (1954), in the atlas of Japanese longline fishing, summarized data on size composition by sex of *ampla* from several areas and all length frequencies showed a mode at about

[10] The maximum sizes of *ampla* attained in the Pacific are much greater than reported from the Atlantic where the angling record is 742 pounds (official 1955 list of the International Game Fish Association).

TABLE 6.—*Weight frequency of blue marlin,* Makaira ampla, *from the Honolulu market, January 1949–February 1952*

[Data collected by the Hawaiian Division of Fish and Game]

Weight group (pounds)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Year 1949:												
10–19												
20–29							1					
30–39								1			1	
40–49					1		1	1	1			
50–59							1			2		
60–69								2	1	2	1	
70–79		1						1		3	1	1
80–89								1		6	1	
90–99						2	1		1	3	1	
100–109			1				2	1	1	3	1	
110–119								1	1	5		
120–129		2	1			1	5	8	3	3		1
130–139	2	4		1	1	3	10	17	7	4		
140–149		5	4	1	6	6	16	32	10	9	2	2
150–159	1	2	4	1	5	5	11	22	13	10	2	1
160–169		1	3	6	4	7	8	21	19	13	4	3
170–179	1	3	1	1	2	4	8	26	14	10	3	1
180–189	1	2	2	3	5	2	2	19	8	3	5	
190–199		2	3	6	2	2	3	14	13	6	2	
200–219		3	1	3	3	5	10	12	7	9	2	2
220–239		3	7	5	1	5	3	6	2	7	6	3
240–259		3	4	10	5	5	1	4	1	3	3	1
260–279		3	8	1	5		1			5	6	2
280–299		2	8	5	4	4	2	4	8	8	5	4
300–319		2	5	9	6	3	2	6	4	9	3	4
320–339		3	5	5	3	1	5	5	2	4	9	3
340–359			4	6	6	3	2	3	2	2	4	3
360–379			3	4	4	3	6	1	2	5	3	4
380–399		2	7	6	3	2	2	4	4	7	4	1
400–419		2	3	1	4	4	4	6	4	2	4	4
420–439		2	2	3	4		5	2	1	3	4	4
440–459			3	3	3	1	3	7	5	1	1	2
460–479		2	1	3	4	4	2	8	2	3	1	3
480–499			1	4	1	2	5	5		2	1	2
500–549		3	2	7	2	6	2	9	8	7	4	5
550–599	1	2	1	4	3	2	5	8	11	3		1
600–649		1	1	2	2	1	2	6	5	5	2	1
650–699			1	1			6	2	2	2	1	
700–749		1			1	1	4	3	2	2		
750–799				1				1	1		1	
800–849			1		1				1	1		
850–899			1		1			1	1	1	1	
900–949												
950–999						1	1		1			
>1,000					1							1
Number	6	56	88	102	93	85	142	270	168	173	89	59
Maximum weight (pounds)					1,015							1,011

TABLE 6.—*Weight frequency of blue marlin,* Makaira ampla, *from the Honolulu market, January 1949–February 1952*—Con.

[Data collected by the Hawaiian Division of Fish and Game]

Weight group (pounds)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Year 1950:												
10–19												
20–29				2			1					
30–39										1		
40–49				2							2	
50–59				1			1			2	1	
60–69											1	1
70–79									1	1	5	
80–89										4	5	
90–99		1				1	1		1	5	4	1
100–109							3	4		4	4	3
110–119						2	1	6	4	4	1	
120–129						1	7	9	7	2	4	
130–139	1	1	1			5	2	19	15	7	8	1
140–149			3	1	2		9	24	32	25	11	3
150–159		3	3	1	2	3	15	21	47	38	13	1
160–169			1		1	3	13	14	26	28	9	3
170–179	1	2	2	2	2	1	7	25	31	25	11	3
180–189		1				1	5	20	16	28	5	4
190–199	1	1			1	4	5	10	18	15	5	3
200–219	4	2	2		1	3	7	15	12	20	12	2
220–239	4		1	3	1		1	9	9	5	4	5
240–259	1	1	2	4		2	3	5	8	9	5	5
260–279	1	5	1	2	2	1	3	5	5	9	4	1
280–299	1	2	2	3	1	4	2	2	1	7	6	4
300–319	1	1	1	6	3		1	2	3	8	2	2
320–339	2	2	1	2	3	2	1	2	6	4	3	1
340–359	2	1	2	1	1		7	1	3	5	3	2
360–379		3	1	2	1	4		5	3	3	6	1
380–399	1	2	4		1	2	3	3	3	4	1	2
400–419	1	2	4	3	3		5	4	5	3		4
420–439	2	1	4	3	3	2	3	5	7	2	1	3
440–459		1			2	3		4	7	5	3	2
460–479	1		2	3	1		2	5	7	3	2	1
480–499				2	2	2	1	2	8	5	3	1
500–549		2	1	4	5		2	11	14	8	6	3
550–599	2			2	1		2	9	7	7	1	1
600–649			1		1	4	3	4	5	3	5	
650–699		2	1	1	1		1	3	3		2	3
700–749		1			3		1	1	3	2	1	
750–799		1		1	1		2	1	1		2	
800–849									1		2	
850–899			1				1		1			
900–949							1		2			
950–999		1					1			1		1
>1,000			1		1			1	1	2	1	
Number	26	39	42	51	46	50	123	251	323	304	164	67
Maximum weight (pounds)			1,002		1,030			1,056	1,001	1,058	1,287	
Year 1951:												
10–19												
20–29												
30–39												
40–49												
50–59												
60–69											1	
70–79											3	
80–89					1		1		1	2	2	
90–99										4	2	2
100–109				1					3	4	3	
110–119							3	6	5	5		1
120–129		1				2	6	15	18	15	4	2
130–139	2			1	1		8	24	29	17	8	1
140–149		1		2			16	39	35	25	14	1
150–159		1	2		3	5	13	34	37	40	11	
160–169	1	1			1	3	5	31	30	46	17	2
170–179					1	2	6	24	35	27	20	7
180–189			1	1	1	2	8	20	15	24	15	1
190–199			1		3	1	5	17	17	8	11	7
200–219		2		1	6	9	6	6	4	17	11	7
220–239			2		1	2	5	7	5	10	5	3
240–259		1		4	3	6	2	3	7	8	4	2
260–279			4		5	3	5	8	1	8	7	1
280–299		2	2	1	7	1	2	9	5	4	14	3
300–319		4	2	2	3	7	3	7	1	4	6	3
320–339	1	3	1	2	2	3	3	5	6	3	7	2
340–359	1	3	2	1	5	1	5	7	7	3	7	2
360–379			1		1	4	3	6	9	8	4	5
380–399	1	2	2		4	3	4	9	4	9	10	
400–419	2	2	3	4	5	6	3	5	3	4	5	3
420–439			4	1	3	4		11	6	6	1	3
440–459		2	4	1	4	2	4	10	6	14	8	3
460–479			2	1	3	1	3	4	9	5	5	1
480–499		2	3		2	1	1	11	7	5	2	
500–549				10	8	6	10	23	16	19	5	3
550–599	1	1	1	1	5	4	7	10	7	8	8	2
600–649			3	3	8	4	5	15	8	3	1	1
650–699		2	2	1	1	2	3	9	5	2	1	1
700–749					2	1	5	5	1	3		2

TABLE 6.—*Weight frequency of blue marlin,* Makaira ampla, *from the Honolulu market, January 1949–February 1952*—Con.

[Data collected by the Hawaiian Division of Fish and Game]

Weight group (pounds)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Year 1951—Continued												
750–799			1		1	2	2	4	1		2	
800–849			2		1	1	4		1	2		
850–899		1		2			1	2				
900–949						1	1	3				
950–999												
>1,000			2	1			2		1			
Number	9	31	47	41	91	89	161	389	345	362	224	71
Maximum weight (pounds)			1,450	1,052			1,107		1,090			
Year 1952:												
10–19												
20–29												
30–39												
40–49												
50–59												
60–69												
70–79	1											
80–89												
90–99	1											
100–109	1											
110–119		1										
120–129	1											
130–139												
140–149												
150–159		1										
160–169												
170–179												
180–189	1											
190–199												
200–219	1											
220–239	1											
240–259	2	2										
260–279		1										
280–299	1	2										
300–319												
320–339		3										
340–359		2										
360–379		4										
380–399		1										
400–419												
420–439		1										
440–459		1										
460–479	1											
480–499												
500–549		2										
550–599												
600–649		1										
650–699												
700–749		1										
750–799												
800–849												
850–899												
900–949												
950–999												
>1,000		1										
Number	11	24										
Maximum weight (pounds)		1,003										

160 cm. (125 lb.) with most of the males ranging from 140 cm. (85 lb.) to 180 cm. (175 lb.).

The *ampla* of less than about 200 pounds, which some of the Japanese authors consider to be mostly males (Ueyanagi 1953; Nakamura et al., 1953; Yabuta 1954), appear in the fishery in quantity only during the summer months. This is thought to indicate a segregation by sex during migrations. A similar phenomenon exists in Hawaii (table 6), where the catch of *ampla* from July to October contains a large modal group from 130 to 220 pounds which may be males. There is also at this time some increase in the catch of larger fish, but not nearly as great an increase as in the modal group.

Spawning

Among the *ampla* specimens examined from the POFI catches, we found no ripe females but did find males with freely flowing milt in the gonads from February through October (and captured only three between November and January). So it is likely that at least some of the males may be ready to spawn at almost any time of the year in the equatorial Pacific.

Nakamura (1942) thought that, like the rest of the spearfishes, *ampla* spawns over long periods of time in wide areas of ocean, and he suspected that the great increase in the proportion of males in the catch off Formosa during May is indicative of the spawning season. He also stated (1951) that *ampla* spawns east of Luzon from May to July.

Synonymy and references

No attempt has been made to include a comprehensive list of references to the Atlantic form.

Tetrapturus amplus, Poey, 1860: 243, tab. 15, fig. 2, (Cuba).

Tetrapturus mazara, Jordan and Snyder, 1901:305 (Japan); Fowler, 1934:400 (Japan, Hawaii).

Makaira mazara, Jordan and Evermann, 1926:53, pl. 11, fig. 2 (Japan, Hawaii); Griffin, 1927:141, pl. 13 (New Zealand); Nakamura, 1938:28 (Formosa); Nakamura, 1941 (Philippine Sea); Nakamura, 1942 (Formosa); Brock, 1950:146 (Hawaii); Nakamura, 1951:37 (northern tropical Pacific); Murphy and Otsu, 1954 (Caroline Islands); LaMonte, 1955:336 (in part).

Makaira nigricans ampla, Conrad and LaMonte, 1937:207 (Bahamas); Shapiro, 1938 (Bahamas); Gregory and Conrad, 1939, pl. V (Bahamas); Gabrielson and LaMonte, 1950:29; Rosa, 1950:145 (northwestern Atlantic, Caribbean Sea to New England).

Makaira ampla, LaMonte, 1955:344.

Makaira ampla mazara, LaMonte and Marcy, 1941:2 (Japan); Nichols and LaMonte, 1941:8 (Japan).

Makaira nigricans mazara, Rosa, 1950:141 (Pacific coast of Mexico, California, Hawaii, Japan, Australia, New Zealand).

Makaira ampla ampla, LaMonte and Marcy, 1941:2 (Cuba to North Carolina).

Eumakaira nigra, Hirasaka and Nakamura, 1947:16, pl. 2, fig. 2 (Formosa); Nakamura, 1949:65 (warm seas of Pacific and Indian Oceans); Nakamura, Yabuta, and Ueyanagi, 1953 (Japan); Yabuta, 1954 (western Pacific, Japan to Australia and east to Line Islands, Indian Ocean off Sumatra).

Istiompax howardi, Whitley, 1954:58, pl. 3, fig. 3 (Australia).

Acapulco black marlin, Gabrielson and LaMonte, 1950:515 (Pacific coast of Mexico).

Kurokajiki, black marlin, Van Campen, 1952 (Caroline Islands); Yabuta, 1953 (Bonin Islands).

Blue marlin, Farrington, 1937; Farrington, 1949:153 (Cuba to New England, Caribbean Sea).

Silver marlin, Farrington, 1953:160 (Hawaii).

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APPENDIX

Because it is necessary to compare the spearfishes of the world by means of measurements, our original data and some computations are presented here. The original observations were obtained by members of the POFI scientific staff in addition to their regular observations on tunas. These members were: Donald K. F. Ching, Thomas S. Hida, Isaac I. Ikehara, Edwin S. Iversen, Joseph E. King, Walter M. Matsumoto, Sueto Murai, Garth I. Murphy, Tamio Otsu, Thomas J. Roseberry, William F. Royce, Richard S. Shomura, Wilvan G. Van Campen, and Henny S. H. Yuen.

APPENDIX TABLE 1-A.—*Original data and morphometric measurements of 8 specimens of* Tetrapturus angustirostris, *by POFI*

[Measurements in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Latitude	2°56′ N.	7°00′ S.	2°57′ S.	15°46′ N.	9°01′ S.	10°00′ N.	10°00′ N.	15°46′ N.
Longitude	150°08′ W.	169°59′ W.	169°49′ W.	154°13′ W.	131°24′ W.	151°02′ W.	151°02′ W.	154°13′ W.
Date taken	2-17-53	5-28-53	11-21-52	1-26-53	3-18-54	5-3-53	5-3-53	1-26-52
Sex	?	?	Male	?	Female [1]	?	?	Female
Weight (pounds)	24	18	21	33		51		46
Tip snout to fork tail	1,470	1,509	1,530	1,589	1,638	([2])	([3])	1,791
Tip snout to upper tail notch		1,415			1,537			
Tip snout to inside 1st dorsal		327			346			
Tip snout to inside pectoral		387			415			
Tip snout to inside pelvic		406			435			
Tip snout to posterior edge opercle	359	387	379	403	408			437
Tip snout to anterior edge orbit		215			234		225	
Orbit diameter	29	38	34	31	33	43		34
Posterior edge orbit to posterior edge opercle		134			141			
Naris to fork of tail	1,296	1,306			1,428	1,526		1,577
Posterior edge orbit to fork of tail		1,256			1,371	1,463		
Length of mandible		216			225	234	239	
Sword width opposite tip mandible	9	15		17	17	14		
Sword depth opposite tip mandible					12			
Depth of head		110			124	124		
Greatest body depth	165	151	161	196	179			217
Body width at tip pectoral		70			88			
Body depth at vent					160			
Ventral groove to inside of anal		135			140			
1st dorsal height longest anterior ray	190	196	212	225	210	222		233
1st dorsal height 20th ray	168	179		172	177	204		171
1st dorsal length base	900	898		955	1,017	998		1,067
2d dorsal height	45	44		53	50	56		56
2d dorsal length base		58			61	59		
1st anal height	100	108	128	132	114	134		143
1st anal length base		164			215	213		
Pectoral length	180	174	205	197	204	217		214
Pelvic length	308	330		[4] 353	332	351		366
Caudal spread		409	402		490	503		
Interspace 1st and 2d dorsals	23	33		15	0	87		48
Interspace 1st and 2d anals	81	114			100	123		
Pectoral fin folds against side	Yes	Yes		Yes	Yes	Yes		
Number stripes on sides	0			0	0	0		0
Number free spines between dorsals	0	0		0	0	0		

[1] *Running ripe;* ovaries 4 cm. diameter, mature ova about 1 mm. diameter.
[2] Snout broken.
[3] Shark-eaten.
[4] Approximate; broken parts.

APPENDIX TABLE 1–B.—*Original data and morphometric measurements of 6 specimens of* Istiophorus orientalis, *by POFI*

[Measurements in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Latitude	7°39′ N.	7°10′ N.	9°05′ N.	7°20′ N.	1°00′ S.	8°59′ N.
Longitude	131°20′ W.	152°14′ W.	131°40′ W.	110°20′ W.	140°05′ W.	110°09′ W.
Date taken	11-14-52	10-25-52	11-15-51	3-4-54	3-13-53	3-3-54
Sex		Female	?	Female	Male	Female
Weight (pounds)		33		64	77	86
Tip snout to fork tail	1,530	1,809	2,031	2,232	(1)	[2] 2,516
Tip snout to upper tail notch				2,090		[2] 2,336
Tip snout to inside 1st dorsal				666		[2] 725
Tip snout to inside pectoral				743		[2] 808
Tip snout to inside pelvic				787		[2] 830
Tip snout to posterior edge opercle	555	633	699	735		[2] 790
Tip snout to anterior edge orbit				513		[2] 535
Orbit diameter	30	30	39	43	33	53
Posterior edge orbit to posterior edge opercle				167		202.
Naris to fork of tail	1,142	1,379	1,550	1,727	1,784	2,001
Posterior edge orbit to fork of tail				1,664		
Length of mandible				288		
Sword width opposite tip mandible						
Sword depth opposite tip mandible						
Depth of head				183		
Greatest body depth	187	229	274	293	300	335
Body width at tip pectoral				119		124
Body depth at vent						
Ventral groove to inside anal				88		109
1st dorsal height longest anterior ray				393		474
1st dorsal height 20th ray				759	[3] 825	[4] 667
1st dorsal length base				1,161	1,173	1,320
2d dorsal height			89	81	104	101
2d dorsal length base				90		107
1st anal height	125	176	173	201	209	249
1st anal length base				253		271
Pectoral length	200	323	345	338	398	500
Pelvic length				581	623	536
Caudal spread		678		764		867
Interspace 1st and 2d dorsals				13	36	50
Interspace 1st and 2d anals				119		155
Pectoral fin folds against side				Yes		Yes
Number stripes on sides				20	21	?

[1] Snout broken.
[2] Includes estimated 50 mm. for broken snout.
[3] Longest ray (#19) was 842 cm.
[4] Longest ray (#18) was 777 cm.

APPENDIX TABLE 1–C.—*Original data and morphometric measurements of 11 specimens of* Istiompax marlina, *by POFI*

[Measurements in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Latitude	0°03′ N.	1°48′ S.	2°34′ S.	2°13′ N.	2°15′ N.	4°58′ S.
Longitude	155°15′ W.	139°59′ W.	155°23′ W.	155°15′ W.	151°19′ W.	149°57′ W.
Date taken	12-4-53	3-11-53	8-19-53	4-15-54	10-30-52	5-15-53
Sex	?	Male	?	Male	Female	?
Weight (pounds)	182	183		270		[1] 291
Tip snout to fork tail	2,379	2,507	2,568	2,716	[2] 2,749	2,836
Tip snout to upper tail notch	2,209		2,375	2,490		2,635
Tip snout to inside 1st dorsal	750		823	858		895
Tip snout to inside pectoral	823		920	1,000		999
Tip snout to inside pelvic	870		970	1,045		1,068
Tip snout to posterior edge opercle	825	928	915	981		
Tip snout to anterior edge orbit	530		613	647		665
Orbit diameter	51	36	51	57	37	58
Posterior edge orbit to posterior edge opercle	244		251	277		
Naris to fork of tail	1,861	1,904	1,983	2,084	2,149	2,198
Posterior edge orbit to fork of tail	1,798		1,904	2,012		2,113
Length of mandible	343		378	404		414
Sword width opposite tip mandible	45	41	34	44		50
Sword depth opposite tip mandible				35		
Depth of head	230		210	281		254
Greatest body depth		455		491	505	542
Body width tip pectoral				267		220
Body depth at vent				449		
Ventral groove to inside anal				96		141
1st dorsal height of longest anterior ray	284	280	311	280		335
1st dorsal height of 20th ray	74	71	60	45		78
1st dorsal length base	898	1,153		1,216		1,345
2d dorsal height	87	86	95	98	97	94
2d dorsal length base	115		123	146		136
1st anal height	231	243		281	274	274
1st anal length base	250			314		290
Pectoral length	413	467	443	481	574	535
Pelvic length	232	279	256	186		270
Caudal spread	880		908	980		960
Interspace 1st and 2d dorsals	278	92	113	93		61
Interspace 1st and 2d anals	139	168		146		146
Pectoral fin folds against side	No	No	No	No		No
Number of stripes on sides	0	0	0	[3] 0		
Number of free spines between dorsals	3(?)	0	0	0		0

See footnotes at end of table.

APPENDIX TABLE 1–C.—*Original data and morphometric measurements of 11 specimens of* Istiompax marlina, *by POFI*—Con.

Item	No. 7	No. 8	No. 9	No. 10	No. 11
Latitude	3°22′ N.	5°20′ S.	4°36′ N.	0°08′ N.	3°52′ S.
Longitude	160°24′ W.	179°55′ W.	154°41′ W.	154°51′ W.	155°13′ W.
Date taken	8–23–53	2–22–52	4–20–54	8–13–53	4–11–54
Sex	?	Female	Female	?	Female
Weight (pounds)	293		418		587
Tip snout to fork tail	2,842	2,999	3,027	3,214	3,467
Tip snout to upper tail notch	2,638		2,788		3,210
Tip snout to inside 1st dorsal	952	975	940		1,124
Tip snout to inside pectoral	1,005		1,054		1,151
Tip snout to inside pelvic	1,085	1,145	1,135		1,228
Tip snout to posterior edge opercle	1,039	1,024	1,090	1,141	1,235
Tip snout to anterior edge orbit	715		703	743	808
Orbit diameter	52		64	61	63
Posterior edge orbit to posterior edge opercle	272		323	337	364
Naris to fork of tail	2,160		2,353	2,508	2,693
Posterior edge orbit to fork of tail	2,075		2,260	2,410	2,596
Length of mandible	405		440		518
Sword width opposite tip mandible	50		56		61
Sword depth opposite tip mandible			43		51
Depth of head	230		310	277	386
Greatest body depth		568	591		647
Body width tip pectoral			339		355
Body depth at vent			505		535
Ventral groove to inside anal			52		194
1st dorsal height of longest anterior ray	308	348	386	387	393
1st dorsal height of 20th ray	72		67	69	72
1st dorsal length base	1,231		1,425	1,316	1,501
2d dorsal height	102		121	107	
2d dorsal length base	142		148	163	
1st anal height	275		308	297	295
1st anal length base	294		336	367	336
Pectoral length	534	531	566	596	644
Pelvic length	304		255	295	255
Caudal spread	1,023	1,112	1,120		1,166
Interspace 1st and 2d dorsals	127		66	243	
Interspace 1st and 2d anals	148		150	134	210
Pectoral fin folds against side	No		No	No	No
Number of stripes on sides	0			0	0
Number of free spines between dorsals	0			0	0

[1] Excluding stomach contents.
[2] Approximate measurement; tip of snout broken.
[3] About 12 stripes faintly showing when first caught.

APPENDIX TABLE 1–D.—*Original data and morphometric measurements of 25 specimens of* Makaira audax, *by POFI*

[Measurements in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
Latitude	5°58′ N.	8°07′ N.	5°36′ S.	8°07′ N.	4°18′ N.	2°23′ N.	3°23′ N.	1°59′ S.	3°23′ N.
Longitude	161°11′ W.	149°57′ W.	120°25′ W.	149°57′ W.	130°11′ W.	130°25′ W.	130°29′ W.	120°03′ W.	130°29′ W.
Date taken	5–21–54	8–11–52	10–29–52	8–11–52	11–12–52	11–10–52	11–11–52	10–29–52	11–11–52
Sex	?	?	?	?	?	?	?	?	?
Weight (pounds)	21	52		75		86	92		99
Tip snout to fork tail	1,423	[1] 1,869	1,891	1,968	2,036	2,160	2,165	2,282	2,294
Tip snout to upper tail notch	1,315								
Tip snout to inside 1st dorsal	495		689	732	712	764	745	801	818
Tip snout to inside pectoral	547								
Tip snout to inside pelvic	560		808	833	837	867	868	914	935
Tip snout to posterior edge opercle	548		740	753			781	829	848
Tip snout to anterior edge orbit	383								
Orbit diameter	35	36	35	36	36	36	37	36	37
Posterior edge orbit to posterior edge opercle	130								
Naris to fork tail	1,049	1,402	1,417	1,464	1,550	1,649	1,670	1,742	1,720
Posterior edge orbit to fork of tail	1,005								
Length of mandible	219								
Sword width opposite tip mandible	14								
Sword depth opposite tip mandible									
Depth of head	109								
Greatest body depth		259	279	309	293	305	321	338	329
Body width tip pectoral									
Body depth at vent									
Ventral groove to inside anal									
1st dorsal height longest anterior ray	232	340	374	354	359	390	405	413	397
1st dorsal height 20th ray	151								
1st dorsal length base	665								
2d dorsal height	55		84		82	97	96	87	94
2d dorsal length base	51								
1st anal height	146	201	254	217	230	243	266	258	262
1st anal length base	200								
Pectoral length	204	330	376	371	387	398	429	434	438
Pelvic length	297								
Caudal spread	455								
Interspace 1st and 2d dorsals	17								
Interspace 1st and 2d anals	44								
Pectoral fin folds against side	Yes								
Number stripes on sides	16								
Number free spines between dorsals									

See footnotes at end of table.

APPENDIX TABLE 1–D.—*Original data and morphometric measurements of 25 specimens of* Makaira audax, *by POFI*—Con.

[Measurements in millimeters]

Item	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17
Latitude	5°15′ N.	0°59′ S.	8°59′ N.	3°19′ S.	1°11′ N.	1°04′ N.	2°34′ S.	0°51′ N.
Longitude	110°17′ W.	111°28′ W.	110°09′ W.	112°11′ W.	130°15′ W.	151°05′ W.	155°23′ W.	158°53′ W
Date taken	3-5-54	3-9-54	3-3-54	3-10-54	11-9-52	2-10-53	8-15-53	6-10-54
Sex	Male	Female	Male	Female	Female	?	?	?
Weight (pounds)		157	145	205			245	[2] 180
Tip snout to fork tail	[1] 2,443	2,518	2,545	2,548	2,571	2,622	2,736	2,747
Tip snout to upper tail notch		2,333	2,342	2,362			2,500	2,530
Tip snout to inside 1st dorsal		813	798	835	877		909	929
Tip snout to inside pectoral		895	873	923			1,002	1,028
Tip snout to inside pelvic		914	900	964	963		1,025	1,065
Tip snout to posterior edge opercle		878	859	915	884	1,001	1,002	1,015
Tip snout to anterior edge orbit		587	562	605			664	700
Orbit diameter	53	53	53	55	43	42	67	58
Posterior edge orbit to posterior edge opercle	225	238	244	255			271	257
Naris to fork of tail	1,904	1,959	2,012	1,969	2,019		2,094	2,076
Posterior edge orbit to fork of tail	1,827	1,878	1,930	1,888			2,005	1,989
Length of mandible	361	398	396	418			446	441
Sword width opposite tip mandible	30	29	28	36		32	39	20
Sword depth opposite tip mandible	20	19	18	20				
Depth of head	208	220	222	205			194	197
Greatest body depth	365	365	369	390	387	405		363
Body width tip pectoral	195	216	200	260				243
Body depth at vent	265	274	273	336				
Ventral groove to inside anal	63	88	77	57				
1st dorsal height longest anterior ray	399	436	438	411	461	448	481	416
1st dorsal height 20th ray	86	115	82	109		89	127	109
1st dorsal length base	1,210	1,245		1,237		1,227		1,271
2d dorsal height	91		119	100	103	107	123	89
2d dorsal length base	84		96	93			105	99
1st anal height	241	290	289	277	305	304	293	280
1st anal length base	321	340	268	358			362	348
Pectoral length	448	488	525	463	490	527	535	531
Pelvic length	379	319	387	220		348	361	357
Caudal spread	875	916	962	844			1,045	901
Interspace 1st and 2d dorsals	20			49		53		63
Interspace 1st and 2d anals	83	105	75	61			72	75
Pectoral fin folds against side	Yes	Yes	Yes	Yes			Yes	Yes
Number stripes on sides	[3] 16	21	[3] 16			Ca. 15	16	10
Number free spines between dorsals	0	0	0	0		0	0	0

Item	No. 18	No. 19	No. 20	No. 21	No. 22	No. 23	No. 24	No. 25
Latitude	2°39′ S.	1°20′ S.	6°07′ N.	9°57′ N.	1°20′ N.	5°47′ N.	8°39′ N.	1°47′ N.
Longitude	179°54′ E.	169°00′ W.	154°47′ W.	155°06′ W.	155°03′ W.	162°06′ W.	154°57′ W.	158°16′ W.
Date taken	2-20-52	3-8-52	4-22-54	7-29-53	2-3-52	1-25-53	7-30-53	6-9-54
Sex	Female	Female	Female		Female	?	?	?
Weight (pounds)			290				314	[2] 280
Tip snout to fork tail	2,757	2,798	2,842	[1] 2,889	2,911	2,933	3,039	3,101
Tip snout to upper tail notch							2,792	2,870
Tip snout to inside 1st dorsal	978	1,010	946				969	1,000
Tip snout to inside pectoral			1,024				1,065	1,120
Tip snout to inside pelvic	1,107	1,154	1,051				1,097	1,173
Tip snout to posterior edge opercle	1,022	1,050	1,027		1,028	1,083	1,071	1,096
Tip snout to anterior edge orbit			655				691	715
Orbit diameter	47	48	67	65		47	67	67
Posterior edge orbit to posterior edge opercle			305				313	314
Naris to fork of tail	2,100	2,115	2,223		2,256	2,247	2,385	2,413
Posterior edge orbit to fork of tail			2,120	2,166			2,281	2,319
Length of mandible			467				473	490
Sword width opposite tip mandible			40			35	36	25
Sword depth opposite tip mandible			22					
Depth of head			280				238	243
Greatest body depth	435	422	490		545	474		476
Body width tip pectoral			281					283
Body depth at vent			395					
Ventral groove to inside anal			63					60
1st dorsal height longest anterior ray	460	500	450	486	573	486	466	475
1st dorsal height 20th ray			77			110	99	101
1st dorsal length base			1,346			1,288	1,364	1,405
2d dorsal height		121	111			70	136	111
2d dorsal length base			113				117	118
1st anal height	302	327	288			259	294	326
1st anal length base			388				366	443
Pectoral length	549	592	589		522		540	565
Pelvic length			281			416	343	251
Caudal spread			1,075					1,053
Interspace 1st and 2d dorsals			82			163	160	134
Interspace 1st and 2d anals			94			126	165	75
Pectoral fin folds against side			Yes	Yes		Yes	Yes	Yes
Number stripes on sides			16			16	12	12
Number free spines between dorsals			0			0	1	0

[1] Approximate: tip of snout broken.
[2] Without viscera.
[3] 5 intermediate stripes.

APPENDIX TABLE 1-E.—*Original data and morphometric measurements of 68 specimens of* Makaira ampla, *by POFI*

[Measurements in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Latitude	5°03′ S.	3°36′ S.	2°15′ S.	5°53′ N.	2°56′ S.	2°54′ N.	4°03′ S.	6°47′ S.	5°03′ S.	8°59′ N.
Longitude	150°05′ W.	149°55′ W.	169°58′ W.	161°15′ W.	150°08′ W.	150°19′ W.	179°58′ E.	180°	150°05′ W.	110°09′ W.
Date taken	5-15-53	5-14-53	6-1-53	1-27-53	2-17-53	2-3-53	2-21-52	2-24-52	5-15-53	3-3-54
Sex		?	Male	Male	Male	?	Female	Male	Male	
Weight (pounds)	28	77	93	90	110				118	136
Tip snout to fork tail	1,350	1,788	1,824	1,897	1,985	1,989	2,011	2,019	2,086	2,126
Tip snout to upper tail notch	1,233	1,618	1,673						1,917	1,971
Tip snout to inside 1st dorsal	338	529	533				659	634	685	641
Tip snout to inside pectoral	375	597	588						724	707
Tip snout to inside pelvic	388	604	600				734	736	729	708
Tip snout to posterior edge opercle	372	574	588	574	677	656	675	670	723	699
Tip snout to anterior edge orbit	214	379	383						491	466
Orbit diameter	34	47	41	33	37	37	33	40	52	50
Posterior edge orbit to posterior edge opercle	124	148	164						180	183
Naris to fork of tail	1,151	1,438	1,463	1,558	1,560	1,593	1,590	1,599	1,612	1,680
Posterior edge orbit to fork of tail	1,102	1,362	1,400						1,543	1,610
Length of mandible	185	227	241						283	274
Sword width opposite tip mandible	16	28	25	28	30	33			31	33
Sword depth opposite tip mandible										23
Depth of head	117	170	147						132	196
Greatest body depth	189		300	290	328	319	323	321	330	359
Body width tip pectoral	119		199						209	230
Body depth at vent										323
Ventral groove to inside anal	28		44						40	61
1st dorsal height longest anterior ray	171	235	233	226	244	294	260	275	272	245
1st dorsal height 20th ray	84	80	71	80	66	63			63	51
1st dorsal length base	716	890	887	909	950	1,005			975	1,056
2d dorsal height	51	62	65	68	70	68		79	80	85
2d dorsal length base	67	74	76						83	288
1st anal height	138	189	195	206		247	227	233	241	245
1st anal length base	215	286	275						320	335
Pectoral length	187	325	313	332	350	408	369	395	382	377
Pelvic length	310	371	355	352	363	394			300	301
Caudal spread	476	690	684					762	802	758
Interspace 1st and 2d dorsals	9	23	30	48	37	37			34	20
Interspace 1st and 2d anals	40	44	38	55					59	58
Pectoral fin folds against side	Yes	Yes	Yes	Yes					Yes	Yes
Number stripes on sides	(1)	12		13					12	15
Number free spines between dorsals	0	0	0	0	0	0			0	0

Item	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18	No. 19	No. 20
Latitude	5°03′ S.	6°47′ S.	0°02′ N.	1°43′ N.	5°41′ S.	9°01′ S.	3°36′ S.	6°40′ S.	0°01′ N.	1°13′ S.
Longitude	150°05′ W.	180°	179°48′ E.	169°59′ W.	169°44′ W.	131°24′ W.	149°55′ W.	169°03′ W.	169°02′ W.	150°11′ W.
Date taken	5-15-53	2-24-52	2-18-52	6-4-53	5-29-53	3-18-54	5-14-53	3-4-52	3-9-52	2-12-53
Sex	Male	Male	Female	Male	Male	Male	Male	Male	Male	Male
Weight (pounds)	180			123	153	176	130			145
Tip snout to fork tail	2,168	2,184	2,219	2,232	2,244	2,262	2,288	[2] 2,293	[2] 2,302	2,329
Tip snout to upper tail notch	2,000			2,072	2,071		2,108			
Tip snout to inside 1st dorsal	644	711	721	720	689		730			
Tip snout to inside pectoral	703			778	746		781			
Tip snout to inside pelvic	724	786	790	785	760		803			
Tip snout to posterior edge opercle	716	732	736	767	746		784			797
Tip snout to anterior edge orbit	440			514	495		527			
Orbit diameter	61	41	38	57	56		55	39	42	
Posterior edge orbit to posterior edge opercle	215			196	195		202			
Naris to fork of tail	1,762	1,743	1,753	1,745	1,769	1,787	1,779	1,830	1,814	1,834
Posterior edge orbit to fork of tail	1,667			1,661	1,693		1,706			
Length of mandible	294			285	294		305			
Sword width opposite tip mandible	35			37	29		30			45
Sword depth opposite tip mandible										
Depth of head	203			158	185		167			
Greatest body depth	394	384	351	301	361	397		360	364	370
Body width tip pectoral	247			203	247	245				
Body depth at vent						352				
Ventral groove to inside anal	41			51	42	59				
1st dorsal height longest anterior ray	306	295		289	298		305	314	297	265
1st dorsal height 20th ray	70			42	70		61			46
1st dorsal length base	1,090			1,057	1,094		1,088			1,118
2d dorsal height	78	75	77	75	81		90	84		71
2d dorsal length base	92			89	91		101			
1st anal height	257	251	257	230	255		261	257	253	242
1st anal length base	350			324	363		322			
Pectoral length	412	392		412	400		447	412	435	389
Pelvic length				310	357		362			292
Caudal spread	810			790	855		875		853	
Interspace 1st and 2d dorsals	30			53	43		26?			30
Interspace 1st and 2d anals	64			63	52		72			
Pectoral fin folds against side	Yes			Yes	Yes		Yes			
Number stripes on sides	8						14			?
Number free spines between dorsals	0			0	0		0			0

See footnotes at end of table.

APPENDIX TABLE 1–E.—*Original data and morphometric measurements of 68 specimens of* Makaira ampla, *by POFI*—Con.

[Measurements in millimeters]

Item	No. 21	No. 22	No. 23	No. 24	No. 25	No. 26	No. 27	No. 28	No. 29	No. 30
Latitude	15°30′ S.	7°06′ N.	5°43′ N.	8°07′ N.	6°13′ N.	0°02′ N.	9°52′ N.	6°13′ N.	2°12′ S.	3°11′ S.
Longitude	149°30′ W.	152°11′ W.	150°06′ W.	149°57′ W.	131°00′ W.	179°48′ E.	151°12′ W.	131°00′ W.	150°20′ W.	130°17′ W.
Date taken	2-23-53	10-25-52	8-13-52	8-11-52	11-13-52	2-18-52	5-3-53	11-13-52	8-21-52	11-6-52
Sex	Male	Male	Male	Male	?	?	?	?	?	Male
Weight (pounds)	156		170	176			175		185	
Tip snout to fork tail	2,330	2,350	2,374	2,377	2,382	2,402	2,417	2,422	2,435	2,438
Tip snout to upper tail notch							2,235			
Tip snout to inside 1st dorsal		736	785	821	776	783	762	782	816	823
Tip snout to inside pectoral							837			
Tip snout to inside pelvic		780	882	903	843	874	852	840	953	913
Tip snout to posterior edge opercle	775	733	823	832	788	789	835	792	854	839
Tip snout to anterior edgeorbit							552			
Orbit diameter	41		60	47	38	39	57	38	39	44
Posterior edge orbit to posterior edge opercle							226			
Naris to fork of tail	1,853	1,908	1,853	1,842	1,889	1,899	1,880	1,930	1,904	1,921
Posterior edge orbit to fork of tail							1,808			
Length of mandible							320			
Sword width opposite tip mandible	33						38			
Sword depth opposite tip mandible										
Depth of head							160			
Greatest body depth	383	401	371	414	389	408		373	426	448
Body width tip pectoral										
Body depth at vent										
Ventral groove to inside anal										
1st dorsal height longest anterior ray	298	337	302	294	348	300	288	348	296	341
1st dorsal height 20th ray	58						50			
1st dorsal length base	1,116						1,062			
2d dorsal height	80				80		82	97	78	87
2d dorsal length base							106			
1st anal height	242	280	271	257	296	274	259	308	226	285
1st anal length base							346			
Pectoral length	415	446	421	437	440	421	428	470	494	431
Pelvic length	364						257			
Caudal spread		905				875	850			
Interspace 1st and 2d dorsals	56						110			
Interspace 1st and 2d anals	85						99			
Pectoral fin folds against side	Yes						Yes			
Number stripes on sides	13–14						0			
Number free spines between dorsals	0						0			

Item	No. 31	No. 32	No. 33	No. 34	No. 35	No. 36	No. 37	No. 38	No. 39	No. 40
Latitude	6°40′ S.	8°07′ N.	3°23′ N.	8°14′ N.	Hawaii	9°20′ S.	5°52′ N.	9°01′ S.	9°20′ S.	5°03′ S.
Longitude	160°03′ W.	149°57′ W.	130°29′ W.	120°32′ W.		120°53′ W.	120°11′ W.	131°24′ W.	120°53′ W.	150°05′ W.
Date taken	3-4-52	8-11-52	11-11-52	10-19-52	1-23-53	3-15-54	10-22-52	3-18-54	3-15-54	5-15-53
Sex	Male	Male	?	?		Male	Female	Male	Male	Male(?)
Weight (pounds)		205	184			207		183	173	218
Tip snout to fork tail	2,465	[2] 2,477	2,479	2,517	2,528	2,538	2,540	2,550	2,579	2,596
Tip snout to upper tail notch						2,349			2,396	2,404
Tip snout to inside 1st dorsal	826		855	872		789	790		838	835
Tip snout to inside pectoral						861			927	926
Tip snout to inside pelvic	889		910	925			879		924	937
Tip snout to posterior edge opercle	853		860	854	867	867	813		899	918
Tip snout to anterior edge orbit						569			600	608
Orbit diameter	43	45	47	42	42	58	40		61	62
Posterior edge orbit to posterior edge opercle						240			238	248
Naris to fork of tail	1,938	1,957	1,940	1,972	1,985	1,994	2,039	1,998	2,010	2,025
Posterior edge orbit to fork of tail						1,911			1,918	1,926
Length of mandible									360	360
Sword width opposite tip mandible					35	36			35	37
Sword depth opposite tip mandible						25			23	
Depth of head						213			205	224
Greatest body depth	416	404	398	419	396	404	448	407	392	
Body width tip pectoral						269		231	228	
Body depth at vent						366		332	334	
Ventral groove to inside anal						58		68	50	
1st dorsal height longest anterior ray	332	311	319		343	344		333	308	307
1st dorsal height 20th ray					63	69			58	60
1st dorsal length base					1,193	1,224			1,192	1,199
2d dorsal height	95		102	81	87	87	96		78	94
2d dorsal length base						105			109	99
1st anal height	293		262	282	272	289	296		253	270
1st anal length base						380			357	364
Pectoral length	466		431	427	429	452	513		456	473
Pelvic length					282	382			284	297
Caudal spread	894			873		905	972		883	923
Interspace 1st and 2d dorsals					65	40			51	69
Interspace 1st and 2d anals						74			92	61
Pectoral fin folds against side					Yes	Yes			Yes	Yes
Number stripes on sides					8	Ca. 14			Ca. 13	12
Number free spines between dorsals					0	0			0	0

See footnotes at end of table.

APPENDIX TABLE 1–E.—*Original data and morphometric measurements of 68 specimens of* Makaira ampla, *by POFI*—Con.

[Measurements in millimeters]

Item	No. 41	No. 42	No. 43	No. 44	No. 45	No. 46	No. 47	No. 48	No. 49	No. 50
Latitude	1°59′ S.	5°15′ N.	2°46′ N.	1°41′ S.	1°41′ S.	0°30′ S.	1°14′ S.	2°51′ N.	3°30′ N.	3°23′ N.
Longitude	120°03′ W.	110°17′ W.	155°10′ W.	140°02′ W.	140°02′ W.	169°52′ W.	150°51′ W.	150°04′ W.	170°09′ W.	130°29′ W.
Date taken	10-29-52	3-5-54	2-2-52	8-18-52	9-3-52	6-2-53	11-5-52	5-8-53	6-6-53	11-11-52
Sex	Male	Female	Female	?		Female	Female	?	Female	Female
Weight (pounds)				320	367			312	305	
Tip snout to fork tail	2,602	2,607	2,695	2,805	2,853	2,856	2,881	2,943	[3] 2,953	2,984
Tip snout to upper tail notch		2,414				2,650		2,709		
Tip snout to inside 1st dorsal	805	820		958	965	907	972	947		1,024
Tip snout to inside pectoral		894				956		1,028		
Tip snout to inside pelvic	875	924		1,032	1,136	953	1,032	1,048		1,109
Tip snout to posterior edge opercle	815	893	938	982	1,016	974	977	1,021		1,025
Tip snout to anterior edge orbit		595				640		674		
Orbit diameter	43	51		60	58	63	42	61	70	48
Posterior edge orbit to posterior edge opercle		247				271		286	294	
Naris to fork of tail	2,124	2,034	2,086	2,180	2,230	2,244	2,264	2,305	2,332	2,332
Posterior edge orbit to fork of tail		1,961				2,153		2,208	2,252	
Length of mandible		329				362		377	380	
Sword width opposite tip mandible		40				45		44	49	
Sword depth opposite tip mandible		27								
Depth of head		233				225		292	209	
Greatest body depth	423	462	447	501	554	513	497		542	526
Body width tip pectoral		280				309			339	
Body depth at vent		397								
Ventral groove to inside anal		61				59			41	
1st dorsal height longest anterior ray	311	367	381	376	325	347	401	373	399	404
1st dorsal height 20th ray		61				35		80	58	
1st dorsal length base		1,262				1,350		1,373		
2d dorsal height	72	91				85	102	100		85
2d dorsal length base		110				120		110		
1st anal height	239	324		317	267	296	341	285	377	342
1st anal length base		406						398	413	
Pectoral length	477	528	485	582	581	546	521	556	545	496
Pelvic length		418						370	344	
Caudal spread		992				1,074	1,020	1,063		
Interspace 1st and 2d dorsals		28				44		80		
Interspace 1st and 2d anals		47						104	101	
Pectoral fin folds against side		Yes				Yes		Yes	Yes	
Number stripes on sides		11						[4] 14	13	
Number free spines between dorsals						0		0	0	

Item	No. 51	No. 52	No. 53	No. 54	No. 55	No. 56	No. 57	No. 58	No. 59
Latitude	4°00′ N.	2°10′ N.	6°29′ S.	8°59′ N.	7°57′ N.	7°57′ N.	5°30′ N.	4°32′ N.	2°38′ N.
Longitude	152°20′ W.	151°45′ W.	149°60′ W.	110°09′ W.	169°48′ W.	169°48′ W.	149°58′ W.	170°02′ W.	169°59′ W.
Date taken	10-28-52	10-30-52	5-16-53	3-3-54	6-9-53	6-9-53	5-6-53	6-7-53	6-5-53
Sex	Female	Female	Female	Female	Female	Female		Female	
Weight (pounds)			376	361			605		
Tip snout to fork tail	3,005	3,005	3,075	3,088	3,152	3,182	3,236	[5] 3,251	3,308
Tip snout to upper tail notch			2,858	2,846	2,891	2,932	2,997		3,060
Tip snout to inside 1st dorsal	839	1,018	992	1,012	979	987	1,069		962
Tip snout to inside pectoral			1,089	1,075	1,050	1,102	1,154		1,071
Tip snout to inside pelvic	905	1,104	1,110	1,100	1,050	1,135	1,170		1,071
Tip snout to posterior edge opercle	864	1,029	1,084	1,092	1,061	1,101	1,184		1,075
Tip snout to anterior edge orbit			729	758	691	735	806		697
Orbit diameter	41	43	64	60	70	67	70	64	65
Posterior edge orbit to posterior edge opercle			291	274	300	299	308	311	313
Naris to fork of tail	2,462	2,347	2,371	2,357	2,472	2,474	2,455	2,590	2,640
Posterior edge orbit to fork of tail			2,282	2,270	2,391	2,380	2,360	2,499	2,546
Length of mandible			386	379	408	406	424	402	425
Sword width opposite tip mandible			50	50	46	50	53	50	52
Sword depth opposite tip mandible				31					
Depth of head			258	273	263	295	253	280	265
Greatest body depth	420	478	524	517	573	581		502	593
Body width tip pectoral			315	342	337	384		330	358
Body depth at vent				458					
Ventral groove to inside anal			71	61	66	57		77	69
1st dorsal height longest anterior ray	335	446	388	417	439	430	412	460	413
1st dorsal height 20th ray			68	60	61	45	62	71	85
1st dorsal length base			1,462	1,457	1,551	1,540	1,423	1,641	1,641
2d dorsal height	102	115	105	96	106	106	108	96	104
2d dorsal length base			121	128	123	131	132	128	165
1st anal height		388	348	374	392	375	357	400	387
1st anal length base			425	474	466	478	386	441	470
Pectoral length	508	610	564	574	624	585	578	600	556
Pelvic length			318	388	327	381	320	384	271
Caudal spread	998	1,149	1,096	1,164	1,136	1,118	1,194	1,210	1,138
Interspace 1st and 2d dorsals			55	52	31	58	198	126	52
Interspace 1st and 2d anals			136	84	91	119	139	119	119
Pectoral fin folds against side			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number stripes on sides				10			0	10	
Number free spines between dorsals			0	0	0	0	0	0	0

See footnotes at end of table.

APPENDIX TABLE 1-E.—*Original data and morphometric measurements of 68 specimens of* Makaira ampla, *by POFI*—Con.

[Measurements in millimeters]

Item	No. 60	No. 61	No. 62	No. 63	No. 64	No. 65	No. 66	No. 67	No. 68
Latitude	7°57′ N.	2°38′ N.	3°06′ N.	1°00′ S.	3°19′ S.	5°15′ N.	2°42′ S.	4°10′ N.	Hawaii
Longitude	169°48′ W.	169°59′ W.	150°12′ W.	120°13′ W.	112°11′ W.	149°55′ W.	155°05′ W.	168°30′ W.	
Date taken	6-9-53	6-5-53	8-16-52	10-27-52	3-10-54	2-1-53	2-6-52	3-12-52	11-13-54
Sex	Female	Female	?	?	Female		Female	?	Female
Weight (pounds)		540	605		540				1,002
Tip snout to fork tail	3,342	3,402	3,419	3,445	3,521		3,565	[2] 3,766	4,012
Tip snout to upper tail notch	3,082	3,152			3,290				3,714
Tip snout to inside 1st dorsal	1,037	1,083	1,126	1,139	1,162				1,237
Tip snout to inside pectoral	1,128	1,170			1,238				1,357
Tip snout to inside pelvic	1,139	1,207	1,234	1,241	1,277				1,383
Tip snout to posterior edge opercle	1,128	1,188	1,146	1,150	1,250		1,198		1,362
Tip snout to anterior edge orbit	751	784			868				921
Orbit diameter	59	70	69	45	65	41	42	41	59
Posterior edge orbit to posterior edge opercle	318	334			317				382
Naris to fork of tail	2,620	2,609	2,690	2,720	2,682	2,812	2,824	3,096	3,131
Posterior edge orbit to fork of tail	2,532	2,548			2,588				3,032
Length of mandible	396	423			442				472
Sword width opposite tip mandible	50	55			54	58			62
Sword depth opposite tip mandible					40				48
Depth of head	275	318			272				355
Greatest body depth	603	631	597	608	585	655	683	740	723
Body width tip pectoral		286			364				382
Body depth at vent					524				692
Ventral groove to inside anal	73	69			82				104
1st dorsal height longest anterior ray	453	407	432	462	436	359	458	506	512
1st dorsal height 20th ray	58	50			53	55			70
1st dorsal length base	1,654	[6] 1,641			1,631	1,556			1,961
2d dorsal height	110	108		120	108	99			128
2d dorsal length base	129	125			140				193
1st anal height	393	408	408	388	400		443	478	453
1st anal length base	507	456			517				620
Pectoral length	618	632	583	635	637	717	597	696	686
Pelvic length	395	368			280	272			345
Caudal spread	1,087	1,264			1,232		1,283	1,450	1,458
Interspace 1st and 2d dorsals	58	56			80	162			54
Interspace 1st and 2d anals	106	146			129	226			105
Pectoral fin folds against side	Yes	Yes			Yes	Yes			Yes
Number stripes on sides		(4)			Ca. 15				12
Number free spines between dorsals	0					0			0

1 Not visible 2 hours after death.
2 Approximate; tip of snout broken.
3 Includes estimate of 30 mm. for broken snout.
4 About 14 stripes appeared faintly about 1 hr. after death—these were dark or brown on the sides and lighter on the back.
5 Includes estimate of 10 mm. for broken snout.
6 Base of 1st dorsal includes 2 disconnected spines.

APPENDIX TABLE 2-A.—*Original data and morphometric measurements of two specimens of* Tetrapturus angustirostris *taken in Hawaiian waters*

[Measurements by the Hawaiian Division of Fish and Game; in millimeters]

Item	No. 1	No. 2
Date taken	3-20-50	3-18-50
Sex	?	?
Weight (pounds)	47	50
Tip snout to fork tail	1,751	1,857
Orbit diameter	39	40
Naris to fork tail	1,593	1,645
Greatest body depth	208	219
1st dorsal height longest anterior ray	211	229
1st dorsal height 20th ray	173	174
1st dorsal length base	1,077	1,150
Pectoral length	220	211

APPENDIX TABLE 2-B.—*Original data and morphometric measurements of five specimens of* Istiompax marlina *taken in Hawaiian waters*

[Measurements by the Hawaiian Division of Fish and Game; in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5
Date taken	6-6-50	4-12-50	4-11-50	3-29-50	4-14-50
Sex	?	?	?	?	Female
Weight (pounds)	270	341	305	468	517
Tip snout to fork tail [1]	(2,562)	(2,835)	(2,970)	(3,149)	(3,220)
Orbit diameter	44	46	42	47	46
Naris to fork tail	1,974	2,195	2,305	2,450	2,507
Greatest body depth	525	570	523	643	616
1st dorsal height longest anterior ray	286	316	353	324	329
1st dorsal height 20th ray	56	68	60	65	60
1st dorsal length base	1,116	1,146	1,310	1,383	1,410
Pectoral length			580		

1 Measurements in parentheses estimated from regression data of table 3-E.

APPENDIX TABLE 2–C.—*Original data and morphometric measurements of 30 specimens of* Makaira audax *taken in Hawaiian waters*

[Measurements by the Hawaiian Division of Fish and Game; in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Date taken	3-24-50	3-17-50	3-24-50	3-22-50	3-20-50	----------	3-29-50	7-5-50	----------	6-6-50
Sex	?	?	?	?	?	[1] ?	?	Male	?	?
Weight (pounds)	32	41	42	72	58	68	81	78	80	94
Tip snout to fork tail [2]	(1, 665)	(1, 717)	(1, 792)	(1, 985)	(1, 996)	(2, 003)	(2, 105)	(2, 109)	(2, 134)	(2, 149)
Orbit diameter	34	36	39	42	37	37	41	40	40	42
Naris to fork of tail	1, 240	1, 282	1, 343	1, 499	1, 508	1, 514	1, 596	1, 600	1, 620	1, 632
Greatest body depth	223	235	236	279	260	----------	304	295	----------	306
1st dorsal height longest anterior ray	284	299	299	332	312	----------	370	297	----------	367
1st dorsal height 20th ray	147	167	155	105	180	105	106	129	138	107
1st dorsal length base	803	793	866	974	933	916	967	977	975	1, 009
Pectoral length	282	310	292	374	361	376	382	376	420	413

Item	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18	No. 19	No. 20
Date taken	6-6-50	3-22-50	7-5-50	3-23-50	6-6-50	6-6-50	6-22-50	4-12-50	6-6-50	6-5-50
Sex	?	Female	Male	?	?	?	----------	?	Female	?
Weight (pounds)	85	95	90	110	89	104	94	110	110	100
Tip snout to fork tail [2]	(2, 160)	(2, 184)	(2, 211)	(2, 227)	(2, 250)	(2, 275)	(2, 292)	(2, 302)	(2, 307)	(2, 312)
Orbit diameter	43	43	43	41	41	41	42	41	44	44
Naris to fork of tail	1, 641	1, 660	1, 682	1, 695	1, 714	1, 734	1, 748	1, 756	1, 760	1, 764
Greatest body depth	303	325	310	338	296	319	315	345	338	328
1st dorsal height longest anterior ray	346	379	354	361	338	387	336	413	424	388
1st dorsal height 20th ray	91	----------	105	108	88	112	110	116	124	117
1st dorsal length base	1, 010	982	1, 000	993	1, 090	1, 068	1, 062	1, 088	1, 134	1, 116
Pectoral length	390	415	395	452	359	390	397	487	434	443

Item	No. 21	No. 22	No. 23	No. 24	No. 25	No. 26	No. 27	No. 28	No. 29	No. 30
Date taken	6-5-50	6-21-50	6-6-50	7-5-50	6-6-50	7-5-50	7-5-50	6-5-50	3-23-50	3-31-50
Sex	?	----------	Female	Male	?	Female	Female	Female	?	Female
Weight (pounds)	111	161	125	124	110	124	129	107	147	164
Tip snout to fork tail [2]	(2, 319)	(2, 344)	(2, 366)	(2, 405)	(2, 412)	(2, 463)	(2, 470)	(2, 479)	(2, 512)	(2, 528)
Orbit diameter	45	48	45	46	46	45	42	47	46	46
Naris to fork of tail	1, 770	1, 790	1, 808	1, 839	1, 845	1, 886	1, 892	1, 899	1, 926	1, 939
Greatest body depth	342	369	358	333	318	350	366	342	369	409
1st dorsal height longest anterior ray	411	389	356	373	[3] 280	379	396	383	429	435
1st dorsal height 20th ray	102	102	86	102	94	118	100	109	105	82
1st dorsal length base	1, 055	1, 177	1, 080	1, 038	1, 107	1, 117	1, 159	1, 156	1, 169	1, 201
Pectoral length	459	454	349	433	443	470	464	439	435	530

[1] Immature.
[2] Measurements in parentheses estimated from regression data of table 3–E.
[3] Questionable measurement.

APPENDIX TABLE 2–D.—*Original data and morphometric measurements of 27 specimens of* Makaira ampla *taken in Hawaiian waters*

[Measurements by the Hawaiian Division of Fish and Game; in millimeters]

Item	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
Date taken	4-10-50	7-5-50	4-10-50	4-17-50	5-8-50	6-6-50	4-17-50	5-8-50	4-18-50
Sex	?	Male	?	Female	Female	Female	Female	Female	Female
Weight (pounds)	58	147	170	220	260	207	256	330	297
Tip snout to fork tail [1]	(1, 731)	(2, 315)	(2, 458)	(2, 549)	(2, 592)	(2, 609)	(2, 633)	(2, 754)	(2, 756)
Orbit diameter	34	45	51	43	44	45	45	46	46
Naris to fork of tail	1, 385	1, 829	1, 938	2, 007	2, 040	2, 053	2, 071	2, 163	2, 165
Greatest body depth	359?	363	380	412	438	424	472	502	473
1st dorsal height longest anterior ray	217	258	334	332	349	368	389	382	413
1st dorsal height 20th ray	77	53	61	64	63	66	54	58	56
1st dorsal length base	860	1, 085	1, 213	1, 252	1, 166	1, 253	1, 268	1, 289	1, 301
Pectoral length	272?	391	441	479	490	469	515	540	540

Item	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18
Date taken	4-27-50	4-18-50	4-27-50	6-5-50	4-28-50	6-21-50	4-14-50	4-17-50	4-17-50
Sex	Female	Female	Female	Female	Female	Female	Female	Female	Female
Weight (pounds)	342	304	332	448	431	426	290	469	433
Tip snout to fork tail [1]	(2, 800)	(2, 821)	(2, 839)	(2, 932)	(2, 944)	(2, 962)	(2, 969)	(3, 024)	(3, 026)
Orbit diameter	46	48	46	49	45	48	48	47	50
Naris to fork of tail	2, 198	2, 214	2, 228	2, 299	2, 308	2, 322	2, 327	2, 369	2, 370
Greatest body depth	459	454	490	541	566	537	513	539	555
1st dorsal height longest anterior ray	365	412	357	433	410	415	386	378	409
1st dorsal height 20th ray	39	64	52	61	60	62	41	43	46
1st dorsal length base	1, 326	1, 332	1, 220	1, 356	1, 399	1, 413	1, 274	1, 325	1, 391
Pectoral length	505	522	525	542	574	544	536	526	551

See footnote at end of table.

APPENDIX TABLE 2–D.—*Original data and morphometric measurements of 27 specimens of* Makaira ampla *taken in Hawaiian waters*—Continued

[Measurements by the Hawaiian Division of Fish and Game; in millimeters]

Item	No. 19	No. 20	No. 21	No. 22	No. 23	No. 24	No. 25	No. 26	No. 27
Date taken	5–4–50	8–1–50	5–8–50	4–11–50	4–5–50	4–14–50	5–12–50	4–10–50	5–8–50
Sex	?	Female	Female	Female	Female	Female	Female	Female	Female
Weight	458	572	408	564	508	570	553	791	701
Tip snout to fork tail [1]	(3, 127)	(3, 220)	(3, 244)	(3, 245)	(3, 250)	(3, 320)	(3, 363)	(3, 629)	(3, 681)
Orbit diameter	50	51	48	50	50	50	47	52	49
Naris to fork of tail	2, 447	2, 518	2, 536	2, 537	2, 541	2, 594	2, 627	2, 829	2, 869
Greatest body depth	559	627	533	610	570	579	592	685	609
1st dorsal height longest anterior ray	412	364	361	383	425	443	410	494	480
1st dorsal height 20th ray	54	60	52	43	33	54	54	58	47
1st dorsal length base	1, 362	1, 472	1, 451	1, 475	----------	1, 531	1, 495	1, 735	1, 683
Pectoral length	565	617	495	560	552	591	617	671	621

[1] Measurements in parentheses estimated from regression data of table 3–E.

APPENDIX TABLE 3–A.—*Reduced regression statistics for various morphometric relationships, by species*

[Symbols follow Snedecor (1946); X=log total length in cm.; Y=log weight in pounds]

Location	Source of data	N	SX	SY	SX^2	SY^2	SXY	Sx^2	Sy^2
I. marlina:									
New Zealand–Australia	Gregory and Conrad (1939)[1 2]	12	5. 271	5. 708	2. 380077	3. 691712	2. 756802	0. 064790	0. 976607
Central Pacific	POFI [3]	6	14. 686	14. 810	35. 963524	36. 757096	36. 307817	. 017091	. 201079
Hawaii	Hawaiian Division Fish and and Game.[1 2]	5	2. 341	2. 831	1. 102288	1. 661375	1. 342524	. 006231	. 058463
M. audax:									
New Zealand–Australia	Gregory and Conrad (1939)[1 2]	27	12. 338	10. 504	5. 647082	4. 255982	4. 832820	. 009073	. 169537
New Zealand	Morrow (1952a)[1]	48	21. 460	112. 531	9. 627610	264. 261669	50. 410703	. 033202	. 444462
Central Pacific	POFI [3]	13	30. 672	26. 773	72. 459840	56. 429689	63. 510290	. 902795	1. 291725
Hawaii	Hawaiian Division Fish and Game.[1]	30	10. 294	58. 886	3. 594782	116. 392004	20. 421341	. 062567	. 806637
M. ampla:									
Bimini	Conrad and LaMonte (1937)[4]	23	79. 075	55. 947	271. 926081	136. 977437	192. 575952	. 062793	. 887576
Central Pacific	POFI [3]	56	133. 495	127. 410	318. 581533	293. 195804	304. 770010	. 350909	3. 315303
Hawaii	Hawaiian Division Fish and Game.[1]	27	12. 434	68. 580	5. 841042	175. 673566	31. 984950	. 114955	1. 480366

Location	Source of data	Sxy	$\bar{x}$	$\bar{y}$	b	a	s	$\hat{Y}_{250\ x}$	$\hat{Y}_{500\ x}$
I. marlina:									
New Zealand–Australia	Gregory and Conrad (1939)[1 2]	0. 249563	2. 439	2. 476	3. 85188	−6. 919	0. 0391	208. 0	418. 8
Central Pacific	POFI [3]	. 057874	3. 448	2. 468	3. 38622	−9. 208	. 0357	199. 1	369. 0
Hawaii	Hawaiian Division Fish and Game.[1 2]	. 017050	2. 468	2. 566	2. 73631	−4. 187	. 0627	----------	390. 0
M. audax:									
New Zealand–Australia	Gregory and Conrad (1939)[1 2]	. 032881	2. 457	2. 389	3. 62405	−6. 515	. 0449	149. 7	289. 8
New Zealand	Morrow (1952a) [1]	. 099968	2. 447	2. 344	3. 01090	−5. 024	. 0558	----------	271. 7
Central Pacific	POFI [3]	. 342486	2. 359	2. 059	3. 69078	−6. 648	. 0502	159. 2	311. 9
Hawaii	Hawaiian Division Fish and Game.[1]	. 215592	2. 343	1. 963	3. 44578	−6. 110	. 0477	142. 3	266. 1
M. ampla:									
Bimini	Conrad and LaMonte (1937)[4]	. 227734	2. 438	2. 432	3. 62674	−6. 410	. 0542	193. 7	374. 2
Central Pacific	POFI [3]	1. 045047	2. 384	2. 275	2. 97811	−4. 825	. 0613	207. 5	356. 5
Hawaii	Hawaiian Division Fish and Game.[1]	. 402590	2. 461	2. 540	3. 50215	−6. 079	. 0531	208. 9	394. 5

[1] Sums of X, X^2, and XY computed in log of meters.
[2] Sums of Y, Y^2, and XY computed in log of weight in hundreds of pounds.
[3] Sums of X, X^2, and XY computed in log of centimeters.
[4] Sums of X, X^2, and XY computed in log of millimeters.

APPENDIX TABLE 3–B.—*Reduced regression statistics for various morphometric relationships, by species*

[Symbols follow Snedecor (1946); X=fork length in cm.; Y=head length in cm.]

Location	Source of data	N	SX	SY	SX^2	SY^2	SXY	Sx^2	Sy^2
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	12	3347. 5	1149. 5	960824. 67	112924. 59	329095. 76	27011. 6492	2812. 0692
Central Pacific	POFI	9	2571. 9	917. 8	744995. 49	94846. 98	265754. 50	10032. 2000	1251. 7756
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	8463. 0	3037. 5	2400373. 04	309132. 89	861104. 33	12960. 7400	1586. 0150
Central Pacific	POFI	20	5069. 1	1843. 0	1318922. 51	173745. 38	478411. 45	34133. 7695	3912. 9300
M. ampla:									
Bimini	Conrad and LaMonte (1937)	23	6353. 3	2161. 3	1779512. 43	205521. 07	604409. 36	24537. 6087	2424. 6487
Central Pacific	POFI	58	15165. 9	5126. 3	4123041. 91	474395. 33	1397338. 84	157446. 6891	21309. 9561

Location	Source of data	Sxy	$\bar{x}$	$\bar{y}$	b	a	s	$\hat{Y}_{250\,x}$	$\hat{Y}_{300\,x}$
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	8433. 1559	278. 958	95. 792	0. 25582	−17. 438	2. 928	86. 75	102. 36
Central Pacific	POFI	3477. 8534	285. 766	101. 978	. 34667	2. 912	2. 566	89. 58	106. 91
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	4225. 5800	282. 100	101. 250	. 32603	9. 277	2. 728	90. 79	107. 09
Central Pacific	POFI	11293. 8850	253. 455	92. 150	. 33087	8. 289	3. 128	91. 01	107. 55
M. ampla:									
Bimini	Conrad and LaMonte (1937)	7392. 5214	276. 230	93. 970	. 30127	10. 750	3. 067	86. 07	101. 13
Central Pacific	POFI	56908. 6129	261. 481	88. 384	. 36145	−6. 128	3. 636	84. 24	102. 31

APPENDIX TABLE 3–C.—*Reduced regression statistics for various morphometric relationships, by species*

[Symbols follow Snedecor (1946); X=snout to orbit in cm.; Y=length of mandible in cm.]

Location	Source of data	N	SX	SY	SX^2	SY^2	SXY	Sx^2	Sy^2
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	12	744. 1	382. 3	47201. 65	12664. 85	24337. 68	1061. 2492	485. 4092
Central Pacific	POFI	7	468. 1	290. 2	31758. 01	12210. 94	19676. 41	455. 4943	180. 0771
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	29	1960. 5	1056. 8	133262. 19	38963. 40	71877. 41	725. 6297	452. 1504
Central Pacific	POFI	9	556. 2	374. 8	35217. 54	16132. 20	23808. 67	844. 3800	523. 8622
M. ampla:									
Bimini	Conrad and LaMonte (1937)	21	1314. 5	599. 9	83237. 27	17326. 69	37917. 87	955. 8296	189. 5467
Central Pacific	POFI	25	1531. 8	865. 7	100666. 60	31273. 67	55941. 10	6810. 1504	1296. 2104

Location	Source of data	Sxy	$\bar{x}$	$\bar{y}$	b	a	s	$\hat{Y}_{55\,x}$	$\hat{Y}_{70\,x}$
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	631. 8942	62. 008	31. 858	0. 59543	−5. 063	3. 304	27. 69	36. 62
Central Pacific	POFI	270. 3214	66. 871	41. 457	. 59347	1. 771	1. 982	34. 41	43. 31
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	434. 0859	67. 603	36. 441	. 59822	−4. 000	2. 670	28. 90	37. 88
Central Pacific	POFI	646. 0300	61. 800	41. 644	. 76509	−5. 639	2. 056	36. 44	47. 92
M. ampla:									
Bimini	Conrad and LaMonte (1937)	366. 9867	62. 595	28. 567	. 38395	4. 534	1. 600	25. 65	31. 41
Central Pacific	POFI	2897. 9296	61. 272	34. 628	. 42553	8. 555	1. 656	31. 959	38. 342

APPENDIX TABLE 3–D.—*Reduced regression statistics for various morphometric relationships, by species*

[Symbols follow Snedecor (1946); X=fork length in cm.; Y=greatest body depth in cm.]

Location	Source of data	N	SX	SY	SX^2	SY^2	SXY	Sx^2	Sy^2
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	12	3347. 5	647. 1	960824. 67	36748. 28	187423. 86	27011. 6492	1853. 4125
Central Pacific	POFI	7	2030. 1	379. 9	594384. 21	20874. 09	111351. 36	5626. 2086	256. 3743
Hawaii	Hawaiian Division Fish and Game.	5	1473. 7	287. 7	437125. 11	16669. 59	85231. 60	2766. 7720	115. 3320
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	8463. 0	1342. 2	2400373. 04	60649. 36	381105. 30	12960. 7400	599. 3320
New Zealand	Morrow (1952a)	46	12866. 1	2014. 3	3612137. 27	88823. 75	565496. 86	13517. 0698	619. 3046
Central Pacific	POFI	21	5200. 1	791. 9	1314184. 11	31007. 63	201192. 09	26515. 5381	1145. 4581
Hawaii	Hawaiian Division Fish and Game.	28	6233. 6	891. 1	1401800. 78	28865. 65	200862. 70	14023. 3172	506. 3925
M. ampla:									
Bimini	Conrad and LaMonte (1937)	23	6353. 3	1112. 5	1779512. 43	55274. 25	312813. 85	24537. 6087	1463. 1087
Central Pacific	POFI	61	16047. 7	2709. 1	4389237. 69	128055. 79	747114. 53	167456. 1379	7740. 6620
Hawaii	Hawaiian Division Fish and Game.	27	7879. 3	1384. 1	2343583. 77	72774. 59	412177. 08	44199. 7519	1821. 5230

APPENDIX TABLE 3–D.—*Reduced regression statistics for various morphometric relationships, by species*—Continued

[Symbols follow Snedecor (1946); X=fork length in cm.; Y=greatest body depth in cm.]

Location	Source of data	Sxy	$\bar{x}$	$\bar{y}$	b	a	s	$\hat{Y}_{250\ x}$	$\hat{Y}_{300\ x}$
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	6909.9225	278.958	53.925	0.25582	−17.438	2.928	46.52	59.31
Central Pacific	POFI	1174.9329	290.014	54.271	.20883	−6.293	1.484	45.92	56.36
Hawaii	Hawaiian Division Fish and Game.	434.9020	294.740	57.540	.15719	11.210	3.957	50.51	58.37
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	2470.6800	282.100	44.740	.19063	−9.037	2.141	38.62	48.15
New Zealand	Morrow (1952a)	2101.5289	279.698	43.789	.15547	.304	2.579	39.17	46.95
Central Pacific	POFI	5098.7952	247.624	37.710	.19229	−9.906	2.947	38.67	47.78
Hawaii	Hawaiian Division Fish and Game.	2478.3800	222.629	31.825	.17673	−7.520	1.622	36.66	45.50
M. ampla:									
Bimini	Conrad and LaMonte (1937)	5507.4915	276.230	48.370	.22445	−13.630	3.287	42.48	53.71
Central Pacific	POFI	34412.4961	263.077	44.411	.20550	−9.651	3.367	41.72	52.00
Hawaii	Hawaiian Division Fish and Game.	8260.8160	291.826	51.263	.18690	−3.279	3.332	43.45	52.79

APPENDIX TABLE 3–E.—*Reduced regression statistics for various morphometric relationships, by species*

[Symbols follow Snedecor (1946); measurements in cm.; specimens from POFI collection in Central Pacific]

Relationship and species	N	SX	SY	SX^2	SY^2	SXY	Sx^2	Sy^2
X=greatest body depth Y=height 1st dorsal								
I. marlina	6	329.4	202.2	18323.84	6935.74	11265.11	239.7800	121.6000
M. audax	21	791.9	898.5	31007.63	39045.69	34640.32	1145.4581	602.7257
M. ampla	58	2623.1	2010.2	126395.29	72748.00	95315.50	7763.3313	3077.2407
X=tip of snout to upper tail notch Y=fork length								
I. marlina	7	1834.5	1983.5	486997.19	569335.99	526554.53	6227.1543	7297.0972
M. audax	9	2168.3	2349.9	538835.07	632949.73	583992.11	16443.4156	19390.8400
M. ampla	25	6095.8	6594.8	1556682.98	1820646.10	1683480.40	70331.8744	80990.6184
X=naris to fork of tail Y=fork length								
I. marlina	10	2211.7	2855.5	495707.37	825424.45	639618.84	6545.6810	10036.4250
M. audax	21	3971.4	5184.8	773558.78	1314676.26	1008316.15	22510.3058	34573.8296
M. ampla	61	12430.7	15793.2	2616040.45	4233130.96	3327257.42	82887.9502	144193.8086
X=posterior edge orbit to fork of tail Y=fork length								
I. marlina	8	1716.8	230.49	373314.74	672633.95	501082.16	4889.4600	8563.4487
M. audax	9	1741.5	2349.9	348776.21	632949.73	469790.74	11795.9600	19390.8400
M. ampla	26	5100.8	6794.7	1045728.88	1860606.11	1394685.89	45030.3939	84915.7989

Relationship and species	Sxy	$\bar{x}$	$\bar{y}$	b	a	s	$\hat{Y}_{40}$= depth	$\hat{Y}_{55}$= depth
X=greatest body depth Y=height 1st dorsal								
I. marlina	164.3300	54.900	33.700	0.68534	−3.925	1.498	23.49	40.62
M. audax	758.3129	37.710	42.786	.66202	17.821	2.302	44.30	54.23
M. ampla	4402.4721	45.226	34.650	.56709	9.012	3.220	31.70	40.20
X=tip of snout to upper tail notch Y=fork length								
I. marlina	6735.8514	262.071	283.357	1.08169	−.123	1.483		
M. audax	17848.9800	240.922	261.100	1.08548	−.416	1.518		
M. ampla	75457.1264	243.832	263.792	1.07287	2.192	1.232		
X=naris to fork of tail Y=fork length								
I. marlina	8067.9050	221.170	285.550	1.23255	12.947	3.397		
M. audax	27796.4015	189.114	246.895	1.23483	13.371	3.627		
M. ampla	108888.0554	203.782	258.905	1.31368	−8.799	4.414		
X=posterior edge orbit to fork of tail Y=fork length								
I. marlina	6450.6200	214.600	288.113	1.31929	4.993	2.978		
M. audax	15085.0900	193.500	261.100	1.27884	13.644	3.709		
M. ampla	61670.2839	196.185	261.335	1.36953	−7.346	4.361		

APPENDIX TABLE 4.—*Reduced statistics for ratios and mean lengths of various parts, by species*

[Symbols used follow Snedecor (1946)]

Species and location	Source of data	N	Minimum	Maximum	SX	SX^2	Sx^2	$\bar{x}$	s
$X=\frac{\text{snout to orbit}}{\text{head length}}$									
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	12	0.598	0.683	7.783	5.054525	0.006601	0.6486	0.02450
Central Pacific	POFI	7	.642	.688	4.610	3.037550	.001536	.6586	.01600
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	.626	.701	20.057	13.416037	.006595	.6686	.01508
Central Pacific	POFI	9	.638	.699	5.971	3.964641	.003214	.6634	.02143
M. ampla:									
Bimini	Conrad and LaMonte (1937)	23	.637	.694	15.230	10.089880	.004971	.6622	.01503
Central Pacific	POFI	26	.575	.694	17.193	11.382779	.013577	.6613	.02378
$X=\frac{\text{height 1st dorsal}}{\text{fork length}}$									
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	11	.121	.134	1.397	.177657	.000238	.1270	.00488
Central Pacific	POFI	10	.103	.128	1.158	.134552	.000456	.1158	.00755
Hawaii	Hawaiian Division Fish and Game.	5	.102	.119	.547	.060039	.000197	.1094	.00810
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	.147	.185	5.048	.853002	.003592	.1683	.01113
Central Pacific	POFI	25	.151	.198	4.308	.746056	.003701	.1723	.01269
Hawaii	Hawaiian Division Fish and Game.	28	.116	.184	4.551	.744995	.005295	.1625	.01400
M. ampla:									
Bimini	Conrad and LaMonte (1937)	23	.118	.161	3.246	.460900	.002791	.1411	.01126
Central Pacific	POFI	63	.111	.148	8.116	1.050914	.005367	.1288	.00930
Hawaii	Hawaiian Division Fish and Game.	27	.111	.150	3.560	.472408	.003015	.1319	.01098
$X=\frac{\text{pectoral length}}{\text{fork length}}$									
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	12	.176	.204	2.235	.416825	.000556	.1863	.00711
Central Pacific	POFI	11	.173	.209	2.031	.375995	.000999	.1846	.01054
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	.166	.216	5.832	1.137588	.003847	.1944	.01152
New Zealand	Morrow (1952a)	47	.175	.220	9.113	1.772563	.005610	.1939	.01104
Central Pacific	POFI	19	.178	.212	3.655	.704853	.001746	.1924	.00985
Hawaii	Hawaiian Division Fish and Game.	25	.148	.212	4.627	.861259	.004894	.1851	.01428
M. ampla:									
Bimini	Conrad and LaMonte (1937)	23	.168	.198	4.209	.771899	.001652	.1830	.00867
Central Pacific	POFI	57	.166	.207	10.458	1.924614	.005846	.1835	.01022
Hawaii	Hawaiian Division Fish and Game.	26	.153	.196	4.728	.862254	.002485	.1818	.00997
$X=\frac{\text{caudal spread}}{\text{fork length}}$									
M. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	12	.331	.373	4.183	1.459817	.001693	.3486	.01241
Central Pacific	POFI	8	.336	.371	2.861	1.024495	.001330	.3576	.01489
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	.284	.379	10.018	3.360392	.015048	.3339	.02278
Central Pacific	POFI	9	.320	.382	3.179	1.127497	.004604	.3532	.02565
M. ampla:									
Bimini	Conrad and LaMonte (1937)	23	.327	.395	8.211	2.936609	.005282	.3570	.01549
Central Pacific	POFI	39	.325	.386	14.213	5.188813	.009083	.3644	.01567
$X=\frac{\text{height 1st anal}}{\text{height 1st dorsal}}$									
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	11	.681	.756	8.558	6.674676	.016552	.7780	.04068
Central Pacific	POFI	8	.751	1.004	6.712	5.678072	.046704	.8390	.08168
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	.502	.811	20.328	13.878122	.103869	.6776	.05985
Central Pacific	POFI	22	.591	.686	14.211	9.195089	.015429	.6460	.02778
M. ampla:									
Bimini	Conrad and LaMonte (1937)	23	.775	.963	19.621	16.789827	.051408	.8531	.04834
Central Pacific	POFI	58	.764	1.002	50.233	43.659623	.153515	.8661	.05236
X=pelvic length (cm.)									
I. marlina:									
New Zealand-Australia	Gregory and Conrad (1939)	11	212	283	277.1	7,036.01	55.6091	25.191	2.358
Central Pacific	POFI	9	186	304	233.2	6,141.88	99.4089	25.911	3.525
M. audax:									
New Zealand-Australia	Gregory and Conrad (1939)	30	230	373	958.8	30,933.88	290.6320	31.960	3.166
Central Pacific	POFI	12	220	387	395.9	13,433.21	371.8092	32.992	6.098
M. ampla:									
Bimini	Conrad and LaMonte (1937)	22	242	427	765.7	27,023.19	373.3495	34.805	4.216
Central Pacific	POFI	33	257	418	1,111.6	38,052.96	608.8825	33.685	4.432
X=length 20th ray of 1st dorsal (cm.)									
I. marlina:									
Central Pacific	POFI	9	45	78	60.8	418.44	7.7022	6.756	.9812
Hawaii	Hawaiian Division Fish and Game.	5	56	68	30.9	191.85	.8880	6.180	.544
M. audax:									
Central Pacific	POFI	11	77	127	110.4	1,131.88	23.8655	100.36	1.628
Hawaii	Hawaiian Division Fish and Game.	24	82	138	255.6	2,762.72	40.5800	106.50	1.328
M. ampla:									
Central Pacific	POFI	35	35	85	217.7	1,401.39	47.2960	6.220	1.197
Hawaii	Hawaiian Division Fish and Game.	27	33	77	148.5	840.31	23.5600	5.500	.971

APPENDIX TABLE 5.—*Summary of stomach contents and sexual condition of the POFI specimens*

Specimen	Stomach contents	Sex	Sexual condition
Istiompax marlina:			
No. 1	Empty	?	No data.
No. 2	1 aku (30 cm.)	Male	Maturing.
No. 3	Empty	?	Immature.
No. 4	1 *Mola* (18")	Male	Not active.
No. 5	No data	Female	No data.
No. 6	2 *Mola*; 1 squid (8 cm.)	?	Gonads very thin.
No. 7	1 *Mola* (5 lb.)	?	Immature.
No. 8	Albacore (94 cm.)	Female	No data.
No. 9	Fish remains	do	Not active.
No. 10	Empty	?	Immature.
No. 11	Large fish skeleton; 6 vertebrae (5 cm.); fin rays (8").	Female	Not active.
Makaira audax:			
No. 1	1 squid; 2 tunas (juvenile).	?	Immature.
No. 2	50% fish; 50% squid	?	No data.
No. 3	*Auxis* and bramid	?	Very immature.
No. 4	1 fish (100 lb.)	?	Immature.
No. 5	Empty	?	No data.
No. 6	2 fish remains; 1 tunalike fish.	?	Do.
No. 10	2 tunalike fish (35 and 32 cm.)	Male	Testes (8 mm. diameter) with milt.
No. 11	1 *Auxis* (33 cm.); 1 squid with 8 cm. mantle; fish bones.	Female	Not active (ovary 1 x 4 x 25 cm.).
No. 12	Fish remains	Male	Small testes (1 cm. diameter) with milt and fatty appearance.
No. 13	No data	Female	Ovaries enlarged, but not near spawning (6 x 3 cm. diameter).
No. 14	Squid and scombrid fish	do	Immature.
No. 15	Empty	?	No data.
No. 16	do	?	Immature.
No. 17	Flying fish remains; carapace of large shrimp.	?	Do.
No. 18	Empty	Female	Not quite mature.
No. 19	No data	do	Immature.
No. 20	*Mola* (45 cm.); fish remains.	do	Ova not visible to naked eye.
No. 21	1 small scombrid	?	Immature.
No. 22	No data	Female	No data.
No. 23	40% fish; 60% squid	?	Mature.
No. 24	Empty	?	No data.
No. 25	do	?	Do.
Makaira ampla:			
No. 2	2 squid (5 cm.); remains 1 small *Mola*.	?	Immature.
No. 3	20% squid; 80% fish; remains 1 surgeonfish (5 cm.).	Male	Milt in center gonad.
No. 4	45% fish; 55% squid	do	Young.
No. 5	100% fish	do	Little milt.
No. 6	Empty	?	No data.
No. 7	Bait; squid; 2 scombrids (6").	Female	Immature.
No. 8	Tunicates	Male	Maturing.
No. 9	3 squid (6 cm. each); 3 fish (10-15 cm. each) well digested.	do	Milt spurts from duct.
No. 10	1 tunalike fish (20 cm.)	?	No data.
No. 11	1 gempylid (30 cm.); 2 fish (4 cm. each).	do	Milt in lumen of testes.
No. 12	No data	do	Maturing.
No. 13	Fish vertebrae; squid; 2 (4") fish.	Female	No data.
No. 14	Bait	Male	Do.
No. 15	Fish remains, including 2 *Mola* (1 about 30 cm.).	do	Testes pink with fatty appearance, milt in central duct.
Makaira ampla—Continued			
No. 16	Fish remains, including 1 *Coryphaena* (about 30 cm.).	Male	Milt running from cut testes.
No. 17	4 small squid (6 cm.); remains of 1 fish (3 cm.).	do	Milt in testes.
No. 18	Empty	do	No data.
No. 19	1 small unidentified fish	do	Do.
No. 20	1 unidentified fish (10 cm.).	do	Milt in testes.
No. 21	Almost empty; fragments of fish; squid remains.	do	Do.
No. 22	No data	do	Do.
No. 23	3 unidentified fish (about 15 cm. each).	do	Mature.
No. 24	80% fish; 20% squid	do	No data.
No. 25	No data	?	Do.
No. 26	1 fish (15 cm.)	?	Very immature.
No. 27	Empty	?	No data.
No. 28	do	?	Immature.
No. 29	1 *Katsuwonus* (?) (2 lb.)	?	No data.
No. 30	Empty	Male	Milt in testes.
No. 31	Fish vertebrae	do	No data.
No. 32	90% fish; 5% squid; 5% crustaceans.	do	Slightly running milt.
No. 33	Empty	?	Immature.
No. 34	1 small *Coryphaena*	?	Very immature.
No. 36	50% cephalopods; 50% fish, including 1 *Coryphaena* (15 cm.).	Male	Milt flows freely when cut; testes enlarged (6 cm. diameter).
No. 37	Empty	Female	Immature.
No. 38	Octopus (¼ lb.)	Male	Milt in testes.
No. 39	90% fish; 10% cephalopods.	do	Testes with running milt when cut (about 4 cm. diameter).
No. 40	Empty	do	No milt visible.
No. 41	2 baits	do	Milt in testes.
No. 42	5 *Auxis* (33 cm., avg.)	Female	Not active (ovary 3 cm. diameter).
No. 44	2 pieces bait; 1 small unidentified fish.	?	No data.
No. 45	Empty	?	Do.
No. 46	2 *Katsuwonus* (1 about 65 cm., other digested).	Female	Gonad with thick wall; inside like nonspawning tuna ovary.
No. 47	Empty	do	No data.
No. 48	do	?	Do.
No. 49	do	Female	Do.
No. 50	No data	do	Mature.
No. 51	do	do	Not ripe.
No. 52	Empty	do	No data.
No. 53	do	do	Gonad enclosed in heavy connective tissues; semicylindrical; does not appear fatty as males.
No. 54	1 tuna (42 cm.)	do	Not active (ovary about 2½ cm. diameter).
No. 55	No data	do	Eggs visible to naked eye.
No. 56	do	do	No data.
No. 58	1 bait	do	Do.
No. 60	No data	do	Do.
No. 61	Empty	do	Do.
No. 62	do	?	Do.
No. 63	Fish bones and squid	?	Immature.
No. 64	1 *Katsuwonus* (66 cm.)	Female	Not active (ovary 2 x 4 cm. diameter).
No. 66	1 *Katsuwonus* (28 cm.)	do	No data.
No. 67	1 *Katsuwonus* (8 lb.)	?	Spent.
No. 68	No data	Female	Not active.

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