Body-Forms of the Black Marlin (Makaira nigricans marlina) and Striped Marlin (Makaira mitsukurii) of New Zealand and Australia

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Article VIII.—BODY-FORMS OF THE BLACK MARLIN (*MAKAIRA NIGRICANS MARLINA*) AND STRIPED MARLIN (*MAKAIRA MITSUKURII*) OF NEW ZEALAND AND AUSTRALIA[1]

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Plates III to VI; Text Figures 1 to 2

INTRODUCTION

During the course of the Michael Lerner-American Museum Australia-New Zealand Expedition of 1939 measurements and other data of forty-two marlins were obtained. Of these, thirty were striped marlin and twelve were Pacific black marlin. These marlins were caught at the following localities:

Mayor Island (Bay of Plenty), New Zealand..... 9 striped marlin
Cape Brett (Bay of Islands), New Zealand.....17 striped marlin
Cape Brett (Bay of Islands), New Zealand..... 7 black marlin
Bermagui, N. S. W., Australia. 4 striped marlin
Bermagui, N. S. W., Australia. 5 black marlin

Of the New Zealand marlins measured, four striped and two black were caught by Michael Lerner and two striped and one black by Mrs. Lerner. Of the Australian marlins one striped and four black were caught by Mr. Lerner and two striped by Mrs. Lerner. For the privilege of measuring the others we have to thank the many members and guests of the Tauranga Big Game Fishing Club at Mayor Island, New Zealand, the Bay of Islands Swordfish and Mako Shark Club at Russell, New Zealand, and the Bermagui Big Game Angler's Club at Bermagui, N. S. W., Australia.

For various courtesies and much assistance in the work summarized in the present paper the expedition is under lasting obligation to Mr. W. H. Tisdall and Dr. Harold Pettit, both of Auckland, New Zealand; to Mr. J. Mowlem and Mr. B. Keith Gifford, both of Tauranga, New Zealand; to Mr. H. Neville Ross of Russell, New Zealand; and to Mr. Clive Firth and Mr. G. F. Sissons of the Bermagui Club.

In view of the chaotic state of the taxonomy of the marlins, the simplified classification suggested by Nichols and LaMonte (1935) will serve here as a basis of comparison. Nichols and LaMonte consider only three of the many described species as valid, viz., the white marlin (*Makaira albida*), the black marlin (*Makaira nigricans*) and the striped marlin (*Makaira mitsukurii*). These species may, in turn, be divided into subspecies or geographical varieties. Such a synthesis may be too extreme, but discussion of possible modifications will be reserved for a later paper. For present purposes the striped marlin is identified as *Makaira mitsukurii*, the black as *Makaira nigricans marlina* and the Atlantic blue marlin as *Makaira nigricans ampla*.

As little was known concerning the sexual differences among the various species of marlins we secured thin slices

[1] Results of the Michael Lerner Ichthyological Expeditions, No. 18.

of gonads from a series of freshly killed specimens and fixed them in Bouin's solution. After our return to New York these sections were examined microscopically and recognizable ova and sperm were found in the different individuals. The fact that both male and female black marlins have been recorded by us tends to do away with the possibility that these varieties and subspecies are merely unrecognized sexual dimorphisms. As a matter of fact little or no difference in external body-form between the sexes is recognizable in the black marlin

The discussion below is based on measurements, taken with the assistance of Mr. Ludovico Ferraglio, which cover almost all of the elements of external body-form. Thirty-nine different dimensions were recorded on each individual. These measurements, with several additions, are those used by Conrad and LaMonte (1937) in an analysis of blue marlin body-form. Each individual measurement was multiplied by one hundred and divided by the standard length, i.e., the distance from the tip of the snout to the midpoint of the shallowest vertical diameter of the caudal peduncle. The percentage indices thus derived were plotted in the form of frequency polygons. In this graphic form the bodily proportions were studied. No attempt has been made in this preliminary study to apply any of the statistical measures of dispersion, variability or central tendency. Nor has extensive use been made of Gregory's (1928) body-form terminology, for experience has shown that intra-generic distinctions in the Istiophoridae are too slight to be reflected by his scheme which finds its greatest usefulness in the comparison of super-generic groups.

Figure 1, which illustrates the modal body proportions in *mitsukurii*, *ampla* and *marlina*, is constructed on the same plan as that published by Conrad and LaMonte (*op. cit.*). The standard length is arbitrarily assigned one hundred units and, as all other body-elements have been proportioned to this standard length, they have been plotted accordingly. Thus by counting the number of units of any part covered by the measurements one may derive its proportion of the standard length. The mode of each proportion has been plotted regardless of individual specimens to form these composite pictures. Needless to say, no one individual is completely like the composite, although many approach it.

Table I lists the measurements, in millimeters, of the striped marlin (*Makaira mitsukurii*), while Table II lists the dimensions of *Makaira nigricans marlina*, the Pacific black marlin. Table III lists the high, low and modal percentage indices regardless of individuals, as well as the indices of the largest and smallest specimens of the striped marlin. Table IV does the same for the black marlin.

BODY-FORM AS A WHOLE

In total bulk the black marlin (*M. n. marlina*) averaged 435 pounds in the 13 individuals studied, with a range from 105 to 1226 pounds. The latter weight was that of "Boydtown Ben," a huge fish which became stranded near Eden, N. S. W., Australia, in April, 1938. The preserved fish was examined by our party at Kiama, N. S. W., in March of the following year. Its measurements and weight, said to be a world's record, are thoroughly documented and, as far as they go, quite accurate.[1] The blue marlin (*M. n. ampla*) averages 297 pounds, with a range from 91 to 537 pounds in 23 specimens. Smallest of the three types is the striped marlin (*M. mitsukurii*) with a range from 173 to 336 pounds in 30 specimens to make an average of 249 pounds. While there is no pretension that these average weights are truly so, they give an indication of the widespread observations of anglers which suggest that the Pacific black marlin is the largest and the striped the smallest of the three studied. The white marlin (*Makaira albida*) of the Atlantic is apparently the smallest member of the genus.

[1] Published in "The Referee" of Sydney, N. S. W., Thursday, April 21, 1938.

TABLE I.—Absolute Measurements in Millimeters of *Makaira mitsukurii*, the Striped Marlin

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Total body weight in pounds			186	206	194	219	191	240	173	205	213	222	208	253	260		220	259	280	280	246	327	284	268	308	316	241	336	287	302
Body length, snout to tail base	2030	2060	2460	2475	2490	2508	2510	2515	2535	2550	2600	2600	2610	2620	2630	2645	2650	2652	2680	2690	2710	2715	2724	2730	2750	2756	2770	2790	2840	2860
Body depth (max.)	330	340	415	420	410	417	437	448	385	406	428	451	441	462	460	420	455	477	470	475	445	520	497	475	480	507	470	515	471	495
Greatest width of body	175	165	190	225	240	255	255	260	239	251	251	261	263	262	250	250	255	290	302	310	260	310	272	285	250	310	251	282	280	248
Min. depth of pedicle	75	75	88	90	93	88	96	88	80	85	94	90	91	90	92	92	100	97	102	95	100	104	96	91	96	101	94	105	107	103
Width across caudal pedicle	62	65	83	80	76	84	85	77	76	60	76	80	80	90	73	80	80	89	96	85	72	95	95	85	85	90	79	82	96	80
Snout tip to transv. plane max. body area	810	870	1035	1150	1060	1022	1115	985	1034	1072	1081	1050	1064	1065	1100	1010	1077	1054	1135	1055	1061	1110	1121	1105	1100	1090	1095	1080	1155	1230
Transv. plane max. body area to tail base	1215	1190	1425	1325	1445	1486	1395	1530	1501	1478	1519	1550	1562	1555	1530	1635	1573	1598	1545	1635	1650	1620	1603	1635	1650	1666	1688	1710	1685	1610
Tip of snout to summit of back	840	760	975	980	1050	1015	1050	980	1068	1070	1095	1020	1107	1093	1020	975	1040	1060	1160	1010	1042	1110	1080	1120	1020	1030	1113	1080	1170	1030
Greatest width across pectoral fin bases	150	135	190	200	200	195	210	239	188	195	210	220	222	222	215	205	210	227	235	224	200	230	221	215	245	247	214	218	220	235
Maximum spread of tail	645	640	965	940	1020	1030	925	838	950	925	800	970	1000	965	902	970	900	950	960	1000	980	1070	990	935	990	1020	974	1060	1010	970
A.P. length tail, mid-line from min. width pedicle	152	150	210	200	197	210	210	200	225	180	200	212	230	222	198	182	215	220	220	215	185	210	210	212	210	220	225	218	230	210
A.P. depth of tail notch	200	175	173	260	235	250	240	230	250	265	250	235	210	220	264	260	260	215	260	235	215	232	223	210	250	310	227	217	265	280
Oblique length caudal fin, dorsal moiety	505	450	640	675	665	710	680	580	680	660	630	680	690	680	674	662	681	655	700	690	650	720	690	630	710	710	700	729	720	722
Oblique length caudal fin, ventral moiety	430	430	598	625	630	665	600	560	630	610	585	635	615	640	645	608	620	630	650	680	610	645	600	580	660	680	620	650	671	655
First dorsal fin, length of base	1010	1030	1210	1280	1200	1320	1320	1320	1260	1260	1190	1350	1352	1380	1270	1350	1156	1320	1350	1390	1320	1350	1325	1360	1430	1460	1400	1490	1470	1450
Depth of first dorsal fin, longest ray	395	360	467	445	480	490	480	500	470	510	485	502	515	485	420	480	448	510	460	455	450	490	450	485	455	515	452	520	540	510
Second dorsal fin, A.P. length	70	95	97	100	110	125	120	110	100	115	115	115	120	117	125	115	105	112	125	120	100	125	130	110	95	140	115	150	135	125
Second dorsal fin, depth longest ray	135	108	130	110	105	130	120	115	115	118	110	100	131	120	120	100	121	120	110	108	110	130	140	105	110	130	100	140	135	120
First anal fin, length at base			322	360	350	350	320	300	320	320	350	350	350	300	370	350	290	320	370	375	360	310	374	300	390	360	340	352	350	390
First anal fin, depth longest ray	240	220	310	315	300	350	355	315	335	340	310	352	360	345	320	320	225	380	310	330	300	320	365	300	345	330	310	330	381	330
Pelvic fin, A.P. length at base	10	10	14	11	10	11	11	10	13	15	10	14	12	11	11	11	11	11	11	13	10	11	11	12	6	14	13	10	15	11
Pelvic fin, depth longest ray	305	230	336	346	350	356	300	295	360	296	310	305	337	303	320	300	272	325	335	373	350	355	310	300	300	307	370	310	347	285
Pectoral fin, width of base	60	65	95	80	90	95	90	90	75	95	90	100	92	100	100	80	100	100	90	95	95	80	100	95	95	100	100	100	100	100
Pectoral fin, longest ray	405	405	560	537	570	565	508	452	550	530	520	610	588	525	530	565	526	560	559	595	550	585	605	540	575	550	609	552	644	590
Snout tip to ant. border pectoral*	770	815	990	964	1040	980	999	942	1025	1000	1025	1030	1010	1030	1072	1024	1030	1038	1045	995	1062	1080	1075	1062	1010	1030	1089	1042	1122	1075
Snout tip to ant. border pelvic fin*	800	810	1008	984	1060	1002	1045	963	1025	1026	1055	1040	1022	1060	1070	1049	1059	1054	1025	1010	1100	1080	1075	1100	1040	1045	1113	1055	1140	1095
Snout tip to ant. border first dorsal fin*	725	745	885	866	925	872	907	849	951	923	932	910	887	950	980	920	919	965	965	940	975	1010	997	970	920	964	1023	950	1118	965
Snout tip to ant. border second dorsal fin*	1810	1845	2192	2230	2250	2227	2252	2244	2245	2265	2325	2305	2310	2364	2345	2352	2378	2365	2495	2398	2442	2415	2430	2465	2460	2468	2465	2473	2520	2525
Snout tip to anterior border anal fin*	..	1480	1780	1760	1815	1735	1786	1785	1810	1802	1860	1820	1835	1870	1862	1861	1885	1890	1935	1915	1970	1920	1931	1960	1960	1970	1980	1999	2005	2025
Tip of snout to post. bord. operc.	760	804	990	962	1012	975	1000	949	1005	1001	1030	1020	1000	1030	1065	1034	1019	1054	1045	985	1060	1075	1075	1055	1010	1045	1095	1030	1120	1070
Tip snout to ant. bord. eye	510	542	675	643	693	659	670	609	705	700	695	691	673	691	700	680	682	707	700	645	705	730	714	706	680	654	733	663	750	700
Ant. bord. eye to post. bord. operc.	250	262	315	319	320	316	330	340	300	301	335	329	328	339	360	354	337	347	350	340	355	348	361	347	350	391	362	365	370	375
Head depth suproccip. to isthmus	220	165	235	260	210	240	223	220	202	220	220	240	234	250	244	215	255	260	240	235	200	259	290	250	280	253	281	255	249	291
A.P. length gill-chamber (preop. to post. bord. operc.)	120	133	155	169	155	160	167	163	160	150	160	158	150	165	185	184	168	178	172	160	170	170	182	171	170	190	180	178	190	180
Width across base of snout	70	69	82	75	61	85	93	100	75	80	78	85	75	92	67	80	90	98	75	75	69	85	78	70	73	90	81	80	95	73
Width across preoperculum	..	..	190	200	212	205	205	221	177	210	205	221	225	211	230	205	215	232	225	230	238	265	256	230	250	262	222	255	220	240
"Maxillary" length (total upper jaw)	580	610	767	737	790	748	775	715	795	798	800	795	780	795	810	780	785	811	810	750	810	840	824	811	780	776	846	780	855	835
Length of mandible to angle of jaw	260	265	340	280	360	368	365	350	355	350	350	360	390	380	380	379	371	370	360	340	370	410	415	382	375	421	412	410	400	210
A.P. length eye	52	52	60	63	60	60	66	63	60	60	64	61	64	61	60	65	61	64	66	64	61	65	69	65	69	70	66	71	70	68

* Fin projected on snout-tail line.

The striped marlins were caught at the following localities:
Mayor Island, New Zealand (January 24–February 11), Nos. 1, 2, 5, 15, 19, 21, 25, 28, 30.
Cape Brett, Bay of Islands, New Zealand (February 20–March 10), Nos. 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18, 22, 23, 24, 26, 27, 29.
Bermagui, N. S. W., Australia (March 19–March 31), Nos. 3, 4, 17, 20.
Of the fish sexed (Nos. 11, 19, 22, 24, 25) all were found to be females.

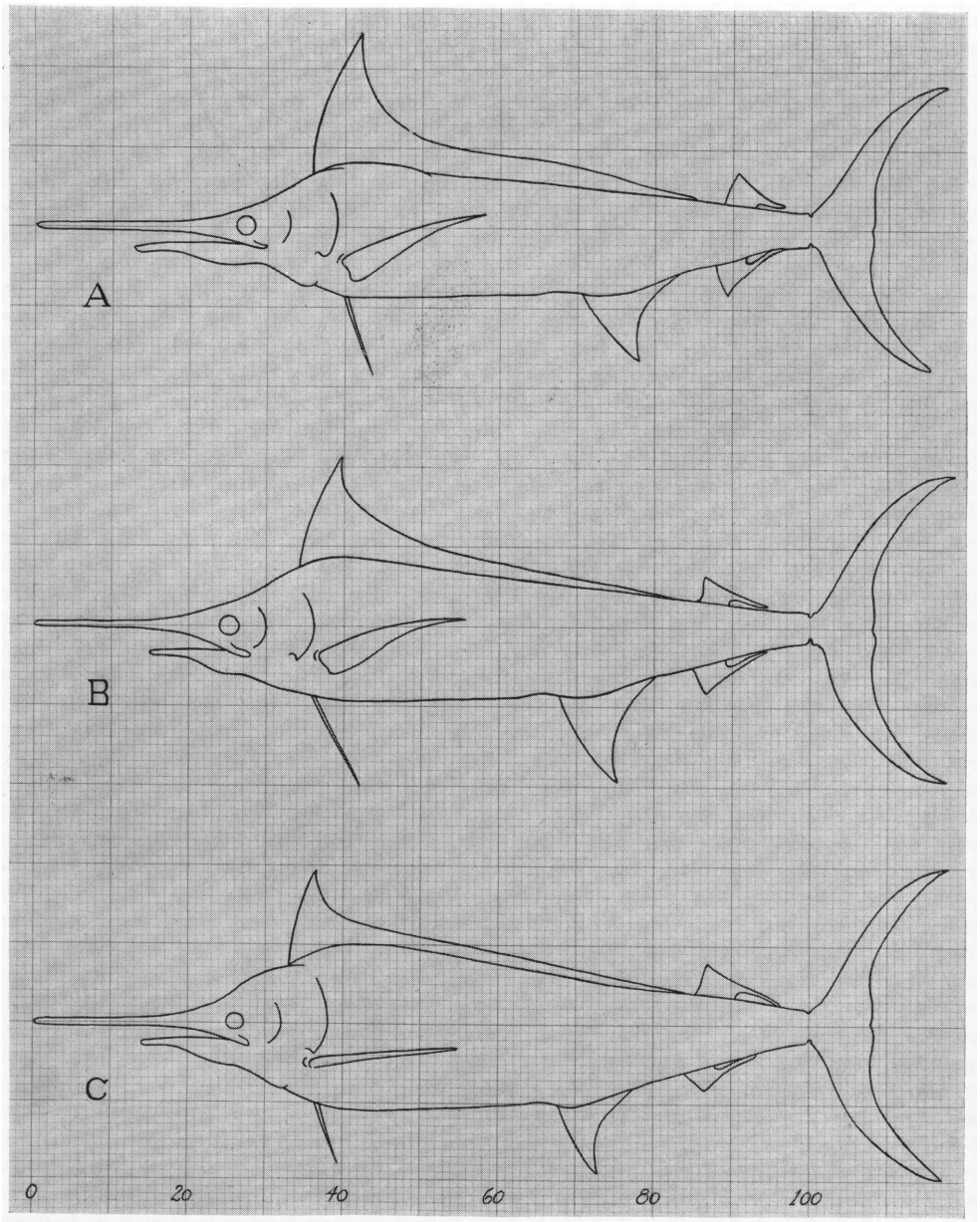

Fig. 1. The typical body-forms of (A) the striped marlin (*Makaira mitsukurii*); (B) the blue marlin (*Makaira nigricans ampla*) and (C) the Pacific black marlin (*Makaira nigricans marlina*).

TABLE II.—Absolute Measurements in Millimeters

	1	2	3	4	5	6
Total body weight in pounds	105	120	164	204	244	304
Body length, snout to tail base	1950	1985	2162	2380	2410	2480
Body depth (max.)	384	410	435	430	455	519
Greatest width of body	190	210	210	220	230	308
Min. depth of pedicle	68	70	75	78	80	83
Width across caudal pedicle	56	60	70	64	80	81
Snout tip to transv. plane max. body area	820	810	905	982	985	860
Transv. plane max. body area to tail base	1130	1175	1257	1398	1425	1630
Tip of snout to summit of back	800	820	920	1004	1005	890
Greatest width across pectoral fin bases	150	164	200	190	200	222
Maximum spread of tail	750	756	790	860	890	920
A.P. length tail, mid-line from min. width pedicle	170	161	170	175	200	210
A.P. depth of tail notch	190	196	233	190	185	230
Oblique length caudal fin, dorsal moiety	530	529	602	600	605	615
Oblique length caudal fin, ventral moiety	510	500	540	560	568	615
First dorsal fin, length of base	730	940	990	1084	1110	1350
Depth of first dorsal fin, longest ray	282	260	290	320	330	330
Second dorsal fin, A.P. length	120	112	110	115	125	135
Second dorsal fin, depth longest ray	95	80	70	90	87	95
First anal fin, length at base	240	210	240	230	230	300
First anal fin, depth longest ray	215	197	228	218	276	265
Pelvic fin, A.P. length at base	11	10	10	13	13	12
Pelvic fin, depth longest ray	212	250	217	272	283	268
Pectoral fin, width of base	70	65	85	80	91	92
Pectoral fin, longest ray	430	390	433	453	485	502
Snout tip to ant. border pectoral*	700	707	812	880	875	780
Snout tip to ant. border pelvic fin*	725	730	867	820	920	846
Snout tip to ant. border first dorsal fin*	685	657	770	802	814	704
Snout tip to ant. border second dorsal fin*	1630	1677	1855	2015	2050	2158
Snout tip to anterior border anal fin*	1340	1365	1490	1640	1677	1695
Tip of snout to post. bord. operc.	745	750	844	930	920	825
Tip snout to ant. bord. eye	498	496	561	635	612	493
Ant. bord. eye to post. bord. operc.	247	254	283	295	308	332
Head depth suproccip. to isthmus	195	180	245	250	260	265
A.P. length gill-chamber (preop. to post. bord. operc.)	135	115	135	160	154	172
Width across base of snout	62	60	80	68	74	80
Width across preoperculum	164	165	180	180	215	235
"Maxillary" length (total upper jaw)	577	569	660	725	711	600
Length of mandible to angle of jaw	235	242	270	320	310	305
A P. length eye	50	47	61	58	60	60

The black marlins were caught at the following localities
Cape Brett, Bay of Islands, New Zealand (February 21–March 10), Nos. 6, 7, 8, 9, 10, 11, 12.
Bermagui, N. S. W., Australia (March 19–March 31), Nos. 1, 2, 3, 4, 5.
Of the fish sexed, numbers 1, 10, 11 and 12 were females and numbers 6 and 7 were males.

* Fin projected on snout-tail line.

of *Makaira nigricans marlina*, the Pacific Black Marlin

7	8	9	10	11	12	
297	322	387	763	708	815	Total body weight in pounds
2590	2639	2670	3125	3280	3290	Body length, snout to tail base
538	530	573	720	717	760	Body depth (max.)
280	300	325	425	340	425	Greatest width of body
89	85	94	111	115	131	Min. depth of pedicle
89	85	84	110	100	131	Width across caudal pedicle
1065	1020	1105	1223	1201	1340	Snout tip to transv. plane max. body area
1540	1619	1565	1902	2079	1950	Transv. plane max. body area to tail base
1105	1001	1034	1126	1222	1340	Tip of snout to summit of back
220	234	223	288	260	295	Greatest width across pectoral fin bases
1045	1000	1058	1170	1175	1250	Maximum spread of tail
220	220	230	260	260	290	A.P. length tail, mid-line from min. width pedicle
265	204	222	230	..	330	A.P. depth of tail notch
700	650	704	800	805	900	Oblique length caudal fin, dorsal moiety
660	620	675	710	785	835	Oblique length caudal fin, ventral moiety
1290	1362	1365	1617	..	1630	First dorsal fin, length of base
365	380	386	415	..	440	Depth of first dorsal fin, longest ray
160	155	150	170	123	170	Second dorsal fin, A.P. length
105	115	102	130	162	135	Second dorsal fin, depth longest ray
255	352	280	330	350	345	First anal fin, length at base
290	310	292	329	320	340	First anal fin, depth longest ray
15	11	15	15	16	19	Pelvic fin, A.P. length at base
230	251	262	251	275	Very short	Pelvic fin, depth longest ray
110	110	110	132	145	150	Pectoral fin, width of base
515	509	530	640	670	680	Pectoral fin, longest ray
960	938	930	1040	..	1171	Snout tip to ant. border pectoral*
1030	980	982	1130	..	1223	Snout tip to ant. border pelvic fin*
889	819	858	970	..	1140	Snout tip to ant. border first dorsal fin*
2225	2296	2310	2710	..	2860	Snout tip to ant. border second dorsal fin*
1831	1829	1891	2160	..	2348	Snout tip to anterior border anal fin*
1005	950	985	1111	1191	1239	Tip of snout to post. bord. operc.
665	616	630	680	760	795	Tip snout to ant. bord. eye
340	334	355	431	431	444	Ant. bord. eye to post. bord. operc.
255	268	270	340	358	400	Head depth suproccip. to isthmus
185	168	175	225	228	250	A.P. length gill-chamber (preop. to post. bord. operc.)
107	80	96	110	..	120	Width across base of snout
245	230	260	335	300	355	Width across preoperculum
770	720	745	811	895	925	"Maxillary" length (total upper jaw)
310	261	330	390	395	455	Length of mandible to angle of jaw
56	60	62	65	69	70	A.P. length eye

* Fin projected on snout-tail line.

The body-length of *mitsukurii* varies from 5.2 to 6.5 times the body-depth with the largest number of individuals falling in the 5.7 and 6.0 classes. The black marlins are, for the most part, deeper and shorter bodied with a range from 4.3 to 5.5, the greatest number lying between 4.3 and 4.9 (inclusive). The blue marlins have the greatest range of all, 4.5 to 6.3, and as pointed out by Conrad and LaMonte (1937) the body may be classed as either mesosomatic or dolichosomatic. In general it may be said that THE STRIPED MARLIN IS RELATIVELY LONG AND SLIM; THE BLACK, SHORT AND STOUT; WHILE THE BLUE MAY BE FOUND IN EITHER CATEGORY.

In greatest body-width *mitsukurii* and *ampla* have identical ranges (7%–11%), whereas the range of *marlina* (9%–13%) includes three individuals which exceed the range of the others. This tendency toward greater width in the black marlin is probably correlated with its generally greater bulk. The width across the pectoral fin bases is quite alike in all three types, one specimen of *ampla* (11%), however, falls outside of the otherwise common range from 6% to 9%.

Just as body-width in *marlina* tends to be greater so does its depth. In body-depth the three types fall into three more or less well-defined groups. As noted above, *mitsukurii* is quite shallow-bodied with a mode of 17%, *ampla* is slightly deeper (18%) and *marlina* with a mode of 21% is deepest-bodied of all.

The plane of greatest depth is usually also the plane of greatest cross-sectional area, but because of daily and seasonal fluctuations in the size of the viscera, the width and the resultant area varies so greatly that this plane moves back and forth on one individual making most observations unreliable.

Often the greatest depth is the chord of a circle passing through the summit of the back with the sword tip as its center. Many times, however, the fluctuations mentioned above are reflected in the failure of these points to coincide.

THE HEAD

Head length, as measured from the tip of the sword to the posterior extremity of the operculum, shows the greater relative length of head in *mitsukurii*. On the other hand, the ranges of length in *ampla* and *marlina* are so similar as to suggest that we are indeed dealing with intraspecific populations. A distribution table will serve to clarify these observations:

Percentage Index	33	34	35	36	37	38	39	40	41
Striped (*M. n. mitsukurii*)	0	0	0	3	4	6	14	3	1
Blue (*M. n. ampla*)	1	1	2	8	7	4	0	0	0
Black (*M. n. marlina*)	1	1	1	3	2	3	2	0	0

These tendencies with regard to the length of head are, in great part, a reflection of the relative snout length, that is, the distance from the anterior border of the eye to the tip of the sword. As would be expected, the length of the sword is relatively greater in *mitsukurii* than in either of the other two.

The depth of head seems to be one of the best characters for easily distinguishing between *mitsukurii* on the one hand, and *marlina* and *ampla* on the other. As a rule, the striped marlin is more shallow-headed than the others. The modal head depth of *mitsukurii* is 8%, of *marlina*, 10% and of *ampla*, 11%.

Correlated, no doubt with the apparently identical respiratory requirements of the three types is the remarkable uniformity in gill chamber length. In all three forms, the range is 5% to 7% of the standard length with a common mode of 6%.

See the frequency distribution table below:

Percentage Index	5	6	7
Striped (*M. n. mitsukurii*)	4	25	1
Blue (*M. n. ampla*)	5	16	2
Black (*M. n. marlina*)	1	8	3

The width of the head across the preopercular, which is a major factor in determining the volume of the respiratory

chamber, is but slightly less than the width of the body at its widest part. Like gill chamber length, the uniformity of the three types is quite marked. Black and striped have a mode of 8%; blue, 7%.

The "maxil'ary" length is measured from the tip of the snout to the posterior extremity of the maxilla. Such a dimension should be expected to vary as the snout length noted above. In accordance with such an expectation it is noticed that *mitsukurii* and *ampla* are similar in extent.

In order to match the relative extension of the upper jaw, the mandibles vary in the same way.

It is interesting to note that the "heavy" appearing sword of the black marlin is relatively no wider, when referred to the standard length, than that of the more delicately built striped marlin, for both have a mode of 3%. The apparent fact that the blue marlin sword is narrower than the other two may be due to difference in place of measurement and may not be considered reliable. (Blue marlins were measured in 1937; the others in 1939.) In *mitsukurii* and *marlina* the width was measured above the tip of the closed mandible (predentary). Thus the criterion of short, wide sword which is often used in distinguishing the black marlin from other varieties is only half true, for, while the sword is indeed shorter, it is no wider.

DORSAL FIN FORM

The relative height of the dorsal fin seems to be one of the best characters for distinguishing the three marlin types considered here. There is comparatively little overlapping between any two forms as the following distribution table shows:

Percentage Index	11	12	13	14	15	16	17	18	19	20
Striped (*M. n. mitsukurii*)	0	0	0	0	1	6	5	8	9	1
Blue (*M. n. ampla*)	0	1	3	6	7	4	2	0	0	0
Black (*M. n. marlina*)	1	0	6	4	0	0	0	0	0	0

Not only is there this tendency toward a higher first dorsal in the striped marlin, but there is a similar tendency for it to have a relatively longer first dorsal. The large range of variation (Tables III and IV) in this character is no doubt a reflection of the retention of juvenile conditions, when the first and second dorsals are continuous and well elevated. As growth continues the dorsal splits into two and the posterior extremity of the first dorsal recedes, relatively speaking. However, in reality the first dorsal of *ampla* increases 1.14 units for every one unit increase of body-length (Shapiro, 1938), and probably there is a similar movement in *marlina* and *mitsukurii* as well.

A frequency distribution table of relative second dorsal lengths gives almost identical groupings for *ampla* and *mitsukurii*, while that of *marlina* is skewed markedly to the right:

Percentage Index	3	4	5	6
Striped (*M. n. mitsukurii*)	6	22	2	0
Blue (*M. n. ampla*)	2	18	3	0
Black (*M. n. marlina*)	1	2	7	2

The tendency thus revealed for increased length in the black marlin may be correlated with its greater bulk and consequent need for greater area and efficiency in its locomotive "tail sweeps."

In second dorsal height, preliminary analysis of the samples shows only a marked tendency toward height in *mitsukurii*. The blue and black marlins are similar in range (3%–4%), but differ in modal points, three per centum being the mode of the blue, 4% of the black.

Unlike the condition noted in the blue marlin in which the dorsal occasionally arises posterior to the pectorals (Conrad and LaMonte, 1937), in both the black and striped forms the first dorsal always arises either directly above the pectoral base, or generally, in front of it to varying degrees.

TABLE III.—Percentage Indices in the Striped Marlin (*Makaira mitsukurii*)

[In terms of the standard length]

	High	Mode	Low	Table I, No. 1	No. 30
Body depth (max.)	19	17	15	16	17
Greatest width of body	11	9	7	8	8
Min. depth of pedicle	3.8	3.6	3.1	3.6	3.6
Width across caudal pedicle	3.5	3.0	2.3	3.0	2.7
Snout tip to transv. plane max. body area	46	40	38	39	43
Transv. plane max. body area to tail base	62	60	54	61	57
Tip of snout to summit of back	43	40	36	41	36
Greatest width across pectoral fin bases	9	8	6	7	8
Maximum spread of tail	41	36	30	31	33
A.P. length tail, mid-line from min. width pedicle	8	8	6	7	8
A.P. depth of tail notch	11	9	7	10	10
Oblique length caudal fin, dorsal moiety	28	25	21	24	25
Oblique length caudal fin, ventral moiety	26	23.5	20	21	22
First dorsal fin, length of base	53	50	43	49	50
Depth of first dorsal fin, longest ray	20	19	15	19	17
Second dorsal fin, A.P. length	5	4	3	3	4
Second dorsal fin, depth longest ray	6	4	3	6	4
Anal fin, length at base	14	13	10	..	13
Anal fin, depth longest ray	14	11	8	11	11
Pelvic fin, A.P. length at base	0.5	0.4	0.2	0.4	0.3
Pelvic fin, depth longest ray	15	11	10	15	10
Pectoral fin, width of base	3	3	2	3	3
Pectoral fin, longest ray	23	20	17	19	20
Snout tip to ant. border pectoral*	41	39	36	37	37
Snout tip to ant. border pelvic fin*	42	40	37	39	38
Snout tip to ant. border first dorsal fin*	37	36	33	35	33
Snout tip to ant. border second dorsal fin*	93	89	85	89	88
Snout tip to anterior border anal fin*	72	71	69	..	70
Tip of snout to post. bord. operc.	41	39	36	37	37
Tip snout to ant. bord. eye	27	26	23	25	24
Ant. bord. eye to post. bord. operc.	14	12	11	12	13
Head depth suproccip. to isthmus	10	8	7	10	10
A.P. length gill-chamber (preop. to post. bord. operc.)	7	6	5	6	6
Width across base of snout	3	3	2	3	2
Width across preoperculum	9	8	6	..	8
"Maxillary" length (total upper jaw)	31	30	27	28	29
Length of mandible to angle of jaw	15	14	7	12	7
A.P. length eye	2.6	2.3	2.2	2.5	2.3

* Fin projected on snout-tail line.

ANAL FIN FORM

The measurements given by Conrad and LaMonte (1937) include only those of the anal fin as a whole. For *mitsukurii* and *marlina*, however, there are measurements for the first and second anals, but none of the two combined.

In relative first anal length *mitsukurii* with a mode of 13% far outstrips *marlina* which has a mode of 10%. This same tendency is noted in first anal depth as well, *mitsukurii* ranging from 8% to 14%; *marlina* from 9% to 11%.

In second anal length the black and striped marlins are much alike, both having a mode of 4%. In depth of second anal *mitsukurii* has a mode of 4%; *marlina*, 3%.

TABLE IV.—Percentage Indices in the Pacific Black Marlin (*M. nigricans marlina*)

[In terms of the standard length]

	High	Mode	Low	Table II, No. 1	Table II, No. 12
Body depth (max.)	23	21	18	19	23
Greatest width of body	13	9.5	9	9	12
Min. depth of pedicle	3.5	3.5	2.9	3.4	3
Width across caudal pedicle	3.5	3.2	2.6	2.8	3
Snout tip to transv. plane max. body area	42	41	30	42	40
Transv. plane max. body area to tail base	70	59	58	58	60
Tip of snout to summit of back	42	41.5	31	41	40
Greatest width across pectoral fin bases	9	8	7	7	8
Maximum spread of tail	40	36.5	32	38	37
A.P. length tail, mid-line from min. width pedicle	8	8	7	8	8
A.P. depth of tail notch	10	7	7	9	10
Oblique length caudal fin, dorsal moiety	27	27	21	27	27
Oblique length caudal fin, ventral moiety	26	24	21	26	25
First dorsal fin, length of base	51	51	37	37	49
Depth of first dorsal fin, longest ray	14	13	11	14	13
Second dorsal fin, A.P. length	6	5	3	6	5
Second dorsal fin, depth longest ray	4	4	3	4	4
Anal fin, length at base	13	10	9	12	10
Anal fin, depth longest ray	11	10	9	11	10
Pelvic fin, A.P. length at base	0.5	0.45	0.4	0.4	0.5
Pelvic fin, depth longest ray	12	8.5	8	10	..
Pectoral fin, width of base	4	3.5	3	3	4
Pectoral fin, longest ray	22	19.5	17	22	20
Snout tip to ant. border pectoral*	37	35	27	35	35
Snout tip to ant. border pelvic fin*	39	36.5	29	37	37
Snout tip to ant. border first dorsal fin*	35	33	31	35	34
Snout tip to ant. border second dorsal fin*	87	85.5	83	83	86
Snout tip to anterior border anal fin*	71	68	68	68	71
Tip of snout to post. bord. operc.	39	38	33	38	37
Tip snout to ant. bord. eye	26	25	17	25	24
Ant. bord. eye to post. bord. operc.	13	13	11	12	13
Head depth suproccip. to isthmus	12	10	9	10	12
A.P. length gill-chamber (preop. to post. bord. operc.)	7	6	5	6	7
Width across base of snout	4	3	2	3	3
Width across preoperculum	10	8	7	8	10
"Maxillary" length (total upper jaw)	30	28	21	29	28
Length of mandible to angle of jaw	13	12	9	12	13
A.P. length eye	2.8	2.1	2.0	2.5	2.1

* Fin projected on snout-tail line.

PECTORAL FIN FORM

There is a remarkable uniformity in the relative width of the pectoral fin base in all three types. This is especially true in view of the fact that the pectoral fin length is so variable. Whereas the width varies from 2% to 5% of the length of the body, its mode is three per centum in all three forms. On the other hand the length ranges from 17% to 23%, which outside range is that of the striped marlin. Both *ampla* and *marlina* fall within this observed extreme range. It is readily noted that although the black marlin is characterized, according to Jordan and Evermann (1926), by long pectorals, the striped has relatively longer ones. In pectoral length all three types may be classed as mediradial, with the exception of the lowest striped and blue at 17%—a border-line breviradial type.

PELVIC FIN FORM

The long, almost thread-like pelvics of the Istiophoridae are well known and their seeming inadequacy as stabilizers or brakes leads to the conclusion that they are passing out of the family. Such a position is strengthened by the fact that in the swordfish, *Xiphias gladius*, a parallel line of development from the Scombridae, the pelvic fins and girdle are both completely lost.

The length of pelvic fin, that is, the "spread," is exceedingly small when compared to the length. All three types combined show a spread of from 0.2% to 0.7%, with a common modal point of 0.4%, as the distribution table shows:

Percentage Index	0.2	0.3	0.4	0.5	0.6	0.7
Striped (*M. n. mitsukurii*)	1	5	19	5	0	0
Blue (*M. n. ampla*)	0	1	10	8	2	1
Black, (*M. n. marlina*)	0	0	6	6	0	0

In so fine a measurement as this it is surprising how constant and similar the lengths are in the three forms.

The "depth," or length of pelvic rays, in contrast to the "spread" has a wide range of variation. However, all ranges overlap and the total range is from 8% to 18%. The distribution table which follows shows the relative "depth" of pelvic fins in the three types studied.

Percentage Index	8	9	10	11	12	13	14	15	16	17	18
Striped (*M. n. mitsukurii*)	0	0	5	10	6	5	3	1	0	0	0
Blue (*M. n. ampla*)	0	0	2	2	4	5	1	4	2	1	1
Black (*M. n. marlina*)	3	3	2	2	1	0	0	0	0	0	0

Although there is considerable overlapping of these characters in the three forms, there is certainly a tendency for the pelvic fin rays of the blue marlin to be longer than either of the others; those of the black are certainly the shortest. This may, with caution, serve as one criterion for distinguishing between the three.

CAUDAL FIN FORM

The tail length, measured from the minimum depth of the peduncle to the middle caudal rays, tends to be much the same in all three marlins. All have a modal length of eight per centum. However, in lobe lengths, this similarity of proportions is not seen, for while the modes of *marlina* and *mitsukurii* are similar, that of *ampla* is considerably greater. The greater length of lobes in the blue marlin results in a deeper "tail notch" and a wider tail spread.

In view of the postulated classification (page 443) it seems odd that members of two different species should be so similar, while the subspecies of one of them should be so different from either.

The tendency which *ampla* shows for an increased length of tail in larger specimens (Conrad and LaMonte, 1937, p. 209; Shapiro, 1938, p. 13) and the consequent lessened concavity, is not seen in either *mitsukurii* or *marlina*. If such an increase in tail length would aid the efficiency of streamline in the blue marlin by providing a less abrupt "run" as suggested by Shapiro as weight and general bulk increases, we should expect to find the heavier *marlina* with a relatively longer tail than *mitsukurii*, or even *ampla*. Such is not the case, however, for there is no such change in concavity in either *marlina* or *mitsukurii*. Nor does the concavity[1] in *marlina* show such a tendency, for while there is an extreme range from 19% to 29%, the largest fish (815 pounds) has a more concave tail (26%) than the smallest (105 pounds; 25%).

[1] This relative concavity is measured thus:

$$\frac{\text{Depth of tail notch} \times 100}{\text{Maximum spread of tail}}$$

FIN DISPLACEMENTS

For *mitsukurii* and *marlina* there are data indicating the relative displacement of the various appendages posterior to the tip of the sword.

In the striped marlin the first dorsal fin is usually 36% of the standard length behind the tip of the snout, although it may range from 33% to 37%. This distance is usually less in *marlina*, where the mode is 33%. The latter's range from 31% to 35% overlaps considerably that of *mitsukurii*.

Were it not for one individual there would be no overlapping between *mitsukurii* and *marlina* in the displacement of the second dorsal. In *mitsukurii* the second dorsal is much more posterior than that of *marlina*. The distribution table of percentages follows:

Percentage Index	83	84	85	86	87	88	89	90	91	92	93
Striped (*M. n. mitsukurii*)	0	0	1	0	0	10	13	5	0	0	1
Black (*M. n. marlina*)	1	2	3	3	1	0	0	0	0	0	0

Such a character as this with so small an amount of overlapping serves admirably to distinguish between *mitsukurii* and *marlina*. This relatively forward position may be correlated with *marlina*'s relatively longer second dorsal in increasing locomotive efficiency.

Anal fin displacement, as one would expect, shows a tendency to balance the relative positions of the second dorsals in the two forms. The anal fin of *mitsukurii* is placed more posteriorly than is the anal fin of *marlina*. The frequency distribution which follows shows these tendencies:

Percentage Index	68	69	70	71	72
Striped (*M. n. mitsukurii*)	0	1	10	14	4
Black (*M. n. marlina*)	4	3	2	1	0

Inasmuch as the pectoral girdle is united to the skull in fishes one should expect the pectoral displacement to vary directly with the length of the head. Indeed such is the case, for the modal pectoral displacement in *mitsukurii* is 39%; the pectoral origin is thus on a tangent to the opercular curve, for the modal head length is also 39%. The shorter-headed black marlin has a smaller pectoral displacement (35%), but in this case the pectoral origin lies somewhat in front of the most posterior part of the operculum.

In both *mitsukurii* and *marlina* the modal displacement of the pelvic fin is slightly greater than that of the pectoral although, of course, in many individuals the pelvics lie directly below the pectorals.

QUALITATIVE CHARACTERS

The problem of the identity of these three types is complicated by the fact that although the body proportions overlap in all cases, as we have seen, the several forms are generally easily distinguished by color and other qualitative differences upon gross examination. As implied by its name, the striped marlin is characterized by a series of vertical stripes, or bands, on the flanks. Although the number is somewhat variable there are usually about seventeen pale blue stripes on a slate blue background. The black marlin, on the other hand, lacks any indication of this vertical striping. If the background color of the striped (*mitsukurii*) is described as slate BLUE, the general body color of the black (*marlina*) is best described as a slate GRAY. As in the case of the quantitative characters studied above, however, these colors are extremely variable and in a large sample would, no doubt, intergrade completely.

How do the anglers tell them apart if they intergrade to any great extent? This is the question we asked ourselves and the anglers. Their answer proved in practice to be our best criterion for identifying the black marlin. In most fishes the adducted pectoral fin lies flat against the side of the body, that is, the plane of the upper surface of the fin is in a vertical position (Fig. 1 A, B). This normal twist which brings the adducted fin (in which the upper

surface is horizontal) to the snug, vertical, adducted position is noted in most marlins. In *marlina* (Fig. 1C), however, the twist which streamlines the pectoral against the flank of the body is lacking and thus, when adducted, the pectoral remains in the horizontal position. This character was observed on all of the black marlins examined (Pl. IV).

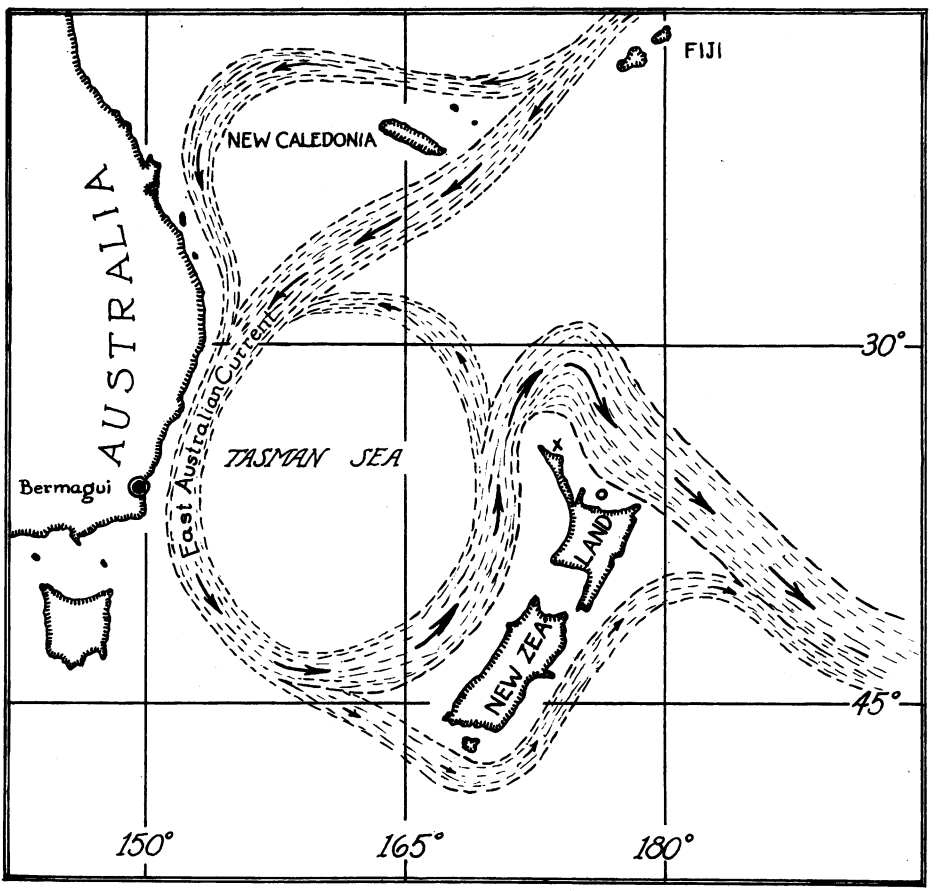

Fig. 2. Map showing the chief ocean currents in the East Australian and New Zealand waters. X marks the position of the Bay of Islands, N. Z.; O marks the position of Mayor Island.

GEOGRAPHICAL VARIATION

Although our samples were taken from rather widely separated localities, i.e., the east coast of the North Island of New Zealand and the eastern coast of New South Wales, Australia, there are no obvious differences in body proportions other than those of absolute size.

The striped marlins of Bermagui, N. S. W. (Table I, Nos. 3, 4, 17, 20) are scattered through the New Zealand series in size and proportions. On the other hand, the black marlins taken at Bermagui (Table II, Nos. 1, 2, 3, 4, 5) are all smaller than those of New Zealand, although the body proportions are similar. The small size of the blacks which we obtained does not indicate the absence of large individuals for "Boydtown Ben" (see page 444) captured

in New South Wales waters weighed 1226 pounds—a world's record. The presence of a number of small *marlina*, however, is of interest in determining the possible migration routes of the Australasian marlins.

The East Australian Current (Fig. 2) flows southwest of the Fiji Islands to be split by New Caledonia into a western stream which is deflected southward by the Great Barrier Reef to meet the eastern stream off the shores of New South Wales. At Cape Howe the recombined East Australian Current swings east as if to encircle the Tasman Sea but most of its force rounds the northernmost tip of New Zealand, passes down the east coast of the North Island and spends itself in the South Pacific. This may well be the route of migration of the black marlins. Although it would hardly be proof of such a migration, which could be proved only by tagging methods, one would expect to find that after all the marlins had left the Australian coast they would still be passing New Zealand. In this connection it is interesting to note that in Bermagui, in 1937–38, the greatest number of catches was in February followed by a dropping off in March, ending finally with one black marlin on March 9 (although fishing continued until April 22). In New Zealand during the same season the Bay of Islands Swordfish and Mako Shark Club records show that, although the black marlins were not so numerous, the last catch of one was made on April 18 (although fishing continued until May 21).

TABLE V.—A Summary Comparison of the Body-Forms of *M. mitsukurii*, *M. n. ampla* and *M. n. marlina*

[Percentages are in terms of the standard length, unless stated otherwise]

	Striped Marlin *M. mitsukurii*	Atlantic Blue Marlin *M. n. ampla*	Pacific Black Marlin *M. n. marlina*
1.	A long slim body in which the length varies from 5.2 to 6.5 times the depth.	Long slim, to short stout types in which the length varies from 4.5 to 6.3 times the depth.	A relatively short stout body in which the length varies from 4.3 to 5.5 times the depth.
2.	A relatively long head, usually 39%.	A relatively short head, usually 36%.	Similar to *ampla*.
3.	A shallow head, usually 8%.	A relatively deep head, usually 11%.	A medium head, usually 10%.
4.	A long sword, usually 26%.	A relatively short sword, usually 24%.	Similar to *ampla*.
5.	A narrow body, usually 9%.	Same as in *mitsukurii*.	A tendency toward a wide body, as much as 13%.
6.	A relatively very high dorsal fin, usually 19%.	A medium high dorsal fin usually 15%.	A relatively low dorsal fin, usually 13%.
7.	A relatively short second dorsal fin, usually 4%.	Same as in *mitsukurii*.	A relatively long second dorsal, usually 5%.
8.	Relatively long pectoral fins, as high as 23%.	Shorter pectorals than the other two, never more than 21%, usually 20%.	Similar to *mitsukurii*, never more than 22%.
9.	Medium long pelvic fins, usually about 11%.	Relatively long pelvics, as high as 18%.	Relatively short pelvic fins, usually about 8.5%.
10.	Relatively short caudal lobes; shallow tail notch; smaller spread.	Long caudal lobes with resultant deeper tail notch and greater tail spread.	Similar to *mitsukurii*.
11.	Upper surface of pectoral fin folds flat against flank.	As in *mitsukurii*.	Upper surface of pectoral fin cannot be folded flat against body flank.
12.	Body prominently striped.	Usually striped, but not always.	No stripes.

SUMMARY

Although there is intergradation in all features of the body-form in *mitsukurii*, *marlina* and *ampla*, there are proportional tendencies which when considered in groups serve to aid in distinguishing them.

The table above (Table V) lists these distinguishing tendencies in the three forms studied.

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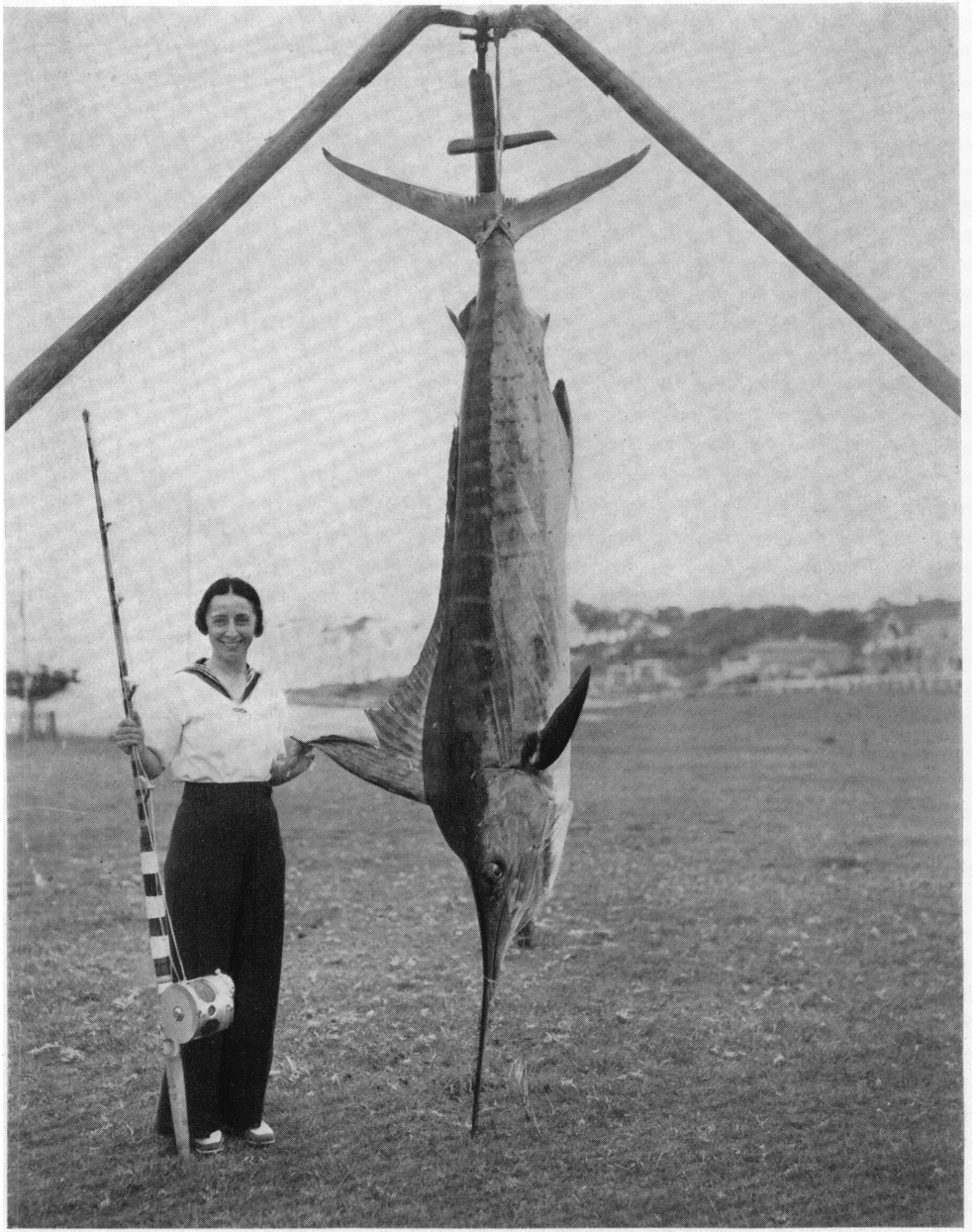
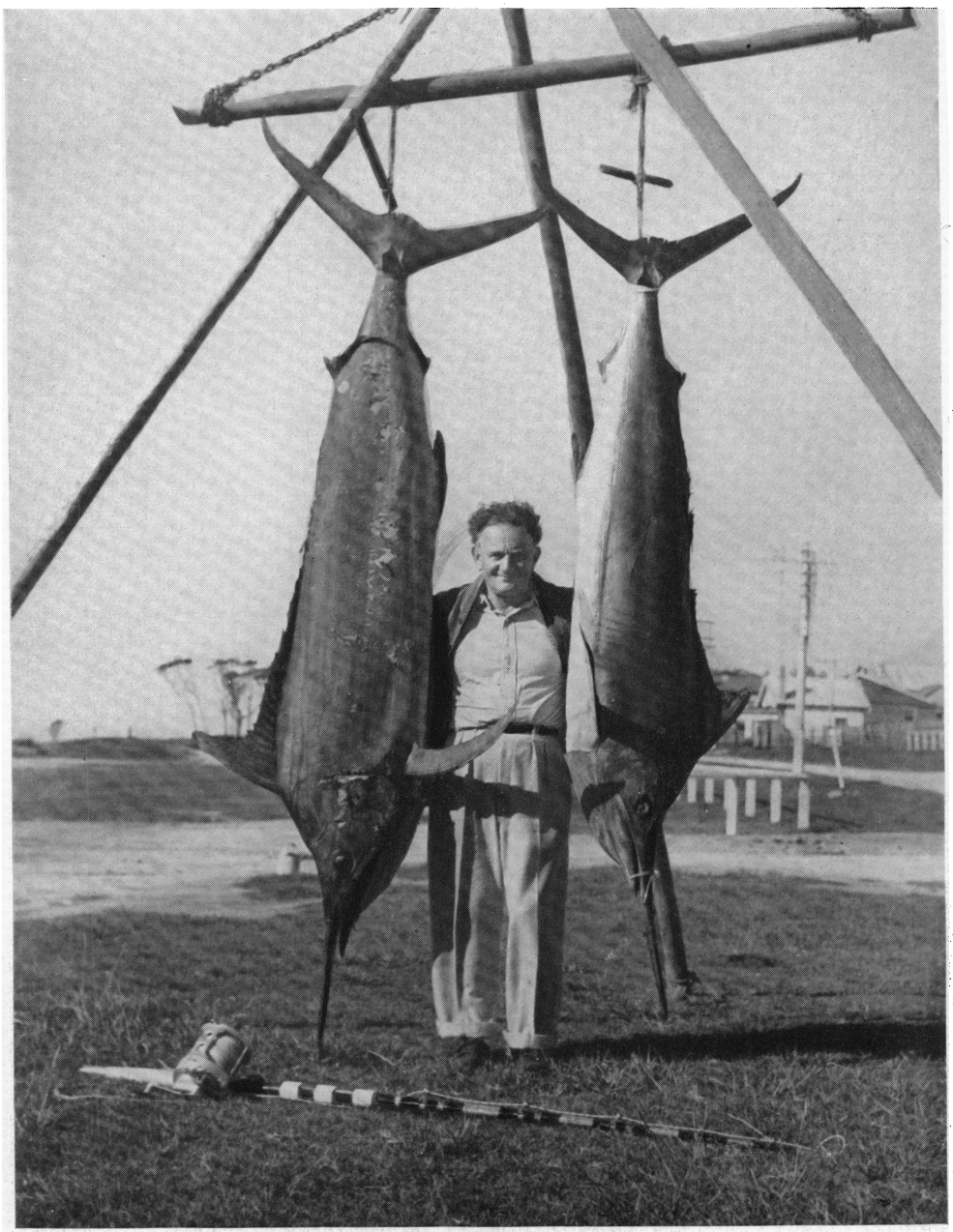
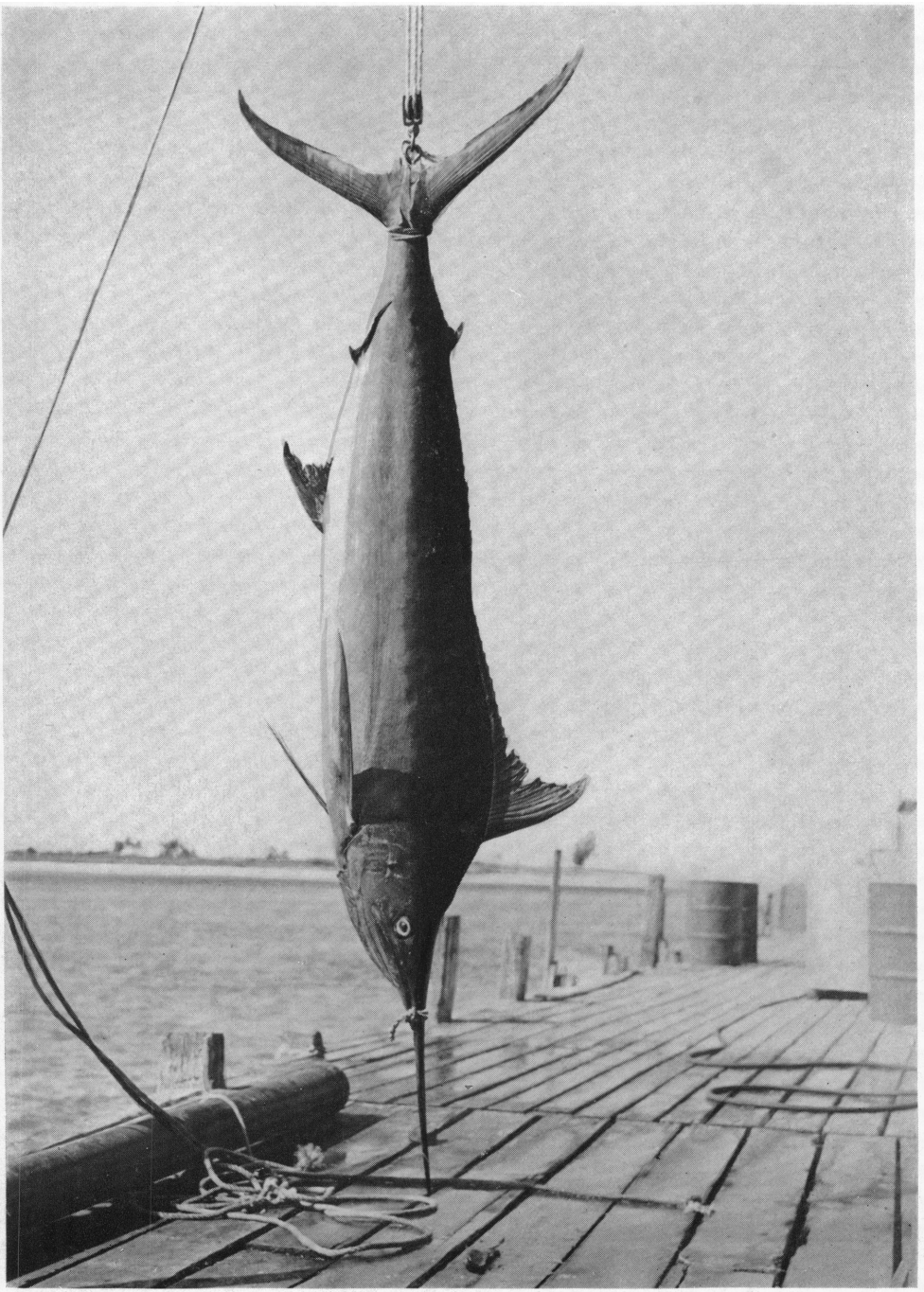


Striped marlin (*Makaira mitsukurii*) taken by Mrs. Michael Lerner off the coast of Bermagui, New South Wales, Australia.



Two black marlins (*Makaira nigricans marlina*) taken by Michael Lerner off the coast of Bermagui, New South Wales, Australia.



Blue marlin (*Makaira nigricans ampla*) taken by Michael Lerner in the Gulf Stream off Bimini, Bahama Islands.

A freshly caught striped marlin being hauled aboard in the Bay of Islands, N. Z. Note the prominently marked stripes, almost zebra-like in quality. Taken by Michael Lerner.