# *Observations on the Body Form of the Blue Marlin (Makaira nigricans ampla Poey)*

By G. Miles Conrad and Francesca La Monte

BULLETIN

OF

THE AMERICAN MUSEUM OF NATURAL HISTORY

Vol. LXXIV, Art. IV, pp. 207–220

*New York*

*Issued December 31, 1937*

# Article IV.—OBSERVATIONS ON THE BODY FORM OF THE BLUE MARLIN (*MAKAIRA NIGRICANS AMPLA* POEY)

By G. Miles Conrad and Francesca La Monte

Detailed measurements of twenty-three blue marlins (*Makaira nigricans ampla*), one white marlin (*M. albida*), and one wahoo (*Acanthocybium solandri*) were secured at Bimini, Bahamas Islands, by the Michael Lerner Bimini Expedition of The American Museum of Natural History during July, 1937. These measurements, supplemented by those of other scombroids made by Dr. William K. Gregory on the Arcturus Expedition of the New York Zoological Society in 1925, form the basis for this study.

The percentages and ratios here recorded will be of little taxonomic value until the other species of *Makaira* have been as fully measured, so it is not with a view to redescribing this species that we set down the following data but rather of augmenting the all too meager information by which these giant mackerel-like fishes have of necessity been described. If, as is hoped, we are able to secure equivalent data on the Pacific black marlin (*M. marlina*), it may be found that the latter falls well within the extremes of *M. nigricans ampla.*

According to authors the only considerable difference between the Pacific black marlin and the Atlantic blue is the higher dorsal of the latter. It will be seen that the range of variations of numerous quantitative characters in the blue marlin is large. The qualitative manifestation of color is likewise variable, many individuals being almost black when they are gaffed while others are of an indescribably brilliant blue; some have the suggestion of vertical striping, while in others this is not apparent.

Because of the large size of the marlins and the difficulty in preserving them in museums, the criteria by which many species have been described are, to say the least, scanty. In order, therefore, to substantiate the established species or to synonymize the existing ones it will be necessary in the future to take as complete measurements and photographs as possible of each marlin available. It is desirable that no species nor subspecies be described on the basis of a spear, isolated fins, or even a mutilated fish. Such species are valueless and tend to fog the already cloudy picture of the genus *Makaira.*

A thorough analysis of our measurements reveals the ratios and per-

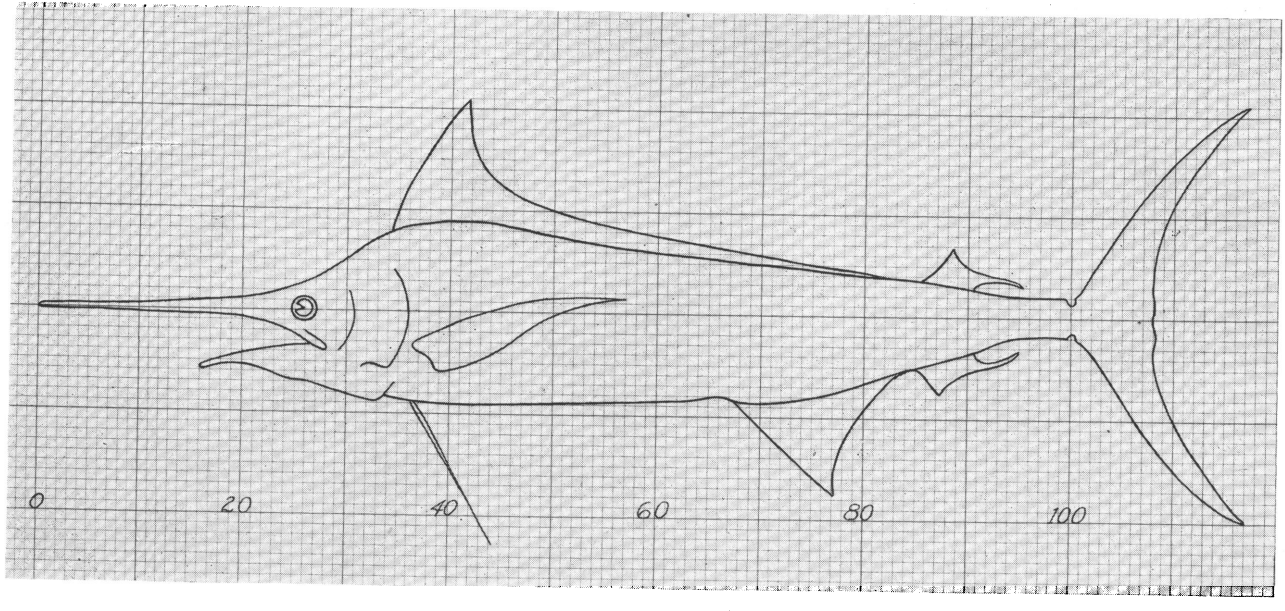


Fig. 1. The body form of the typical blue marlin (*Makaira nigricans ampla*). Peduncle notch slightly exaggerated.

TABLE I.—Absolute Measurements in Millimeters of *Makaira nigricans ampla* (1–23), *Makaira albida*, and *Acanthocybium solandri*.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | *Makaira albida* | *Acanthocybium solandri* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Body length, snout to tail base | 1950 | 2100 | 2215 | 2228 | 2250 | 2210 | 2320 | 2558 | 2355 | 2425 | 2480 | 2732 | 2700 | 2590 | 2640 | 2725 | 2810 | 2695 | 2910 | 3040 | 2972 | 2800 | 3040 | 1800 | 1468 |
| (2) Snout tip to ant. bord. eye | 490 | 535 | 550 | 527 | 548 | 546 | 554 | 663 | 601 | 613 | 595 | 710 | 678 | 685 | 621 | 655 | 675 | 663 | 643 | 701 | 640 | 685 | 730 | 457 | 180 |
| (3) Body depth (max.) | 330 | 365 | 400 | 395 | 405 | 430 | 410 | 405 | 440 | 470 | 495 | 550 | 495 | 540 | 540 | 525 | 515 | 540 | 530 | 570 | 565 | 540 | 670 | 260 | 225 |
| (4) Snout tip to transv. plane of max. body area | 840 | 855 | 880 | 940 | 1000 | 960 | 920 | 1095 | 975 | 1050 | 1040 | 1146 | 1170 | 1175 | 1104 | 1125 | 1140 | 1194 | 1110 | 1243 | 1152 | 1130 | 1315 | 705 | 635 |
| (5) Tip of snout to summit of back | 840 | 850 | 870 | 890 | 990 | 950 | 915 | 1050 | 955 | 1020 | 1000 | 1130 | 1170 | 1095 | 1070 | 1145 | 1142 | 1175 | ... | 1243 | 1143 | 1140 | 1338 | 682 | 635 |
| (6) Max. spread of tail | 712 | 840 | 870 | 875 | 885 | 863 | 892 | 1010 | 865 | 960 | 1010 | 1065 | 1040 | 1010 | 1127 | 1032 | 1065 | 1088 | 1090 | 1095 | 1065 | 1095 | 1075 | 610 | 390 |
| (7) A. P. length of tail, middle line from min. width of pedicle | 160 | 107 | 170 | 165 | 165 | 190 | 183 | 189 | 192 | 190 | 205 | ... | 230 | 210 | 220 | 222 | 212 | 240 | ... | 245 | 260 | 250 | 255 | 110 | 95 |
| (8) A. P. depth of tail notch | 248 | 288 | 250 | 241 | 210 | 200 | 292 | 271 | 253 | 252 | 270 | ... | 310 | 130 | 282 | 233 | 298 | 340 | ... | 300 | 288 | 310 | 280 | 110 | 38 |
| (9) Oblique length caudal fin, dorsal moiety | 550 | 590 | 610 | 625 | 616 | 600 | 655 | 700 | 650 | 670 | 710 | 750 | 755 | 745 | 780 | 715 | 760 | 805 | 772 | 789 | 790 | 805 | 840 | 470 | 239 |
| (10) Oblique length caudal fin, ventral moiety | 525 | 565 | 590 | 580 | 564 | 590 | 635 | 670 | 615 | 623 | 675 | 660 | 745 | 725 | 735 | 675 | 710 | 775 | 740 | 755 | 760 | 770 | 670+ | 420 | 239 |
| (11) Min. depth of pedicle | 67 | 75 | 81 | 79 | 75 | 90 | 80 | 85 | 90 | 85 | 100 | 110 | 102 | 100 | 105 | 105 | 100 | 100 | 95 | 105 | 107 | 120 | 115 | 60 | 48 |
| (12) First dorsal fin, length base | 920 | 975 | 1080 | 1100 | 1105 | 1100 | 1140 | 1200 | 1155 | 1170 | 1180 | 1380 | 1300 | 1295 | 1275 | 1315 | 1375 | 1300 | 1400 | 1490 | 1531 | 1510 | 1410 | 952 | 490 |
| (13) Depth of first dorsal fin, longest ray | 295 | 312 | 385 | 290 | 330 | 320 | 365 | 395 | 410 | 310 | 394 | 415 | 390 | 432 | 425 | 380 | 445 | 435 | 405 | 455 | 460 | 465 | 450 | 280 | 49 |
| (14) Second dorsal fin, A. P. length | 65 | 85 | 110 | 105 | 90 | 100 | 110 | 115 | 90 | 97 | 110 | 140 | 127 | 115 | 125 | 120 | 125 | 115 | 140 | 147 | 130 | 140 | 158 | 70 | 450 |
| (15) Second dorsal fin, depth longest ray | 73 | 80 | 90 | 85 | 72 | 100 | 90 | 95 | 75 | 95 | 92 | 100 | 100 | 98 | 105 | 100 | 111 | 115 | 100 | 124 | 110 | 90 | 125 | 62 | 80 |
| (16) Anal fin, length at base | 435 | 465 | 520 | 530 | 505 | 510 | 555 | 573 | 500 | 540 | 582 | 660 | 620 | 570 | 620 | 595 | 621 | 625 | 725 | 720 | 742 | 760 | 720 | 390 | 408 |
| (17) Anal fin, depth longest ray | 245 | 250 | 312 | 265 | 265 | 282 | 320 | 335 | 335 | 280 | 310 | 370 | 332 | 370 | 340 | 340 | 345 | 370 | 390 | 395 | 395 | 380 | 415 | 195 | 95 |
| (18) Pelvic fin, A. P. length at base | 12 | 10 | 11 | 10 | 14 | 12 | 11 | 15 | 18 | 13 | 11 | 15 | 14 | 11 | 15 | 13 | 10 | 15 | 12 | 13 | 12 | 15 | 15 | 10 | 45 |
| (19) Pelvic fin, depth longest ray | 363 | 330 | 385 | 242 | 346 | 308 | 321 | 413 | 340 | 286 | 375 | 360 | 346 | 389 | 427 | 357 | 306 | 325 | 360 | ... | 330 | 355 | 393 | 267 | 80 |
| (20) Pectoral fin, width of base | 60 | 73 | 74 | 67 | 72 | 75 | 85 | 90 | 85 | 90 | 90 | 90 | 100 | 100 | 95 | 95 | 98 | 98 | 110 | 180 | 108 | 110 | 117 | 47 | 56 |
| (21) Pectoral fin, longest ray | 396 | 425 | 425 | 435 | 465 | 444 | 470 | 507 | 495 | 495 | 490 | 535 | 519 | 540 | 555 | 513 | 510 | 578 | 528 | 572 | 540 | 565 | 598 | 350 | 175 |
| (22) Posterior displacement of pelvics behind pectorals (both projected on snout-tail line) | −10 | −7 | 20 | −5 | 0 | 20 | 10 | 26 | −5 | 6 | 0 | −20 | 25 | 5 | 35 | 6 | 30 | 0 | 0 | 11 | 0 | −35 | 15 | 8 | 21 |
| (23) Post. displ. of ant. bord. first dorsal fin behind pectorals (both projected on snout-tail line) | −40 | −95 | −90 | −80 | −90 | −115 | −60 | 73 | 90 | −65 | −40 | −135 | −115 | −65 | −70 | 125 | 130 | −85 | 30 | −35 | −45 | −95 | −40 | 85 | 15 |
| (24) Post. displ. ant. bord. second dorsal behind pectorals (both projected on eye-tail line) | 960 | 1033 | 1065 | 1095 | 1100 | 1050 | 1190 | 1236 | 1135 | 1170 | 1255 | 1310 | 1350 | 1295 | 1315 | 1465 | 1360 | 1355 | 1545 | 1570 | 1610 | 1560 | 1545 | 905 | 574 |
| (25) Post. displ. ant. bord. anal behind pectorals (both projected on snout-tail line) | 605 | 660 | 660 | 670 | 695 | 645 | 715 | 780 | 755 | 715 | 745 | 765 | 815 | 810 | 835 | 861 | 890 | 825 | 940 | 958 | 945 | 980 | 980 | 570 | 605 |
| (26) Greatest width of body | 165 | 208 | 170 | 200 | 230 | 200 | 230 | ... | 205 | 470 | 225 | 220 | 300 | 262 | 240 | 320 | ... | 305 | 260 | 300 | 305 | ... | 285 | 120 | 154 |
| (27) Width across caudal pedicle | 55 | 58 | 70 | 70 | 74 | 70 | 75 | 73 | 80 | 157 | 90 | 100 | 110 | 95 | 95 | 95 | 85 | 88 | 85 | 90 | 115 | 100 | 100 | 45 | 50 |
| (28) Greatest width across pect. fin bases | 165 | 155 | 160 | 190 | 180 | 200 | 200 | 210 | 200 | 220 | 195 | 250 | 240 | 230 | 205 | 230 | 220 | 255 | 260 | 215 | 250 | 310 | 245 | 110 | 154 |
| (29) Depth of body between pect. fin bases | 75 | 115 | 100 | 80 | 80 | 110 | 90 | 109 | 110 | 120 | 100 | 115 | 120 | 120 | 105 | 115 | 95 | 130 | 115 | 112 | 125 | 120 | 120 | 75 | 125 |
| (1′) Tip snout to post. bord. operc. | 725 | 800 | 830 | 803 | 830 | 830 | 851 | 955 | 902 | 910 | 901 | 1036 | 1003 | 995 | 937 | 1000 | 1035 | 990 | 1000 | 1078 | 1005 | 1075 | 1122 | 675 | 360 |
| (2′) Tip snout to ant. bord. eye | 487 | 535 | 550 | 527 | 548 | 547 | 554 | 663 | 601 | 613 | 595 | 710 | 677 | 685 | 621 | 655 | 675 | 663 | 643 | 701 | 640 | 685 | 730 | 455 | 180 |
| (3′) Ant. bord. eye to post. bord. operc. | 240 | 262 | 285 | 277 | 285 | 285 | 300 | 293 | 301 | 297 | 306 | 326 | 328 | 325 | 316 | 364 | 362 | 330 | 357 | 377 | 372 | 390 | 397 | 220 | 180 |
| (4′) Head depth suproccip. to isthmus | 180 | 225 | ... | 240 | 225 | 300 | 240 | ... | 230 | 260 | 275 | 300 | 310 | 285 | 250 | 310 | 335 | 305 | ... | 330 | 340 | 330 | 333 | 160 | 173 |
| (5′) Length pmx. | 380 | 400 | 408 | 352 | 359 | 445 | 405 | 428 | 443 | 440 | 445 | 500 | 495 | 525 | 433 | 515 | 460 | 430 | ... | 474 | 457 | 498 | 555 | 357 | ... |
| (6′) Length mx. | 190 | 225 | 300 | 280 | 280 | 220 | 250 | 338 | 260 | 278 | 260 | 320 | 305 | 265 | 307 | 255 | 333 | 351 | ... | 356 | 310 | 380 | 310 | 178 | ... |
| (7′) "Maxillary" length (total upper jaw) | 570 | 625 | 708 | 632 | 639 | 665 | 655 | 766 | 703 | 718 | 705 | 820 | 800 | 790 | 740 | 770 | 793 | 781 | ... | 830 | 767 | 828 | 865 | 535 | 178 |
| (8′) Angle of upper jaw to horiz. line of body (not taken) | | | | | | | | | | | | | | | | | | | | | | | | | |
| (9′) Length of mandible to angle of jaw | 220 | 250 | 256 | 263 | 245 | ... | 273 | 275 | 272 | ... | 275 | 305 | 282 | 312 | 280 | 294 | 305 | 297 | 280 | 342 | 318 | 340 | 315 | 218 | 145 |
| (10′) A. P. length eye | 48 | 55 | 58 | 62 | 58 | 60 | 60 | 56 | 59 | 63 | 60 | 59 | 63 | 63 | 64 | 65 | 69 | 66 | 63 | 66 | 68 | 75 | 66 | 50 | 39 |
| (11′) A. P. length gill chamber (preop. to post. bord. operc.) | 125 | 125 | 142 | 132 | 145 | 140 | 155 | 148 | 160 | 140 | 155 | 164 | 173 | 175 | 153 | 190 | 185 | 175 | 185 | 185 | 187 | 210 | 220 | 104 | 95 |
| (12′) Width across base of snout | 40 | 48 | 45 | 42 | 40 | 70 | 55 | 41 | 60 | 43 | 45 | 56 | 50 | 59 | 54 | 67 | 50 | 48 | ... | 63 | 60 | 73 | 83 | 42 | 68 |
| (13′) Width across preop. | 140 | 177 | ... | 180 | 160 | ... | 170 | 205 | 175 | ... | 180 | 220 | ... | 235 | 180 | 218 | 235 | 265 | 200 | 220 | 250 | 280 | 240 | 118 | 133 |
| (14′) Total body weight (fresh) | 91 lbs. | 142 lbs. | 145 lbs. | 175 lbs. | 178 lbs. | 195 lbs. | 208 lbs. | 215 lbs. | 218 lbs. | 248 lbs. | 265 lbs. | 298 lbs. | 310 lbs. | 324 lbs. | 326 lbs. | 354 lbs. | 362 lbs. | 379 lbs. | 420 lbs. | 460 lbs. | 480 lbs. | 518 lbs. | 537 lbs. | Not taken | 44 lbs. |

centages for *M. n. ampla* as recorded in the tables below. Table II shows that the small fish has: (1) a relatively lower body depth than has the large fish; (2) a relatively lower tail spread and its tail is more concave; (3) a relatively narrower pectoral fin; (4) a relatively wider cross-section at the pectoral fins; (5) a relatively longer premaxilla; and (6) a narrower base of snout. Other differences are either less striking or less reliably based.

In order to represent graphically the body form of the typical (modal) blue marlin we have arbitrarily assigned one hundred units to the standard length (tip of snout to the mid-point of the peduncle) and have plotted the relative proportions of the other measurements directly from the modal percentages in Table III, where they are in terms of the length. All measurements not in terms of the length have been converted to conform thereto. The resulting figure (Fig. 1) superimposed on coördinate paper gives at a glance the percentage of any portion in terms of the length. For example, the height of the dorsal is 15 units, or 15 per cent of the standard length. This typical blue marlin, it must be remembered is not an actual fish but a composite of all of the twenty-three which we studied, as well as pictures of numerous others. Figure one is typical of both male and female fishes for none of our measurements indicate definite sex differences.

Body Form As a Whole.—Gregory and Conrad (1937) in a paper on the osteology of the swordfish and the sailfish give a short analysis of the body form of *Makaira ampla*, the information being derived from published drawings and photographs. The data collected at Bimini substantiate the published observations and provide many additional notes of the body form of the blue marlin.

The body of *Makaira nigricans ampla* is generally five times as long as it is deep when the sword is included and thus may be described as mesosomatic. However, in a few specimens the length is more than five and one-half times the depth and is therefore dolichosomatic. When the sword is eliminated from the measurements the body is definitely mesosomatic, the length being about four times the depth. In our one specimen of *Makaira albida*, the white marlin, we found the length to be 6.9 times the depth, as contrasted with Jordan and Evermann's (1926) figure of 6 1/7. Such a ratio is indicative of a dolichosomatic body.

With reference to the ratio of maximum transverse diameter with the body depth there is a great variability, which is probably due to sexual activity in the females and to age in all. The modal type is mesothoracic, that is, a condition in which the body width is from 45/100 to 1/1 of

TABLE II.—Percentages of the 537 Pounds and 91 Pounds Specimens

| RATIOS AND INDICES | | 537 LBS. | 91 LBS. |
|---|---|---|---|
| *A*—Rel. Total Length to Depth | $\frac{(1) \times 100}{(3)}$ | 453.7 | 590.9 |
| *B*—Rel. Snout Length | $\frac{(2) \times 100}{(1)}$ | 24.0 | 25.1 |
| *C*—Rel. Body Depth | $\frac{(3) \times 100}{(1)}$ | 22.0 | 16.9 |
| *D*—Rel. Backw. Disp. of Plane of Greatest Area | $\frac{(4) \times 100}{(1)}$ | 43.2 | 43.0 |
| *E*—Rel. Length Snout to Summit of Back | $\frac{(5) \times 100}{(1)}$ | 44.0 | 43.0 |
| *F*—Rel. Spread of Tail to A. P. Mid-Axis of Tail | $\frac{(6) \times 100}{(7)}$ | 421.5 | 445.0 |
| *G*—Rel. A. P. Length of Tail on Middle Line | $\frac{(7) \times 100}{(1)}$ | 7.3 | 8.2 |
| *H*—Rel. Concavity of Tail | $\frac{(8) \times 100}{(6)}$ | 26.1 | 34.8 |
| *I*—Rel. Length Dors. Moiety Caudal Fin to Body Length | $\frac{(9) \times 100}{(1)}$ | 27.6 | 28.2 |
| *J*—Rel. Length Ventral Moiety Caudal Fin to Body Length | $\frac{(10) \times 100}{(1)}$ | 22.0 | 26.9 |
| *K*—Rel. Depth of Pedicle to Tail Spread | $\frac{(11) \times 100}{(6)}$ | 10.7 | 9.4 |
| *L*—Rel. Length of First Dorsal Fin to Body Length | $\frac{(12) \times 100}{(1)}$ | 46.3 | 47.1 |
| *M*—Rel. Depth of Dorsal Fin to Its Base | $\frac{(13) \times 100}{(12)}$ | 31.0 | 32.0 |
| *N*—Rel. Length Second Dorsal to Body Length | $\frac{(14) \times 100}{(1)}$ | 5.1 | 3.3 |
| *O*—Index Second Dorsal Depth to Its Base | $\frac{(15) \times 100}{(14)}$ | 79.1 | 112.3 |
| *P*—Rel. Length Anal Fin to Body Length | $\frac{(16) \times 100}{(1)}$ | 23.6 | 22.3 |
| *Q*—Rel. Depth Anal Fin to Its Base | $\frac{(17) \times 100}{(16)}$ | 57.6 | 56.3 |
| *R*—Rel. Length Pelvic Fin to Body Length | $\frac{(18) \times 100}{(1)}$ | 0.4 | 0.6 |
| *S*—Pelvic Fin, Index Length of Base | $\frac{(19) \times 100}{(18)}$ | 2620.0 | 3025.0 |

Table II (Continued)

| Ratios and Indices | | 537 lbs. | 91 lbs. |
|---|---|---|---|
| *T*—Pect. Fin. Rel. Width of Base | $\frac{(20) \times 100}{(1)}$ | 3.8 | 3.0 |
| *U*—Pect. Fin, Rel. Length to Its Base | $\frac{(21) \times 100}{(20)}$ | 511.1 | 660.0 |
| *V*—Rel. Post. Displ. of Pelvic Fins | $\frac{(22) \times 100}{(1)}$ | 0.4 | −0.5 |
| *W*—Rel. Displ. Posteriorly of First Dorsal Fin | $\frac{(23) \times 100}{(1)}$ | −1.3 | −2.0 |
| *X*—Rel. Displ. Posteriorly of Second Dorsal | $\frac{(24) \times 100}{(1)}$ | 50.0 | 49.2 |
| *Y*—Rel. Post. Displ. of Anal Fin | $\frac{(25) \times 100}{(1)}$ | 32.2 | 31.0 |
| *Z*—Rel. Width of Body to Depth | $\frac{(26) \times 100}{(3)}$ | 42.5 | 50.0 |
| *AA*—Rel. Width Caudal Pedicle | $\frac{(27) \times 100}{(11)}$ | 86.9 | 82.1 |
| *BB*—Rel. Width of Body to Depth between Pect. Fins | $\frac{(28) \times 100}{(29)}$ | 204.1 | 220.0 |
| *A'*—Total Head Length to Body Length | $\frac{(1') \times 100}{(1)}$ | 36.9 | 37.1 |
| *B'*—Snout Length to Total Head Length | $\frac{(2') \times 100}{(1')}$ | 65.0 | 67.1 |
| *C'*—Shorter Head Length to Total Head Length | $\frac{(3') \times 100}{(1')}$ | 35.3 | 33.1 |
| *D'*—Head Depth to Head Length | $\frac{(4') \times 100}{(1')}$ | 29.6 | 24.8 |
| *E'*—Rel. Length pmx. to mx. | $\frac{(5') \times 100}{(6')}$ | 179.0 | 200.0 |
| *F'*—Rel. Max. Length to Total Head Length | $\frac{(7') \times 100}{(1')}$ | 77.0 | 78.6 |
| *G'*—Rel. Mandible Length to Total Head Length | $\frac{(9') \times 100}{(1')}$ | 28.0 | 30.3 |
| *H'*—Rel. A. P. Eye Length | $\frac{(10') \times 100}{(1')}$ | 5.8 | 6.6 |
| *I'*—Rel. Length Gill Chamber | $\frac{(11') \times 100}{(1')}$ | 19.6 | 17.2 |
| *J'*—Rel. Width Across Base of Snout | $\frac{(12') \times 100}{(1')}$ | 7.3 | 5.5 |
| *K'*—Rel. Width Across Preop. | $\frac{(13') \times 100}{(1')}$ | 21.3 | 19.3 |

TABLE III.—High, Mode, and Low Percentages Regardless of Individuals

| RATIOS AND INDICES | | HIGH | MODE | LOW |
|---|---|---|---|---|
| *A*—Rel. Total Length to Depth | $\frac{(1) \times 100}{(3)}$ | 631 | 510%± | 453 |
| *B*—Rel. Snout Length | $\frac{(2) \times 100}{(1)}$ | 26 | 24.5% | 21 |
| *C*—Rel. Body Depth | $\frac{(3) \times 100}{(1)}$ | 22 | 18% | 15 |
| *D*—Rel. Backw. Disp. of Plane of Greatest Area | $\frac{(4) \times 100}{(1)}$ | 45 | 41; 43% | 38 |
| *E*—Rel. Length Snout to Summit of Back | $\frac{(5) \times 100}{(1)}$ | 44 | 40% | 38 |
| *F*—Rel. Spread of Tail to A. P. Mid-Axis of Tail | $\frac{(6) \times 100}{(7)}$ | 785 | 450%± | 417 |
| *G*—Rel. A. P. Length of Tail on Middle Line | $\frac{(7) \times 100}{(1)}$ | 8.9 | 8.1% | 5.0 |
| *H*—Rel. Concavity of Tail | $\frac{(8) \times 100}{(6)}$ | 34 | 26% | 12 |
| *I*—Rel. Length Dors. Moiety Caudal Fin to Body Length | $\frac{(9) \times 100}{(1)}$ | 29 | 27% | 26 |
| *J*—Rel. Length Ventral Moiety Caudal Fin to Body Length | $\frac{(10) \times 100}{(1)}$ | 28 | 26% | 22 |
| *K*—Rel. Depth of Pedicle to Tail Spread | $\frac{(11) \times 100}{(6)}$ | 10 | 9% | 8 |
| *L*—Rel. Length of First Dorsal Fin to Body Length | $\frac{(12) \times 100}{(1)}$ | 53 | 48% | 46 |
| *M*—Rel. Depth of Dorsal Fin to Its Base | $\frac{(13) \times 100}{(12)}$ | 35 | 30; 32% | 26 |
| *N*—Rel. Length Second Dorsal to Body Length | $\frac{(14) \times 100}{(1)}$ | 5 | 4% | 3 |
| *O*—Index Second Dorsal Depth to Its Base | $\frac{(15) \times 100}{(14)}$ | 112 | 83.5% | 64 |
| *P*—Rel. Length Anal Fin to Body Length | $\frac{(16) \times 100}{(1)}$ | 27 | 23% | 21 |
| *Q*—Rel. Depth Anal Fin to Its Base | $\frac{(17) \times 100}{(16)}$ | 67 | 53% | 50 |
| *R*—Rel. Length Pelvic Fin to Body Length | $\frac{(18) \times 100}{(1)}$ | 0.7 | 0.4% | 0.3 |
| *S*—Pelvic Fin, Index Length of Base | $\frac{(19) \times 100}{(18)}$ | 3536 | 2850%± | 1888 |

Table III (Continued)

| Ratios and Indices | | High | Mode | Low |
|---|---|---|---|---|
| *T*—Pect. Fin. Rel. Width of Base | $\frac{(20) \times 100}{(1)}$ | 5.9 | 3.6% | 3.0 |
| *U*—Pect. Fin., Rel. Length to Its Base | $\frac{(21) \times 100}{(20)}$ | 660 | 580% ± | 317 |
| *V*—Rel. Post. Displ. of Pelvic Fins | $\frac{(22) \times 100}{(1)}$ | 1.3 | 0.0% | −1.2 |
| *W*—Rel. Displ. Posteriorly of First Dorsal Fin | $\frac{(23) \times 100}{(1)}$ | 4.6 | −3.0% ± | −5.2 |
| *X*—Rel. Displ. Posteriorly of Second Dorsal Fin | $\frac{(24) \times 100}{(1)}$ | 55 | 48% | 47 |
| *Y*—Rel. Post. Displ. of Anal Fin | $\frac{(25) \times 100}{(1)}$ | 32 | 31% | 20 |
| *Z*—Rel. Width of Body to Depth | $\frac{(26) \times 100}{(3)}$ | 60 | 56% | 40 |
| *AA*—Rel. Width Caudal Pedicle | $\frac{(27) \times 100}{(11)}$ | 107 | 80% ± | 75 |
| BB—Rel. Width of Body to Depth Between Pect. Fins | $\frac{(28) \times 100}{(29)}$ | 258 | 190% ± | 134 |
| *A'*—Total Head Length to Body Length | $\frac{(1') \times 100}{(1)}$ | 38 | 36% | 33 |
| *B'*—Snout Length to Total Head Length | $\frac{(2') \times 100}{(1')}$ | 69 | 66% | 63 |
| *C'*—Shorter Head Length to Total Head Length | $\frac{(3') \times 100}{(1')}$ | 37 | 34% | 30 |
| *D'*—Head Depth to Head Length | $\frac{(4') \times 100}{(1')}$ | 36 | 28; 30% | 24 |
| *E'*—Rel. Length pmx. to mx. | $\frac{(5') \times 100}{(6')}$ | 202 | 170% ± | 122 |
| *F'*—Rel. Max. Length to Total Head Length | $\frac{(7') \times 100}{(1')}$ | 85 | 78% | 70 |
| *G'*—Rel. Mandible Length to Total Head Length | $\frac{(9') \times 100}{(1')}$ | 32 | 30% | 28 |
| *H'*—Rel. A. P. Eye Length | $\frac{(10') \times 100}{(1')}$ | 7.7 | 6% | 5.6 |
| *I'*—Rel. Length Gill Chamber | $\frac{(11') \times 100}{(1')}$ | 19 | 17% | 15 |
| *J'*—Rel. Width Across Base of Snout | $\frac{(12') \times 100}{(1')}$ | 8.2 | 5% | 4.2 |
| *K'*—Rel. Width Across Preop. | $\frac{(13') \times 100}{(1')}$ | 26 | 19% | 19 |

the depth. There are stragglers which are stenothoracic, with the body width less than 45/100 of the body height. *Makaira albida* falls just within the lower margin of the mesothoracic type, for the body width is 46/100 of the depth.

In the vertical diameter the peduncle is leptopygidial (delicate peduncle) or less than 1/4 of the body depth. In width the peduncle is eurypygidial, or greater than 3/4 its vertical diameter.

Table IV below shows in summary the body and peduncle form in the blue marlin and other scombroids. It will be noted that in all of the species analyzed the body form is essentially the same.

HEAD.—The head form of the blue marlin, studied both with the sword (premaxillaries) and without, yields the following results.

Including the sword the head is macrocephalic, that is, more than 1/3 of the body depth. It is also platycephalic, for the depth is less than 1/2 the length. The width is mesocranial, that is, it lies between 50 per cent and 100 per cent of the depth. The snout length is macrorhynchal, if not hypermacrorhynchal, which indicates that it is about 1/2 of the total head length. The great prolongation of the premaxillaries is indicated by the total upper jaw length, which is called macrognathic (more than 1/3 of the total head length). The eye is less than 1/5 of the head length and may be termed microphthalmic. The anteroposterior dimension of the gill chamber is from 1/3 to 3/4 of the head depth, or mesocameral.

With the elimination of the sword two of these relationships are greatly altered (Table V). The head then should be called microcephalic, because it is less than 1/5 of the body length. The head depth, however, becomes relatively much greater and is now mesocephalic (depth is from 1/2 to 1/1 of the length).

Oddly enough, even with the elimination of the sword, the eye remains less than 1/5 of the head length and continues to be microphthalmic in character. All the other relationships remain unchanged. Table V is a comparison of the head form with and without the sword.

Similar analysis of the head form of *Makaira albida*, based on our one specimen, shows that the head length is macrocephalic; the depth, platycephalic; head width, mesocranial; snout length, macrorhynchal; functional upper jaw, macrognathic; the eye, microphthalmic; and the gill chamber, mesocameral. By eliminating from consideration the premaxillaries, the head length falls within the definition of microcephalic; the head depth becomes mesocephalic. The other relationships remain the same as in *M. n. ampla*. Thus a general analysis of the head form in the two species reveals no differences of major importance.

TABLE IV.—Comparison of the Body Form of the Marlins and Other Scombriforms

| | *Makaira nigricans ampla* | *Makaira albida* | *Scomberomorus maculatus* | *Scomber colias* | *Acanthocybium solandri* | *Gymnosarda pelamis* | *Xiphias gladius* |
|---|---|---|---|---|---|---|---|
| Body length | Mesomatic / Dolichosomatic | Dolichosomatic | Mesomatic | Mesosomatic | Dolichosomatic | Mesomatic | Dolichosomatic |
| Body width | Mesothoracic | Mesothoracic | Mesothoracic | Mesothoracic | Mesothoracic | Mesothoracic | ..... |
| Peduncle vertical | Leptopygidial | Leptopygidial | Leptopygidial | Leptopygidial | Leptopygidial | Leptopygidial | Leptopygidial |
| Peduncle width | Eurypygidial | Eurypygidial | Eurypygidial | Eurypygidial | Eurypygidial | Eurypygidial | ..... |

TABLE V.—Summary of the Head Form of *Makaira nigricans ampla*

| | WITH SWORD | WITHOUT SWORD |
|---|---|---|
| Head length | Macrocephalic[1] | Microcephalic[2] |
| Head depth | Platycephalic[1] | Mesocephalic[2] |
| Head width | Mesocranial[1] | Mesocranial[2] |
| Snout length | Macrorhynchal[1] | ..... |
| Functional upper jaw | Macrognathic[1] | ..... |
| Eye | Microphthalmic[1] | Microphthalmic[2] |
| Gill chamber | Mesocameral[1] | Mesocameral[2] |

[1] In terms of total head length (including sword).
[2] In terms of shorter head length (i.e., omitting pmx.).

TABLE VI.—Comparison of Head Form in Marlins and Other Scombriforms

| | *Makaira nigricans ampla* | *M. albida* | *Scomberomorus maculatus* | *Scomber colias* | *Acanthocybium solandri* | *Gymnosarda pelamis* |
|---|---|---|---|---|---|---|
| Head length | Macrocephalic | Macrocephalic | Nomocephalic | Nomocephalic | Nomocephalic | Nomocephalic |
| Head depth | Platycephalic | Platycephalic | Mesocephalic | Mesocephalic | Platycephalic | Mesocephalic |
| Head width | Mesocranial | Mesocranial | Mesocranial | Mesocranial | Mesocranial | Mesocranial |
| Snout length | Macrorhynchal | Macrorhynchal | Nomorhynchal | Nomorhynchal | Nomorhynchal | Nomorhynchal |
| Maxillary (upper jaw) | Macrognathic | Macrognathic | Macrognathic | Mesognathic | Mesognathic | Mesognathic |
| Eye | Microphthalmic | Microphthalmic | Microphthalmic | Mesophthalmic | Microphthalmic | Microphthalmic |
| Ant.-post. diameter of gill chamber | Mesocameral | Mesocameral | Mesocameral | Mesocameral | Mesocameral | Macrocameral |

TABLE VII.—Comparison of Fin Form in Marlins and Other Scombriforms

| | *Makaira nigricans ampla* | *Makaira albida* | *Scomberomorus maculatus* | *Scomber colias* | *Acanthocybium solandri* | *Gymnosarda pelamis* |
|---|---|---|---|---|---|---|
| First dorsal fin form | | | | | | |
| Length | Perlongibasic<br>Longibasic | Perlongibasic | Longibasic | Medibasic | Longibasic | Longibasic |
| Height | Altiradial | Altiradial | Breviradial | Mediradial | Breviradial | Mediradial |
| Second dorsal fin form | | | | | | |
| Length | Perbrevibasic | Perbrevibasic | Longibasic | Medibasic | Medibasic | Longibasic |
| Height | Breviradial | Breviradial | Mediradial | Breviradial | Mediradial | Breviradial |
| Anal fin form | | | | | | |
| Length | Medibasic | Medibasic | Longibasic | Medibasic | Medibasic | Brevibasic |
| Height | Longiradial | Longiradial | Mediradial | Breviradial | Mediradial | Breviradial |
| Pectoral fin form | | | | | | |
| Length | Mediradial | Mediradial | Breviradial | Breviradial | Breviradial | Breviradial |
| Pelvic fin form | | | | | | |
| Length | Mediradial | Mediradial | Breviradial | Breviradial | Breviradial | Mediradial |
| Spread | Parviareal | Parviareal | Parviareal | Parviareal | No data | Parviareal |
| Caudal fin form | | | | | | |
| Length | Brachycercal | Brachycercal | No data | Brachycercal | Brachycercal | No data |
| Spread | Hypermacrocercal | Hypermacrocercal | Hypermacrocercal | Macrocercal | Hypermacrocercal | Macrocercal |

Table VI below is a comparative table showing the head form in the marlins and in several other scombriforms.

DORSAL FIN FORM.—The length of the first dorsal is longibasic, that is, greater than 1/4 to 1/2 of the body length. In a rare few, as in *Makaira albida*, it is perlongibasic, for it is longer than 1/2 of the body length.

In common with many Xiphiiformes the dorsal height may be described as altiradial, or greater than 3/4 of the body depth.

The second dorsal length is perbrevibasic, for it is from 1/20 to 1/25 the body length, considerably less than the defined 1/12 of the body length. In height the second dorsal is 1/5 of the body depth and falls within the breviradial category.

Of particular interest is the position of the anterior origin of the first dorsal with reference to the pectoral fin. It was early noted in our studies that the dorsal arose in front of the pectorals in some and behind in others, but such a wide variation was apparent that a careful check on a number of marlin photographs was made. This survey substantiates our recorded observations, which indicate that the displacement of the dorsal fin ranges from 5.2 per cent of the body length in front of the pectorals to 4.6 per cent behind. In the majority of cases the dorsal arises in front of the pectorals. It is not known whether or not such variations occur in the other marlins.

ANAL FIN FORM.—The anal fin is split into two and is subdorsalic in position. Our measurements are of the first and second anals combined. Considered as a whole, the anal length is about 1/4 of the body length and is medibasic, that is, from 1/10 to 1/3 of the body length. Its height is longiradial, that is, greater than 1/2 to 1/1 of the body depth. The postero-inferior border of the anal fin is concave.

PECTORAL FIN FORM.—The length of the pectoral is mediradial, or from 1/6 to 1/3 of the body length.

PELVIC FIN FORM.—The spread of the pelvic fin is considerably less than 1/10 of the body length and it may be called parviareal. Its length is mediradial, or from 1/10 to 1/5 of the body length.

Just as the dorsal origin varied, so does that of the pelvic in relation to the pectoral. The mode is for the pelvics to arise directly ventral to the pectorals, but some range from 1.2 per cent of the body length in front to 1.3 per cent behind. The length of the pelvic ranges from about 2000 per cent to 3400 per cent of its base.

CAUDAL FIN FORM.—The caudal fin is brachycercal, that is, the basal length is less than 1/2 the tail spread. It may also be described as

hypermacrocercal, that is, the tail spread is greater than 1 1/2 times the maximum depth of the body. The seemingly symmetrical caudal lobes are never actually so, for the ventral lobe is consistently an inch or more shorter than the dorsal lobe. The lobes are never equal, as stated by Jordan and Evermann (1926). It is interesting to note here that the caudal lobes are actually equal in *Thunnus* (Arcturus, No. 5640).

The relative concavity of the tail ranges from 12 per cent to 34 per cent, with the mode at 26 per cent. Figure 2 illustrates graphically the caudal fin form in these extremes.

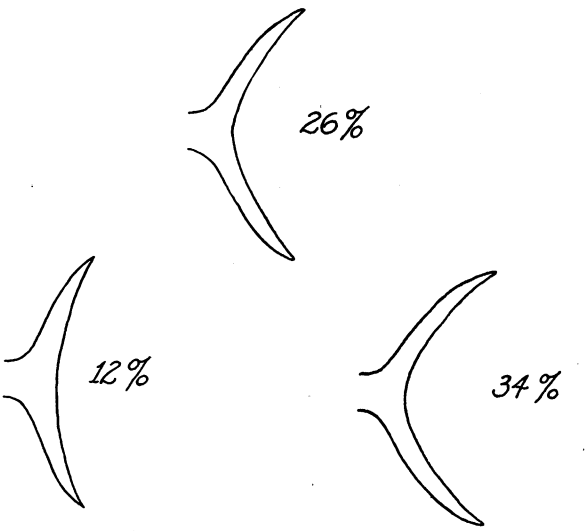


Fig. 2. The relative concavity of the caudal fin of *Makaira nigricans ampla.* 26 per cent, the mode; 12 per cent, 34 per cent, the extremes.

Table VII compares the fin form in the blue marlin with the fins of several other scombroids. It is readily seen that the marlins differ considerably in these characters from any of the other forms examined.

Discussion.—The scombroid fishes have assumed an almost perfectly streamlined body form, which Breder (1926) describes as "... the beautiful response of body and appendage form to streamline conditions." They number among their ranks the fastest swimmers by actual measurement. H. J. Howell records in Field and Stream magazine the speeds of several fishes checked by him with a stop watch as they ran out a hundred yards of line from his reel. With the drag eliminated as much as possible, he gives the following speeds as determined by his method:

Striped bass (*Roccus*).....12 M. P. H.
Dolphin (*Coryphaena*).....20 M. P. H.
Bonefish (*Albula*).....21 M. P. H.
Wahoo (*Acanthocybium*).....41 M. P. H.

However, C. M. Breder tells us that in experiments which he has conducted a "drag," no matter how small, has a seemingly disproportionate effect in lowering the speed. Therefore the figures above probably err on the slow side. It is seen that the scombroid, *Acanthocybium*, far surpasses in speed any of the others. Dr. Roy C. Andrews, in a recent paper, gives 30 miles per hour as the average speed for the giant mackerel-like fishes as contrasted with a maximum of 10 miles an hour for a submerged submarine and 35 miles per hour for a flying fish.

*Makaira nigricans ampla* is no exception to the ordinal trait of fine streamlining, for in spite of its bulk it is designed for fast swimming. However, the swords and "marlin-spikes" of the Xiphiiformes are certainly of no value in the streamline and are probably a detriment, providing a considerable surface for skin friction to act upon as well as fostering a concavity on the dorsal surface of the head in which retarding eddies may be set up.

## BIBLIOGRAPHY

ANDREWS, ROY C. 1937. 'Wings win.' Natural History, XL, No. 3, pp. 559–565. Table.

BREDER, C. M., JR. 1926. 'The locomotion of fishes.' Zoologica (New York), IV, No. 5, pp. 159–297.

GREGORY, WILLIAM K. 1928 *a*. 'Studies on the body-forms of fishes.' Zoologica (New York), VIII, No. 6, pp. 325–421.

1928 *b*. 'The body-forms of fishes and their inscribed rectilinear lines.' Palaeobiologica, I Bd., pp. 93–100.

GREGORY, WILLIAM K., AND CONRAD, G. MILES. 1937. 'The comparative osteology of the swordfish (*Xiphias*) and the sailfish (*Istiophorus*). Amer. Mus. Novitates, No. 952, pp. 1–25.

HOWELL, HENRY J. 1937. 'How fast can a fish swim?' Field and Stream, XLI, No. 10, p. 19.

JORDAN, D. S., AND EVERMANN, B. W. 1926. 'A review of the giant mackerel-like fishes, tunnies, spearfishes and swordfishes.' Occ. Papers, Calif. Acad. Sci., XII, 133 pp.

NICHOLS, J. T., AND LA MONTE, F. R. 1935. 'How many marlins are there?' Natural History, XXXVI, No. 4, pp. 327–330.