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YOUNG JACK CREVALLES (*CARANX* SPECIES) OFF THE SOUTHEASTERN ATLANTIC COAST OF THE UNITED STATES

BY FREDERICK H. BERRY

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ABSTRACT

The young of five species of jack crevalles (*Caranx*) commonly occur off the Atlantic coast of the United States: *Caranx crysos*, *C. ruber*, *C. bartholomaei*, *C. latus*, and *C. hippos*. Morphometric, meristic, and morphological characters, and serial illustrations are presented for each of these species from the smallest larval or early juvenile sizes available into the better-known juvenile and adult stages. Development of certain body parts is defined and discussed, and comparisons are made for the species. The smallest available specimens of *C. dentex* and *C. lugubris*—species which occur in the Western Atlantic, but have not been reliably reported from inshore waters of the United States—are briefly compared with the five common species. Nomenclatorial problems are discussed; several identification and distribution records are corrected; and a key to the seven species is given.

Apparently the five common species have an offshore larval existence. Off the southeastern Atlantic coast of the United States the larval stage occurs in association with the offshore waters of the Gulf Stream. *C. latus* and *C. hippos* lose their preopercular spines (a larval character persisting into the juvenile stage) at about 20 mm standard length—at a smaller body size than occurs in the other three common species—and they tend to migrate inshore at about this size. *C. crysos*, the relatively most-abundant young *Caranx* in this area, apparently does not migrate inshore before its late juvenile stage; *C. bartholomaei* occurs inshore only occasionally as a juvenile or adult; and *C. ruber* has an apparent tendency to remain offshore. As late juveniles or adults, all these species may return to more southern areas.

The following suppositions are made regarding spawning of the five common species: Spawning tends to occur in offshore waters, at least partially in association with major current systems, and extends from about February into September. *C. bartholomaei* probably spawns off the southeastern Atlantic coast of the United States, and the other four common species do spawn there; but the major spawning areas for these species are to the south of this area.

The time and place of spawning and the larval and early juvenile forms are unknown for *C. dentex* and *C. lugubris*. Their juvenile and adult habitats are apparently in offshore waters and in association with offshore islands.

The smallest, definitely identified specimens available for study were, in standard length, *C. crysos*, 5.4 mm.; *C. ruber*, 12.4 mm.; *C. bartholomaei*, 8.1 mm.; *C. latus*, 16.1 mm.; *C. hippos*, 15.3 mm.; *C. dentex*, 87 mm.; and *C. lugubris*, 242 mm. A series of specimens, 5.4 to 8.3 mm., identified only as *Caranx* sp. ("*latus* and/or *hippos*") includes either one or both of these species.

The affinity of *Hemicaranx fasciatus* (Cuvier) and *Uraspis heidi* Fowler to the genus *Caranx* is briefly discussed.

YOUNG JACK CREVALLES (*CARANX* SPECIES) OFF THE SOUTHEASTERN ATLANTIC COAST OF THE UNITED STATES

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The family Carangidae is noted for the diversity of body form of its species. Certain of these species undergo an ontogenetic change of form in having a deep-bodied larval stage and an elongated adult shape that is inverse to the development of many other fishes in which the larvae are narrow-bodied forms and the depth generally increases as the fish mature.

The genus *Caranx* has cosmopolitan distribution in tropical and subtropical waters, and extends into more temperate waters. The young jack crevalles furnish food for many surface-feeding carnivores, and the adults are themselves predatory on other fishes. In some areas they are utilized as food fish or for bait, and everywhere are recognized as respectable game fish.

Five species of *Caranx* commonly occur in waters off the Atlantic coast of the southeastern United States: *C. latus* Agassiz, *C. hippos* (Linnaeus), *C. bartholomaei* Cuvier, *C. ruber* (Bloch), and *C. crysos* (Mitchill). Two other species, *C. dentex* (Bloch and Schneider) and *C. lugubris* Poey, may occur there, but no authentic records exist. Unquestioned records of *C. lugubris* exist for Cuba, the Bahamas, and Bermuda, and of *C. dentex* for Bermuda. Two other species of Carangidae, *Hemicaranx fasciatus* (Cuvier) and *Uraspis heidi* Fowler, are briefly considered relative to their affinity to the genus *Caranx*.

Nichols has published a series of papers (see Literature Cited, p. 530) over the past several decades, giving descriptions, comparisons, and records of distribution for young *Caranx* in the Western Atlantic. Ginsburg (1952) gave accounts of late juveniles and adults of four of the species, primarily from the Gulf of Mexico. Other information on the young of *Caranx* is meager, particularly in the area considered (off the south Atlantic coast of the United States). The nomenclature of five of the seven species is still in question.

The specimens of young *Caranx* taken on eight of the nine cruises of the *Theodore N. Gill* during 1953–54 in the waters off the Atlantic coast of the southeastern United States by the U. S. Fish and Wildlife Service's South Atlantic Fishery Investigations represent the most complete series of young of three of the species ever collected in this area. This collection was supplemented by specimens from the U. S. National Museum (USNM), University of Florida Museum (UF), Bingham Oceanographic Collection (BOC), Academy of Natural Sciences of Philadelphia (ANSP), Chaplin Bahaman Shore Fish Program (CBSFP), Museum of Comparative Zoology (MCZ), American Museum of Natural History (AMNH), Charleston Museum (ChM), Bears Bluff Laboratories (BBL), and the U. S. Fish and Wildlife Service's Gulf Fisheries Exploration and Gear Research (GFEGR) at Pascagoula, Miss., Gulf Fisheries Investigations (GFI) at Galveston, Tex., and Menhaden Investigations (MI) at Beaufort, N. C., and personally acquired and local collections of the South Atlantic Fishery Investigations (SAFI) at Brunswick, Ga.

Although concerned primarily with the *Gill* collections and museum specimens from waters off the southeastern Atlantic coast of the United States, this discussion cannot be confined to that area. Because the larvae of the five common species of *Caranx* and the juveniles of three of them apparently are associated with the Gulf Stream in this area, it is quite likely that the developing young in this area represent only a portion of the population of each species, and that the populations, associated with current systems, extend from off the northern coast of South America into the Caribbean Sea and Gulf of Mexico, through the Florida Straits and along the

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northern Bahamas, into the North Atlantic Current east of the Grand Banks. If such is the case, spawning might be expected to occur along all but the more northern portions of the route, and the young forms might be expected to follow or be moved by the drift of the Gulf Stream and the currents contributing to the Stream until a critical stage, at which time they would act against the effects of the stream.

The purposes of the present work are to expand the known definitions and variability of the morphological, morphometric, and meristic characters of *Caranx* species off the Atlantic coast of the United States, principally the five common species, to facilitate their identification and to furnish a basis for comparison with the poorly known relationships of closely related species or forms from other geographic areas; to provide a set of serial illustrations to depict the changes from the smallest larval forms available into the better-known juvenile stages; to depict growth relationships for selected body parts; and to discuss distribution and theories of time and place of reproduction in waters off the southeastern United States.

I am grateful to Isaac Ginsburg and Elbert H. Ahlstrom of the U. S. Fish and Wildlife Service for their critical review of the manuscript and to John C. Briggs and Arnold B. Grobman of the University of Florida for their propitious suggestions. The loan or procurement of specimens and information on specimens by the following were instrumental in the study: Leonard P. Schultz, U. S. National Museum; John C. Briggs, University of Florida Museum; James E. Böhlke, Academy of Natural Sciences of Philadelphia and Chaplin Bahaman Shore Fish Program; E. Milby Burton, Charleston Museum; James E. Morrow, Bingham Oceanographic Collection; Myvanwy M. Dick, Museum of Comparative Zoology; G. Robert Lunz, Bears Bluff Laboratories; John T. Nichols, American Museum of Natural History; Harvey R. Bullis, Jr., Edgar L. Arnold, Jr., Fred C. June, David K. Caldwell, Doyle Sutherland, and Melba Wilson, U. S. Fish and Wildlife Service; E. Lowe Pierce and Benjamin B. Leavitt, University of Florida; G. Palmer, British Museum (Natural History); David H. Gould, Robert H. Godley, J. A. Jones, and William F. Ricks, Georgia Game and Fish Commission; Edwin H. Chandler, Lewis Crab Co., Brunswick, Ga.; and J. B. Siebenaler and Winfield Brady, Gulfarium, Fort Walton Beach, Fla. The assistance and suggestions of members of the staff of the South Atlantic Fishery Investigations were most helpful in preparation of the manuscript.

METHODS

COUNTS

Meristic counts on fish of less than about 200 mm. standard length were made under magnification. Aberrant counts, such as occur on injured specimens, were either omitted or specifically described.

MEASUREMENTS

All measurements of fish of less than about 45 mm. standard length were made with a calibrated micrometer eyepiece and a stereoscopic microscope, as were smaller structures on fish above this size. Other measurements were made with a pair of fine-point dividers. Measurements of preopercular spines were recorded to the nearest one-one hundredth millimeter. All other measurements were recorded as follows: Up to 45 mm. standard length, to the nearest one-tenth millimeter; 45 to 100 mm. standard length, to the nearest one-half millimeter; over 100 mm. standard length, to the nearest millimeter—with the exception of the standard lengths of fish not included in the graphs, which were measured to the nearest one-half millimeter if smaller than 100 mm., and to the nearest millimeter if larger.

The figures and tables in this report do not include data on the relation of the lengths of the fourth dorsal spine, the second dorsal soft-ray, pelvic fin, and body depth at first anal spine to standard length; or measurements of the first and second anal soft-rays.

CONSTRUCTION AND INTERPRETATION OF GRAPHS

Graphs of the relation of the mean number of scutes, of the mean lateral-line ratio, and of the preopercular-angle spine length to standard length for the individual species have been fitted with visually estimated perimeters enclosing the dots or other described marks that represent coordinates of the individual specimens. The graphical area enclosed by each perimeter is intended to depict the range of variation for that relationship.

Although the perimeters were drawn liberally in an attempt to estimate population variations from the samples, some specimens may be expected to exceed the estimates. Still, it provides a useful treatment of these highly variable relationships. In the composite graphs of these relationships under Comparison of Species, page 426, the perimeter for each species is specifically symbolized.

On the graphs illustrating the relation of third dorsal spine length, first dorsal soft-ray length, pectoral length, body depth at pelvic, head length, eye diameter, and snout length to standard length, each dot or other described mark represents the coordinate of a single specimen. Arithmetical plots of individual variates indicated that in most instances the formula for a rectilinear regression, $Y=a+bX$, adequately described the relationships. The regression lines for the five common species were determined by the method of least squares over a designated size range of the specimens represented in each graph. A line so determined is referred to in the text as the "calculated regression line" and is illustrated in the graphs as a solid line. The trend of such a line is frequently extended on the graphs (as a line of dashes) to allow an estimate of the relation of specimens larger or smaller than those included in the calculated regression line. The composite graphs of these relations under Comparison of Species consist only of the calculated regression lines (specifically symbolized for each species). Because of the limitations of material and methods, only certain size ranges are suitable for comparison.

Use of the term "inflection," applied to the descriptions of the relations of body parts follows Martin (1949) and denotes a change in slope of the relative growth line.

FISH ILLUSTRATIONS

Fish less than 16 mm. standard length were drawn with a camera lucida. Fish above this size were photographed, and an enlargement of the negative was used to reproduce the outlines.

NOMENCLATURE AND SYNONYMY

The discussions of nomenclature point out, with the exception of *ruber* and *bartholomaei*, that the relationships of the Western Atlantic species of *Caranx* to certain closely related forms from other areas are uncertain; consequently, the nomenclature is tentative. Since authors have differed in opinion concerning the nomenclature and synonymy of forms ascribed to the genus *Caranx*, a comprehensive review of the literature was necessary to understand the problems involved. This is briefly outlined under the species concerned. The synonymies are mainly composed of only the earliest reference to each applicable binomial that I have found. The principal purpose is not to revise the nomenclature, but to point out discrepancies that exist and to stabilize the usage until adequate revisions are made.

THEODORE N. GILL COLLECTIONS

All methods employed on the *Gill* cruises—including plankton and dip-net collections, stomach contents of species caught by trolling and hand line, and network of collecting stations—are given by Anderson, Gehringer, and Cohen (1956). The following abbreviations apply to the *Gill* cruises and specimens: Reg. (regular station), Spc. (special station), Std. (standard station, east of Elbow Cay, Bahamas), and TO (Tongue of the Ocean station, Bahamas).

DEFINITIONS

The definitions of measurements and counts and descriptions of terms are arranged in the same sequence in which the characters are considered in this and the following sections. Frequently, descriptions of ontogenetic changes are included. Since earlier workers have used varied, and often inadequately described, methods, some explanations in this section have been expanded for clarification.

BODY LENGTHS

Standard length.—Measured from the tip of the snout to the end of the hypural bones (the caudal base). All body lengths referred to are in standard length unless otherwise noted.

Fork length.—Measured from the tip of the snout to the end of the shortest median caudal ray.

Total length.—Measured from the tip of the snout to a vertical at the tip of the longest lobe of the caudal fin.

Body length conversion factors.—The rectilinear regression formula, $Y=a+bX$, was used to determine the conversions of total length and fork length to standard length. Standard length was used as the independent variate so that fork length$=a+b$ (standard length); total length$=a+b$

(standard length). For conversion to standard length the following formulas apply:

$$\text{Standard length}=\frac{\text{fork length}-a}{b};$$

$$\text{standard length}=\frac{\text{total length}-a}{b}.$$

The following a and b values were obtained:

crysos
  Fork length: $a=0.947$, $b=1.077$
  Total length (less than 85 mm. standard length and 104 mm. total length): $a=-0.228$, $b=1.224$
  Total length (more than 85 mm. standard length and 104 mm. total length): $a=-4.879$, $b=1.280$
ruber
  Fork length: $a=1.020$, $b=1.078$
  Total length: $a=-0.896$, $b=1.251$
bartholomaei
  Fork length: $a=1.260$, $b=1.073$
  Total length (less than 50 mm. standard length and 61 mm. total length): $a=0.151$, $b=1.219$
  Total length (more than 50 mm. standard length and 61 mm. total length): $a=-2.609$, $b=1.267$
latus
  Fork length: $a=1.242$, $b=1.082$
  Total length: $a=-2.671$, $b=1.275$
hippos
  Fork length: $a=1.006$, $b=1.076$
  Total length (less than 50 mm. standard length and 60 mm. total length): $a=0.326$, $b=1.198$
  Total length (more than 50 mm. standard length and 60 mm. total length): $a=-2.936$, $b=1.272$

Body lengths given by workers in total length and fork length and converted to standard length are designated in the following manner: "about x mm. (converted)."

DORSAL AND ANAL SPINES

Counts and descriptions.—The usual number of dorsal spines is nine—eight comprise the first dorsal fin, and the ninth is the first element of the second dorsal fin. In the few specimens which had only 6 or 7 spines in the first dorsal fin, the base or position of the missing spine or spines could usually be determined. On specimens of *hippos* larger than 200 mm., the first dorsal spine is relatively small and partially overgrown by skin.

A procumbent or recumbent dorsal spine in advance of the first dorsal-fin spines has been mentioned or tabulated in the dorsal-spine count by many authors (Nichols, 1912: 185; Fowler, 1941a: 85; Roxas and Agco, 1941: 39; Weber and de Beaufort, 1931; and others). This is not an articulated dorsal spine, but is shown on cleared and stained specimens of the five common species to be a pointed, forward extension of the first pterygiophore (the third or fourth interneural spine). It is more pronounced on smaller specimens and is discernible in figures 69 to 71 and 81 to 83.

There are three anal spines—the first and second remain in close proximity and become appreciably separated from the third with an increase in body size. The third spine has a positional relation to the anal soft-rays identical to that of the last dorsal spine to the dorsal soft-rays. The last dorsal spine and the third anal spine have been ignored or incorporated in the soft-ray counts by many authors.

Lengths.—The spines were measured in an erected position (if possible, otherwise estimated) on a chord from the anterior points of emergence from the skin to the tips.

DORSAL AND ANAL SOFT-RAYS

Definition.—In the early larvae, those rays which from their position in the second dorsal or the anal fin were considered as potentially segmented were counted as soft-rays.

Counts.—The buds or the bases of the soft-rays are readily visible with magnification and transmitted light in specimens from 8 mm. to more than 100 mm. standard length. Occasionally, malformed dorsal and anal fin-ray elements and missing rays were encountered—these are discussed under Comparison of Species, page 428. Malformed rays were enumerated in the total soft-ray counts. Counts for fins with missing soft-rays, indicated by a ray base without a ray, or by an abnormally wide space between any two rays, were not included in establishing ranges.

Tabulations showing the relation of number of dorsal soft-rays to number of anal soft-rays are used because their numbers are apparently intraspecifically correlated.

Lengths.—Measurements were made as for the dorsal spines, except on larger specimens that had developed the fleshy, scale-covered sheath along the base of the fin—in which instance the proximal point of measurement was taken at the emergence of the erected ray from above this sheath.

INTERNEURAL AND INTERHEMAL SPINES

The interneural and interhemal spines (pterygiophores) of at least the five common Atlantic species of *Caranx* possess posterior lateral projections. These are discernible in illustrations by Hollister (1941) in a lateral view from stained and cleared specimens of *ruber* (p. 43, fig. 19) and *latus* (p. 44, fig. 20).

Within certain size ranges in two of the species (*latus* and *hippos*) these projections extend above the dorsal surface of the body along both sides of the soft-rays of the dorsal and anal fins. They are similar to fin spines in appearance, although not so pointed, and are covered by little, if any, epidermis. None of the other five species studied had these projections protruded or extended above the body surface.

CAUDAL FIN

Description.—The principal rays extend to the posterior margin of the fin—the most-dorsal principal ray and the most-ventral principal ray are the only two that remain unbranched. The secondary caudal rays also remain unbranched.

Counts.—The count is given as principal rays above the median line plus those below. The number of secondary rays was determined on only a portion of the specimens examined.

Urostyle.—Described as visible in normally preserved specimens.

PECTORAL AND PELVIC FINS

Counts.—Counts were made of the fins on one side only, usually the left. Each fin contained one spine plus a number of soft-rays. The spines of the paired fins were similar in construction to each other and to the spines of the dorsal and anal fins.

Lengths.—Measurement of the longer of each of the paired fins was recorded if the lengths varied. Each fin was measured from the insertion of its spine to the tip of the longest ray, with the fin against the body.

BODY DEPTH

Depth at pelvic.—Measured as the distance between the ventral midline of the body at the insertions of the pelvic fins and the origin of the first dorsal spine.

Depth at first anal spine.—Measured as the distance between origin of the first anal spine and origin of the spine of the second dorsal fin (the ninth dorsal spine.)

Description.—Both depths are near-vertical. The depth at pelvic is more subject to distortion by stomach contents, but is preferable to depth at the first anal spine, which has a more anterior location with respect to the spine of the second dorsal fin at lengths of more than 50 to 70 mm. standard length.

HEAD

Length.—Measured from the tip of the snout to the posterior edge of the fleshy portion of the operculum.

EYE

Diameter.—Measured as the maximum diameter from the anterior to the posterior inner margins of the circumorbitals.

SNOUT

Length.—Measured as the least distance from the tip of the snout to the anterior inner margin of the circumorbitals.

GILL RAKERS

Counts.—Gill-raker counts were made on the first arch, usually on the left side. A gill raker located at the junction of the upper and lower limbs was included with the count for the lower limb because the major portion of its base originates on the lower limb, and its inclusion facilitated the correlation of the numbers of upper- to lower-limb gill rakers. Rudimentary gill rakers (tubercles or very-shortened gill rakers) occurring at the origin of either limb were included in the total count for that limb. These rudimentary rakers are less definitive on larger specimens, but they could be accurately counted on the largest sizes of each species that were examined (up to 830 mm. standard length on *hippos*). Gill-raker counts on specimens less than 20 mm. were not included in the tables, although specimens between 14 mm. and 20 mm. apparently have formed the adult complement. Relation of the numbers of upper- to lower-limb gill rakers is used to show that they apparently are intraspecifically correlated.

SCUTES

Definition.—In *Caranx*, the term "completely developed scute" defines a modified scale situated along the straight portion of the lateral line. It is vertically and usually horizontally expanded with respect to other body scales, usually is thicker and harder than other body scales, and the posterior margin either terminates in a posteriorly projecting, flattened or slightly elevated spine, or ends in an apex, with the angle of the scute formed by this margin being not greater than 110° to 120°. In the following accounts, a reference to scutes having completed their development implies that they have developed the structural characters that will fit this definition. The physical development of enlarging and hardening continues with growth of the fish.

Scales in the straight lateral line which have not developed the structural characters defined here, but whose positional relationship indicates that they would have become completely developed scutes, are termed "developing scutes."

Counts.—Scutes were counted on both sides of the fish from the most-anterior to the most-posterior completely developed scute.

Relationship.—The mean of the number of scutes of the right and left sides was used because approximately 80 percent of the specimens examined showed an individual bilateral variation in this character. This variation on individual specimens examined ranged from 1 to 5 scutes in *hippos*, 1 to 4 in *latus*, *crysos*, and *ruber*, and 1 to 3 in *bartholomaei*. There was little correlation of this feature with the length of the fish, except that more variation was found at the smallest sizes (less than 30 mm. standard length) when the first scutes to complete their formation do so rapidly.

Explanation.—Some scutes immediately following the most-anterior completely developed scutes may not end in a spine or an apex—on smaller fish they have not completed development and on larger fish they may represent scutes which will never develop spines or whose weak spines have worn off; in either case they are included in the scute count.

Nichols (1920b: 29) remarked, "The most anterior scutes near the angle of the lateral line are small and poorly developed and the most posterior ones minute, so that the personal equation enters into their count somewhat." This applies more to the smaller forms, for in most specimens of more than 100 mm. the scutes are completely developed to the point of junction with the curved part of the lateral line and the terminal scute at the caudal base has a strong spine. Because of the variation in scutes in smaller fish, and because the adult complement of scutes is not present until the fish has grown to a size greater than 100 mm., I have applied an exacting definition and count. This has resulted in my counts being lower for fish of less than 100 mm. than are those usually given in the literature; but the counts on larger fish should approximate previous counts within the limits of personal bias. Use of the mean number of scutes will result in ranges being less variable than is the case when scutes are counted on only one side of a fish.

Ontogeny.—The first scutes to complete their development are located near the posterior two-thirds of the straight part of the lateral line, and the extent of development of the other scutes is graduated from these toward both ends of the lateral line.

LATERAL LINE

Measurements.—The curved part of the lateral line was measured as a chord of the arch from its junction with the upper edge of the shoulder girdle to its junction with the straight part of the lateral line. The straight part of the lateral line was measured from its junction with the curved part of the lateral line to its termination on the caudal fin; on fish less than about 16 to 18 mm. standard length, the formation had not progressed posteriorly to the caudal base, but the measurement was taken to the caudal base. Measurements were taken on both sides of the fish.

The point of junction of the two parts of the lateral line on some fish was marked by an abrupt upturning of the curved part, and on others by a gradual upturning—which forced an estimation of this point. By definition, this point occurs where the curved part bends upward from the straight part. The straight part that continues forward with no scutes or pores marking the continuation is called the false lateral line and is difficult to see on most *Caranx*.

The extension of the lateral line onto the caudal fin in the species of *Caranx* examined is contrary to a statement by Gill (1883: 488) in his description of characteristics of the family: "Lateral line continuous to and ending at the base of the caudal fin."

Ratio.—The mean of the quotients, obtained by dividing the length of the straight part of the lateral line by the length of the curved part of the lateral line from each side, was used as the mean lateral-line ratio. This is expressed by the following formula: [(straight right ÷ curved right) + (straight left ÷ curved left)] ÷ 2 = mean lateral-line ratio.

Use of three variates in determining the relationship of the lateral-line ratio to standard length illustrates the interspecific differences of the lateral line better than use of only two variates. Previous taxonomic emphasis was placed on the ratio by Nichols (1921b, 1937a, 1938b, 1939), Nichols and Breder (1927), Wakiya (1924), and others. The mean of the ratios from both sides was used because frequent and appreciable differences were found between the two sides of a fish. For example, on a 44-mm. specimen of *bartholomaei* the point of junction of the curved and straight parts of the lateral line on the left side was under the fifth dorsal ray and on the right side it was under the eleventh dorsal ray.

PREOPERCULAR SPINES

Description.—The five common species of *Caranx* possess a spine, the preopercular-angle spine, that protrudes from the posterior margin of the preoperculum in the smallest sizes examined and persists to 16 to 49 mm. standard length (the maximum size of retention is variable among the species). Fish within this range may also possess from 1 to 8 smaller spines, the preopercular upper- and lower-limb spines, arranged in graduated series on the margins of the upper and lower limbs of the preoperculum.

Ontogeny.—The preopercular spines increase in length only up to a certain size (possibly to 7 mm. in *crysos*). Above this size, the lengths diminish, due to a cessation or diminution of spine growth and ventral and posterior expansion of the preopercular margin, until the spines are completely absorbed by the preoperculum.

Counts.—Spines were counted only if they protruded from the margin of the preoperculum and were not covered by a thickened layer of skin.

Lengths.—The preopercular-angle spine (the longest preopercular spine and the last to be absorbed) was the only spine measured. The measurement taken is represented by line *a* in figure 24. The longer spine was measured for each fish that showed bilateral variation in this length; if damage was obvious, a spine was not measured.

PIGMENTATION

Descriptions of pigmentation represented in the illustrations were made from microscopic observations of preserved specimens. Most of the specimens were preserved in formalin—a few in ethyl or isopropyl alcohol. Consequently, the yellows, greens, and other shades present in living or freshly caught specimens are absent. Melanophores have apparently faded from some of the smaller specimens, and their pigment descriptions may be incomplete.

DEVELOPMENTAL STAGES

Larval.—Defined as the stage of development commencing with hatching and ending with the completion of formation of the adult complement of fin rays. A ray was considered to be completely formed when it became partially ossified, as indicated by its staining red when treated with alizarin. The secondary caudal-fin rays are the last rays to complete their formation, which progresses anteriorly. The size at termination of the larval stage was difficult to delimit because only a few larval specimens were available, larvae of all species were not identified, and intraspecific variation in the size at completion of fin-ray formation could not be determined. Study of a series of alizarin-stained specimens of *crysos* (the most complete series available) showed that the fin rays had not completed formation on fish 7.5 mm. standard length and smaller, and that the next largest specimen, 8.5 mm., and all larger specimens had adult complements of fin rays. The specimens identified as "*latus* and/or *hippos*" (see p. 487) and the two smallest specimens of *bartholomaei* apparently show a similar size on formation of the adult complement of fin rays. Of the "*latus* and/or *hippos*" series, the 8.3-mm. specimen had completed development of the fin rays and the 6.9-mm. specimen had not. The 6.0-mm. *bartholomaei* had only partially completed formation of the fin rays, the 8.1-mm. *bartholomaei* had completed the formation with the possible exception of one or two dorsal and ventral secondary caudal rays, and the 10.5-mm. *bartholomaei* had completed formation of all fin rays. By analogy, the size at transformation from larva to juvenile in *Caranx* is estimated to be about 8.0 mm. standard length.

Juvenile.—Defined as commencing with the end of the larval stage and terminating with the attainment of sexual maturity. Size at the juvenile–adult transition stage has not been determined for any species because of the scarcity of records and specimens of mature individuals (the smallest adult recorded is a 225-mm. *crysos*). The juvenile fish develop body bars (blotches in *bartholomaei*) at about 15 to 20 mm. that persist to about 100 to 200 mm.; the size at disappearance of the bars varies with the species. The loss of these bars may have some connection with the onset of sexual maturity. Spines on the preoperculum are present on larval forms and disappear during the juvenile stage (between 16 mm. and 45 mm., varying with the species). These spines are considered larval structures that persist into the juvenile stage rather than a character that delimits the larval stage.

Adult.—Defined as commencing with the onset of sexual maturity.

KEY TO WESTERN ATLANTIC SPECIES OF *CARANX*

A key that would identify the seven species at all sizes could not be constructed because a complete size series was not available for comparison. The following key is intended for use with specimens larger than approximately 14 mm. standard length, the minimum size at which counts of gill rakers can be considered adequately accurate for taxonomic separation (fig. 2). The adult complements of dorsal and anal soft-rays have completed formation by 8 mm. (fig. 1). Although *latus* and *hippos* were not separated in specimens less than 10 mm., a "*latus* and/or *hippos*" series can be distinguished as having a greater depth at pelvic than does *crysos* or *bartholomaei* (fig. 9). Below 10 mm., the second anal spine is shorter in *bartholomaei* than in *crysos* (fig. 4).

A. Lower-limb gill rakers 31 to 35 ---------- *ruber*,
(D. 26 to 30; A. 23 to 26; G. R. 10 to 14 + 31 to 35)

AA. Lower-limb gill rakers, 23 to 28

B. Mean number of scutes more than 35 on specimens larger than 50 mm. Mean lateral-line ratio more than 1.0. Dorsal-fin third spine shorter than first soft-ray (on specimens larger than 70 mm.) ---------- *crysos*,
(D. 22 to 25; A. 19 to 21; G. R. 10 to 14 + 23 to 28)

BB. Mean number of scutes less than 35 on specimens larger than 50 mm. Mean lateral-line ratio less than 1.0. Dorsal-fin third spine longer than first soft-ray on specimens larger than 70 mm ---------- *dentex*,[1]
(D. 24 to 27; A. 20 to 23; G. R. 11 to 13 + 26 to 28)

AAA. Lower-limb gill rakers 16 to 21

C. Dorsal soft-rays 25 to 28 ---------- *bartholomaei*,
(D. 25 to 28; A. 21 to 24; G. R. 6 to 9 + 18 to 21)

CC. Dorsal soft-rays 19 to 23

D. Color brown to sooty black ---------- *lugubris*,[2]
(D. 21 to 23; A. 17 to 20; G. R. 6 or 7 + 19 to 21

DD. Color green, yellow, and silver in adults; dark body bars in juveniles to more than 100 mm.; never completely brown or black

E. Chest completely scaled on specimens larger than 20 to 25 mm. Pigment of first dorsal fin concentrated between first and fourth spines in specimens about 17 to 45 mm. Pigment of posterior three body bars terminates immediately below straight lateral line on most specimens between about 20 to 60 mm ---------- *latus*,
(D. 19 to 22; A. 16 to 18; G. R. 6 or 7 + 16 to 18)

EE. Chest with only a small patch of scales before pelvics on specimens larger than 25 mm. (fig. 85). Pigment of first dorsal fin spread over entire fin on specimens about 17 to 45 mm. Pigment of posterior three body bars extends to base of anal fin on specimens between about 15 to 60 mm ---------- *hippos*,[3]
(D. 19 to 21; A. 16 or 17; G. R. 6 to 9 + 16 to 19)

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[1] Specimens of *dentex* of less than 87 mm. standard length apparently have not been described, and characters suggested for use below this size are speculative. A partial separation of *crysos* and *dentex* may be effected by the number of dorsal and anal soft-rays: *crysos* with D. 22 or 23, A. 19 and *dentex* with D. 26 or 27, A. 22 or 23.

[2] Specimens of *lugubris* below 240 mm. standard length apparently have not been described. Above this size *lugubris* can be separated from *latus* and *hippos* by its blunter profile, higher mean lateral-line ratio (see fig. 93), and longer second dorsal fin lobe or first soft-ray length. A partial separation may be effected by numbers of dorsal and anal soft-rays and lower-limb gill rakers: *lugubris* with D. 23, A. 19 or 20, G. R. 20 or 21, and *latus* and *hippos* with D. 19 or 20, A. 16, G. R. 16 to 18. A completely scaled chest separates *lugubris* from *hippos*.

[3] A partial separation of *latus* and *hippos* may be effected by mean number of scutes (fig. 13) and mean lateral-line ratio (fig. 14) on specimens larger than 16 mm. and by body depth at pelvic (fig. 8) for specimens smaller than 17 mm. It is suggested that coordinate points of a questionable specimen be plotted on these figures—a value that does not fall within the overlapping range of the estimated perimeters will indicate a specific identity.

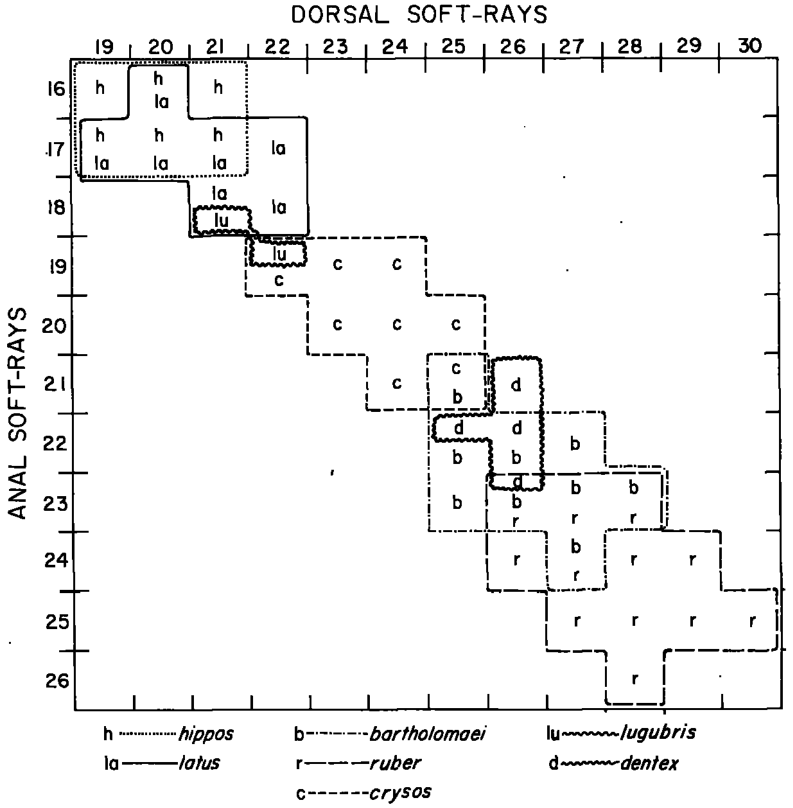

FIGURE 1.—Correlation of dorsal soft-rays and anal soft-rays for seven species of *Caranx*.

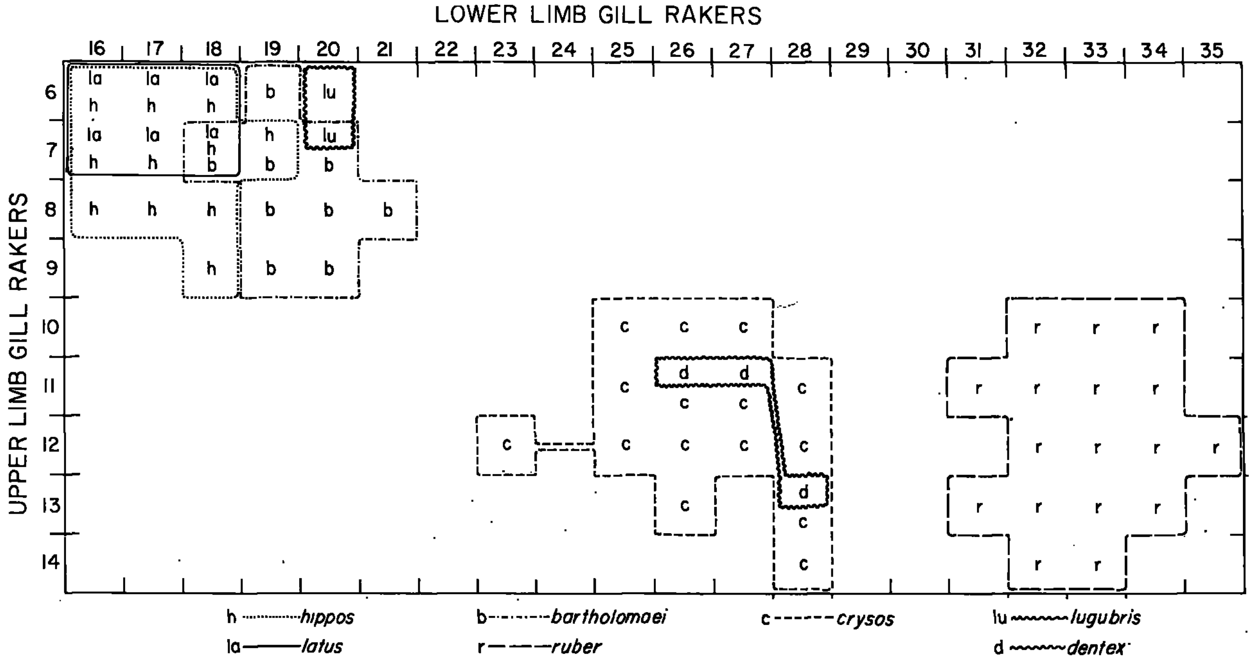

FIGURE 2.—Correlation of lower-limb gill rakers and upper-limb gill rakers for seven species of *Caranx*.

COMPARISON OF SPECIES

The five common species of *Caranx* in the Atlantic off the United States are compared with respect to selected characters—comparisons of *dentex* and *lugubris* with these are less complete. Regression lines for selected characters show trends of differences between the species, but in most instances they are not applicable to taxonomic separation because of the overlapping of individual measurements. Descriptions and comparisons apply to the size ranges given for each species.

Comparison of a series of morphometric characters of larval carangids morphologically similar to *Caranx* showed a converging of body proportions around 4 to 5 mm. standard length. Only species of *Decapterus* and *Selar* were compared, but gross study of other larger carangid larvae and juveniles indicated that species of *Trachurus*, *Chloroscombrus*, and *Hemicaranx* would follow the same trend. No suitable meristic characters were discovered to separate the genera at this size. A treatment of the larvae of most of the species in the family would be necessary to assure generic and specific separation below 5 mm. standard length, and the majority of these are undescribed. Consequently, the series of *crysos* and of the form referred to as *Caranx* sp. ("*latus* and/or *hippos*") were begun with specimens of 5.4 mm.; but a 3.8-mm. specimen that is suspected to be *crysos* and a 4.9-mm. specimen that may belong to the "*latus* and/or *hippos*" group are illustrated. A 6.0-mm. form is the smallest one referred to *bartholomaei*, but an 8.1-mm. specimen is the smallest definitely identified *bartholomaei*. The smallest *ruber* is 12.4 mm. The smallest *latus* is 16.1 mm., but a specimen between 12.7 and 13.0 mm. is tentatively referred to this species. The smallest *hippos* is 15.3 mm., but a specimen of 12.7 mm. is tentatively referred to this species. The series of specimens between 5.4 and 8.3 mm. labeled "*latus* and/or *hippos*" represents either *latus* or *hippos*, or both species. The smallest *dentex* and only *lugubris* available for examination were 87 mm. and 242 mm., respectively.

The largest sizes examined were *crysos*, 267 mm.; *ruber*, 230 mm.; *bartholomaei*, 315 mm. (a damaged specimen) and 243 mm.; *latus*, 146 mm.; *hippos*, 830 mm.; *dentex*, 132 mm.; and *lugubris*, 242 mm.

CHARACTERS

Numbers preceding discussions of meristic characters are the counts or ranges found in the seven species combined. All body lengths are given in standard length unless otherwise noted.

Scales on chest.—All species have fully scaled chests except *hippos* which has a patch of scales anterior to the pelvics on an otherwise scaleless chest (fig. 85).

Dorsal spines.—VIII and I. Rarely 6 or 7 spines were counted in the first dorsal fin, and on such specimens the position of the missing spine or spines could usually be determined. The third spine averages the greatest length of the first dorsal-fin spines on specimens more than 30 to 40 mm. standard length; below this size it is exceeded in length only by the fourth spine. The interspinous membrane that connects the eighth and ninth spines persists to larger sizes in *crysos* and *bartholomaei* (to about 90 mm.) than in the other three species (about 75 to 80 mm.).

A composite graph of the regression lines for third dorsal spine length on standard length of the five common species is shown in figure 3. The species can be adequately compared between 20 mm. and 80 mm. *C. crysos* apparently has the fastest spine growth rate and *ruber* the slowest (0.13-mm. and 0.10-mm. increase in spine length, respectively, per 1.0 mm. increase in standard length). *C. latus* apparently averages the greatest spine length at comparable body lengths and *ruber* the least.

Anal spines.—II and I. The second spine is longer than the first in all species, except *hippos* below 20.4 mm., in which the first spine is the longer. For specimens less than 10 mm., a difference in lengths of the second anal spine is illustrated between *crysos* and *bartholomaei* in figure 4; specimens of the "*latus* and/or *hippos*" series overlap these two. The interspinous membrane connecting the second and third spines is lost at the smallest size in *hippos* (about 25 mm.) and at the largest size in *crysos* (about 45 mm.).

Dorsal soft-rays.—*C. latus*, *hippos*, and *lugubris* are separable from *bartholomaei*, *dentex*, and *ruber* by the smaller number of dorsal rays; *crysos* overlaps these two groups (fig. 1). The first soft-ray is generally the longest soft-ray of the dorsal fin on specimens above 30 to 40 mm. standard length; below this approximate size it is usually exceeded in length only by the second soft-ray.

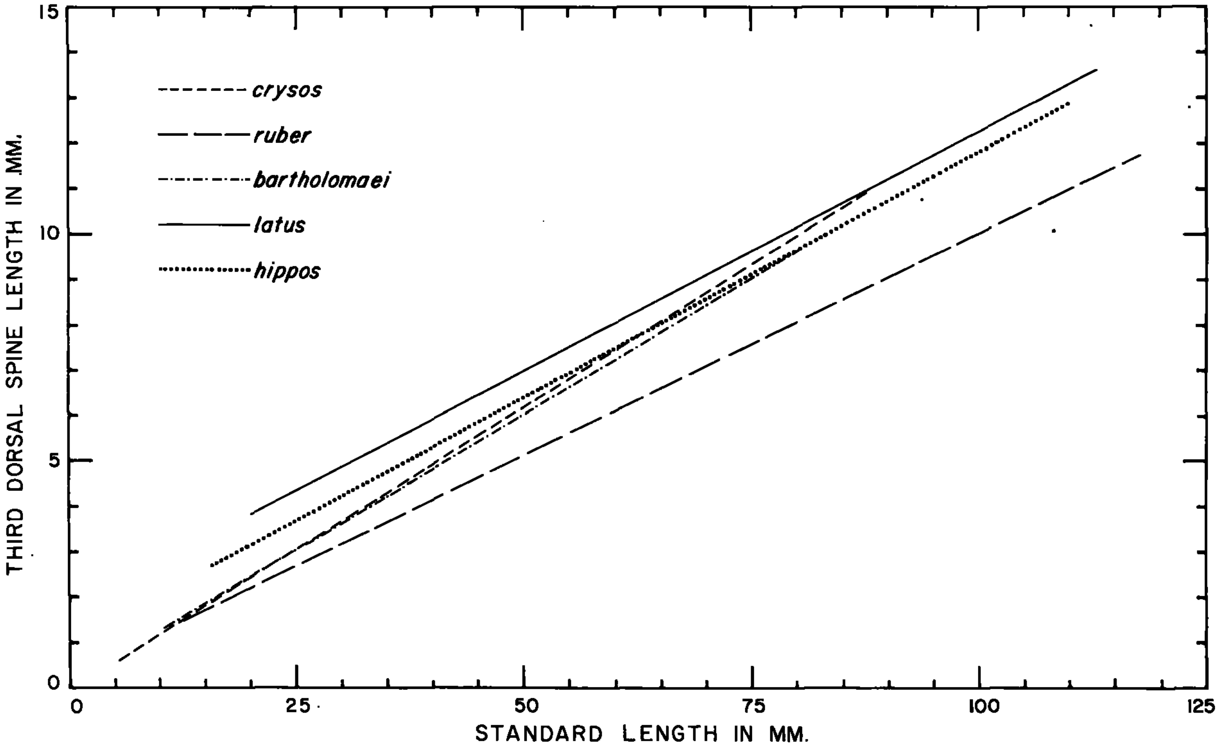

FIGURE 3.—Comparison of the regression lines for the relation of length of the third dorsal spine to standard length for five species of *Caranx*.

A composite graph of the regression lines for length of the first dorsal soft-ray on standard length of the five common species is shown in figure 5. The species can be adequately compared between about 32 mm. and 83 mm. standard length. *C. latus* apparently has the fastest soft-ray growth rate and *ruber* the slowest (0.21-and 0.12-mm. increase in soft-ray length, respectively, per 1.0-mm. increase in standard length). *C. hippos* apparently averages the greatest soft-ray length at comparable body lengths to about 80 mm. where it is equaled and at a larger size exceeded by *latus*. Above approximately 38 mm., *ruber* apparently averages the least soft-ray length at comparable body lengths.

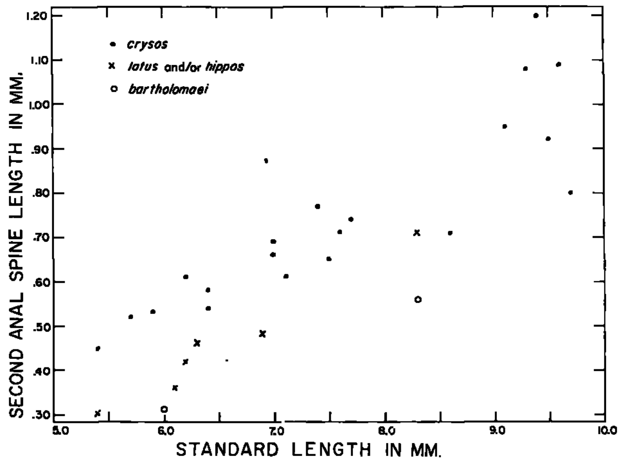

FIGURE 4.—*Caranx crysos*, *Caranx* sp. ("*latus* and/or *hippos*"), and *C. bartholomaei*: Relation of length of the second anal spine to standard length for specimens smaller than 10 mm. standard length.

The greater average length of the first soft-ray of *latus* and *hippos* above approximately 50 mm. standard length (fig. 5) expresses the more pronounced fin lobe of these two species as compared with that of *crysos*, *ruber*, and *bartholomaei*. The lobe of *lugubris* may be even more pronounced (fig. 98). *C. dentex* differs from the other six species in lacking a distinct lobe, and in having the third dorsal spine longer than the first dorsal soft-ray (figs. 25 and 97).

Anal soft-rays.—*C. latus*, *hippos*, and *lugubris* are separable from *bartholomaei*, *dentex*, and *ruber* by the lesser number of anal rays; *crysos* overlaps these two groups (fig. 1). A trend of direct relation between numbers of dorsal and anal soft-rays is shown for these members of the genus. The same intraspecific relationships of the lengths of the first and second soft-rays and interspecific

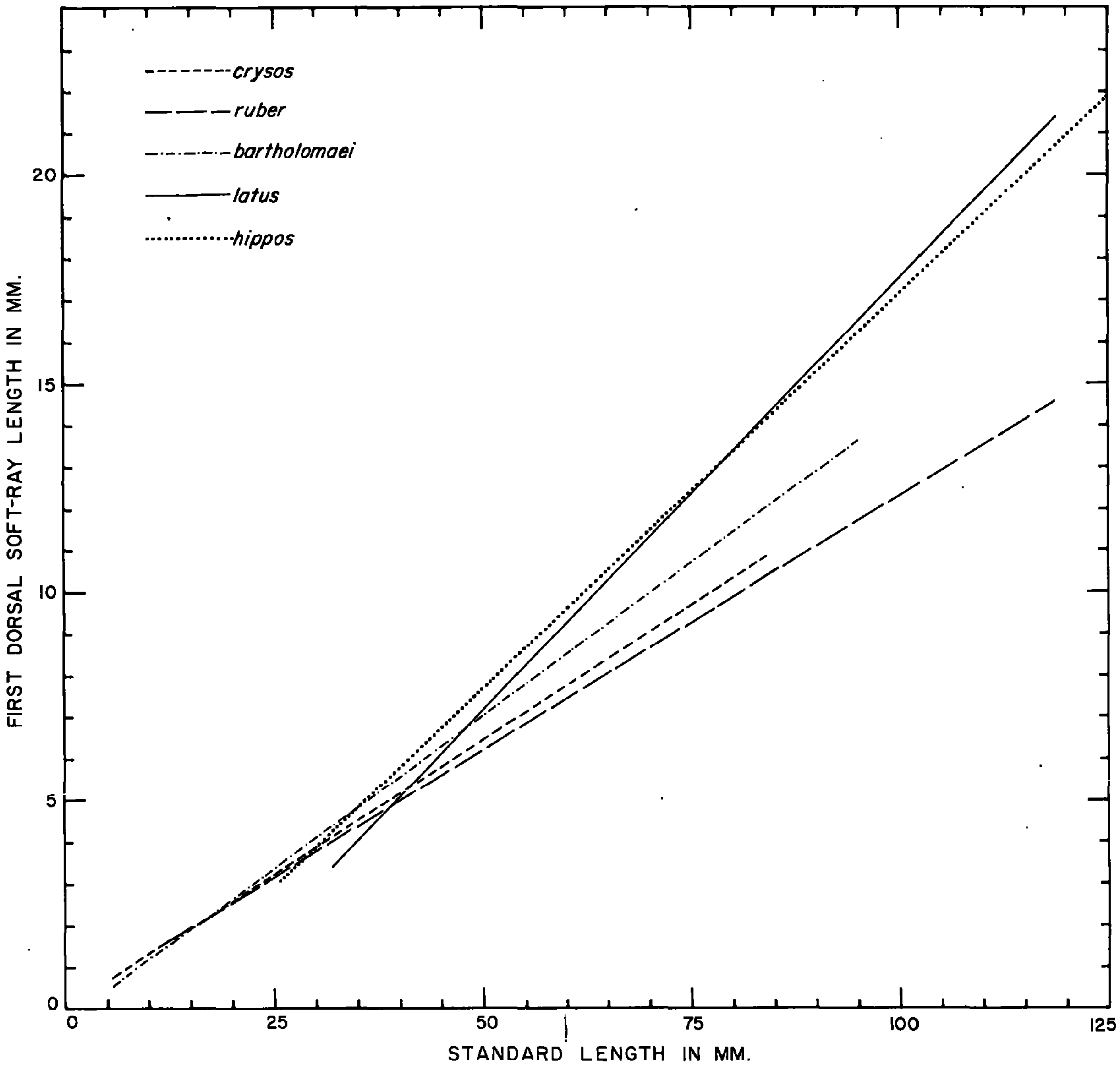

FIGURE 5.—Comparison of the regression lines for the relation of length of the first dorsal soft-ray to standard length for five species of *Caranx*.

relationships of the first soft-ray (fin lobe) lengths that apply to the dorsal soft-rays also apply to the anal soft-rays.

Distortion, loss, or absence of dorsal and anal soft-rays.—Distortion or absence of one or more soft-rays of the dorsal or anal fins were observed in all five of the common species. Some of the rays were of similar length to other rays in the fin, but were bent or thickened; others were rudimentary, their distal ends tapering to a point and of much shorter length than the normal rays. The dorsal and anal fins of fish possessing rudimentary or missing rays usually had distorted rays. Judging from the extent of distortion of these abnormal rays, they could not have regenerated to a normal size and structure. If these abnormal specimens had attained maturity, their soft-ray counts would have been confusing, because the overgrowth of the scaly sheath at the fin bases and the enlargement and near-coalescing of the rays would tend to obliterate evidence of the missing or rudimentary rays.

This abnormality was observed to the greatest degree in specimens of *ruber* from the *Gill* dip-net collections. Of 231 specimens taken, 6.9 percent had rudimentary rays in the dorsal or anal fins, or in both. Six (13.3 percent) of the forty-five dip-net collections containing *ruber* had specimens with rudimentary rays. These collections were distributed in time and place from April through August and from the Bahamas to off North Carolina. Of the six collections containing specimens with rudimentary rays, 22.2 percent of the specimens had rudimentary rays. The most aberrant of these had 8 rudimentary dorsal soft-rays and 5 rudimentary anal soft-rays; the least aberrant, 1 and none, respectively.

No rudimentary rays were found in the caudal, pectoral, or pelvic fins, although specimens with extremely distorted or rudimentary dorsal and anal rays frequently also had misshapen caudal and pelvic rays. Other morphometric characters of these fish were within the range of predicted normality. The size range of specimens examined with aberrant rays was 23 to 77 mm.

Interneural and interhemal spines.—Posterior lateral projections of these spines protrude above the body surface along the bases of the dorsal and anal soft-rays in *latus* and *hippos*, at least within the following size ranges, 16.1 to 141 mm. and 15.3 to 164 mm. They were not present in this protruded manner in any specimens of the other species.

Caudal.—9+8 principal rays. A minimum of interspecific and intraspecific variation was found in the ray counts and development of the fin.

The generic character of paired caudal keels on each side of the body—one beginning above and

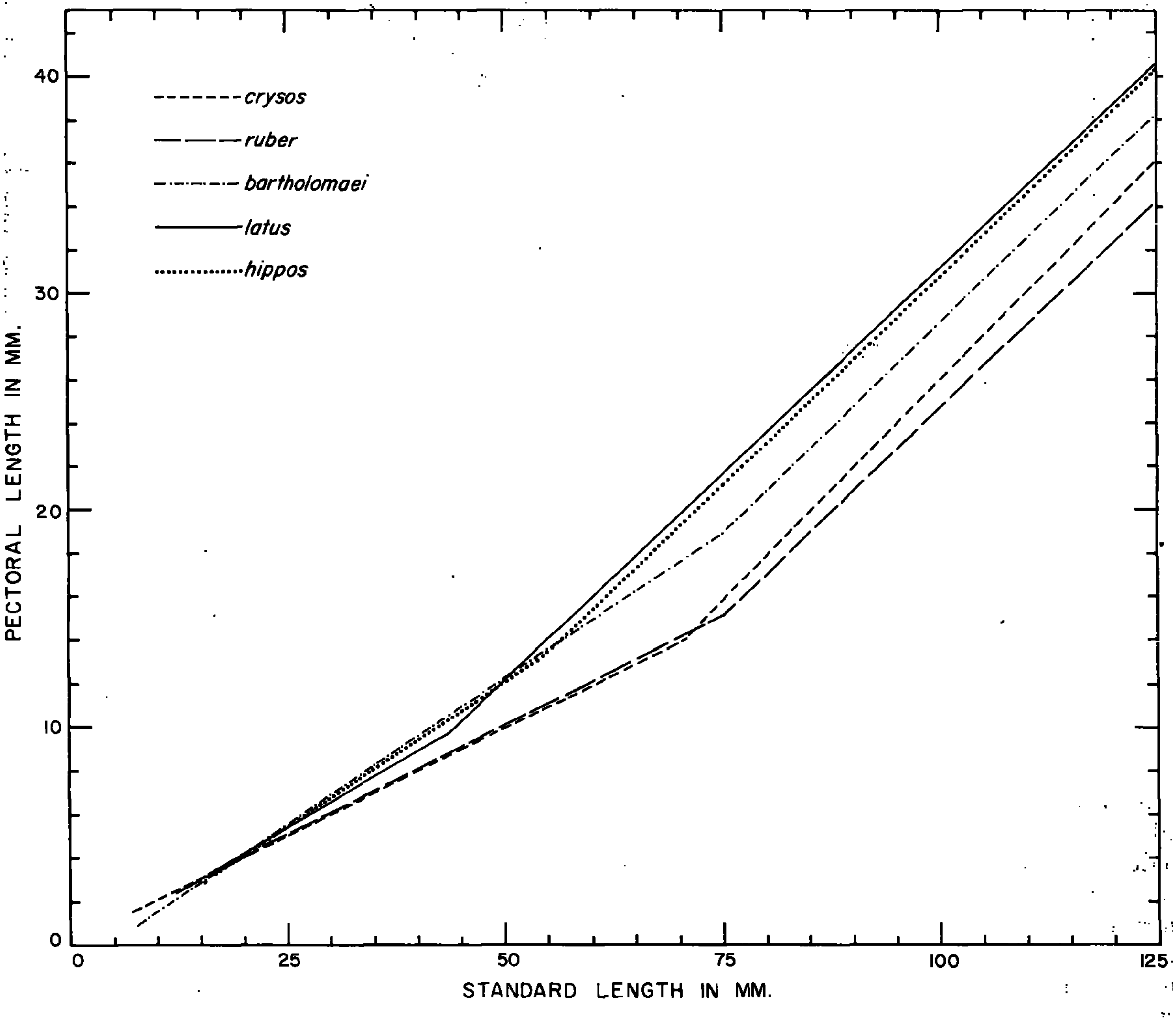

FIGURE 6.—Comparison of the regression lines for the relation of pectoral length to standard length for five species of *Caranx*.

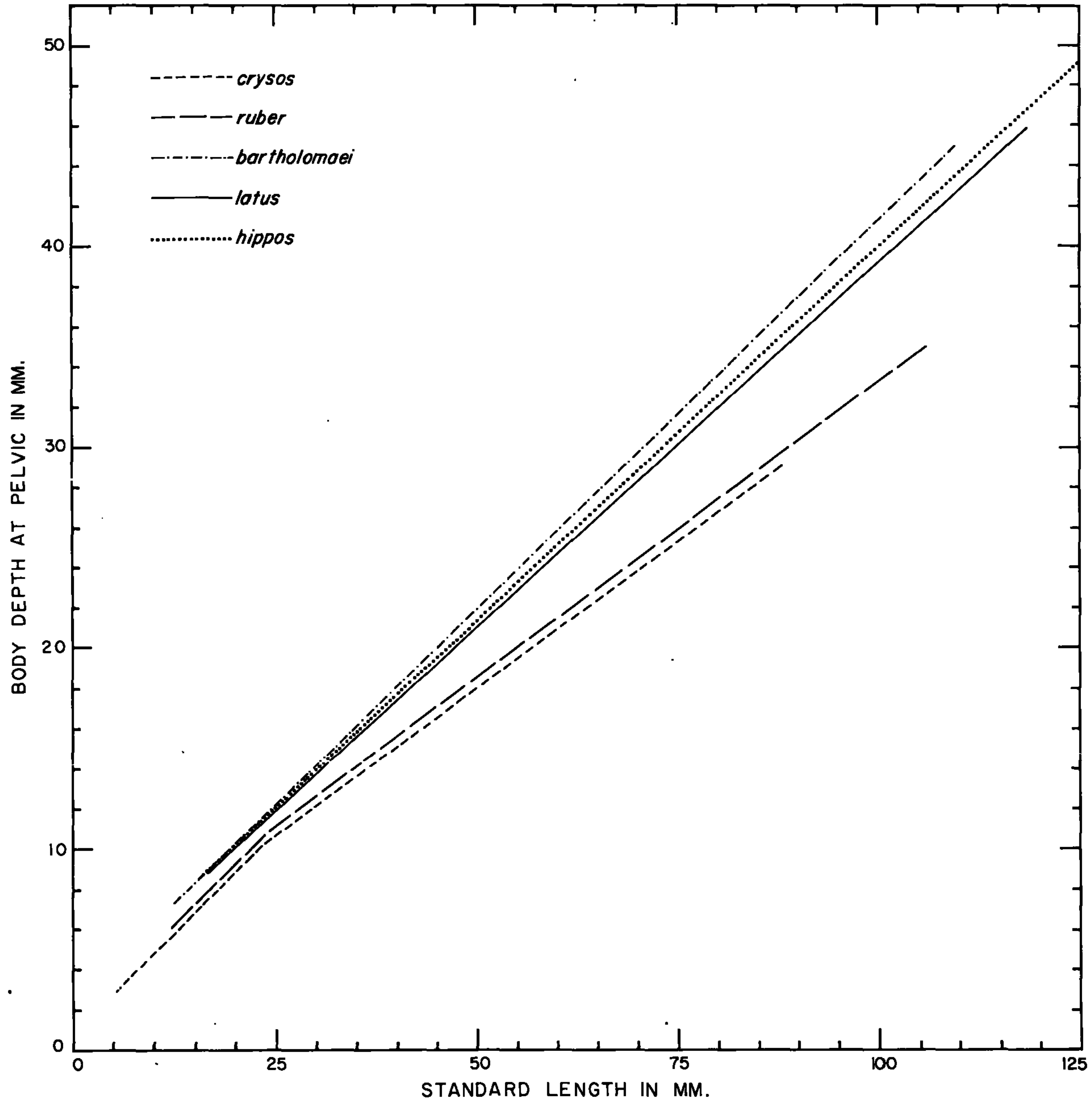

FIGURE 7.—Comparison of the regression lines for the relation of body depth at pelvic to standard length for five species of *Caranx*.

one below the lateral line on the posterior portion of the peduncle, converging toward the lateral line, and ending on the fleshy part of the caudal—is not produced until about 60 to 75 mm. standard length in the five common species examined (present on the smallest *dentex* of 78.5 mm.). This character is more pronounced at sizes larger than 100 mm. The paired caudal keels form at about 30 mm. on *crysos*, *ruber*, and *bartholomaei* (at slightly larger sizes in *latus* and *hippos*) on the fleshy part of the caudal fin posterior to the caudal base.

Pectoral.—I–18 to 23. *C. crysos* averages the greatest number of rays; *ruber*, the least.

A composite graph of the regression lines for pectoral length on standard length of the five common species is shown in figure 6. These species can be adequately compared between 16.1 mm. and 125 mm. standard length. Within this size range all species have an inflection followed by an increased pectoral growth rate. This occurs at the smallest body sizes in *latus* and *hippos* (approximately 43 mm. and 54 mm.) and at the largest in *ruber*, *bartholomaei*, and *crysos* (approximately 75 mm., 75 mm., and 70 mm.). Preceding their inflections, *bartholomaei* and *hippos* apparently have the fastest pectoral growth rates and *crysos* the slowest (0.27-mm. and 0.195-mm. increase in pectoral length per 1.0-mm. increase in standard length). Subsequent to these inflections, *crysos* apparently has the fastest pectoral growth rate and *latus* the slowest (0.41-mm. and 0.37-mm. increase in pectoral length per 1.0-mm. increase in standard length). Above approximately 20 mm., *bartholomaei*, *latus*, and *hippos* apparently average greater pectoral lengths than *crysos* and *ruber*; and above approximately 65 mm., *latus* and *hippos* apparently average the greatest pectoral length and *ruber* the least at comparable body lengths.

Pelvic.—I–5. Generally, similar pelvic lengths occur at corresponding body sizes in all species. *C. dentex* may evidence a significantly greater pelvic length than the other species above 110 or 130 mm. standard length.

Body depth.—A composite graph of the regression lines for body depth at pelvic on standard length of the five common species is shown in figure 7. At approximately 23 or 24 mm. standard length, *crysos* and *ruber* have inflections followed by a decrease in body-depth growth rate; and similar inflections are suspected to occur at smaller sizes in the other three species. The species can be adequately compared between 24 mm. and 88 mm. *C. bartholomaei* apparently has the fastest body-depth growth rate and *crysos* and *ruber* the slowest (0.39-mm. and 0.29-mm. increase in body depth per 1.0-mm. increase in standard length). *C. bartholomaei* apparently averages the greatest body depth and *crysos* the least at comparable body lengths. *C. dentex* compares in depth with *ruber* and *crysos*. The one specimen of *lugubris* has a greater depth than *hippos* at a comparable size.

Figure 8 illustrates the relation of body depth at pelvic to standard length for specimens of *latus* and *hippos* of 30 mm. standard length and smaller. The smallest specimen plotted of each (about 12.7 mm.) is damaged and tentatively identified, but these coordinates represent fairly accurate measurements. At sizes smaller than approximately 25 mm., *latus* averages a lesser body depth than *hippos*.

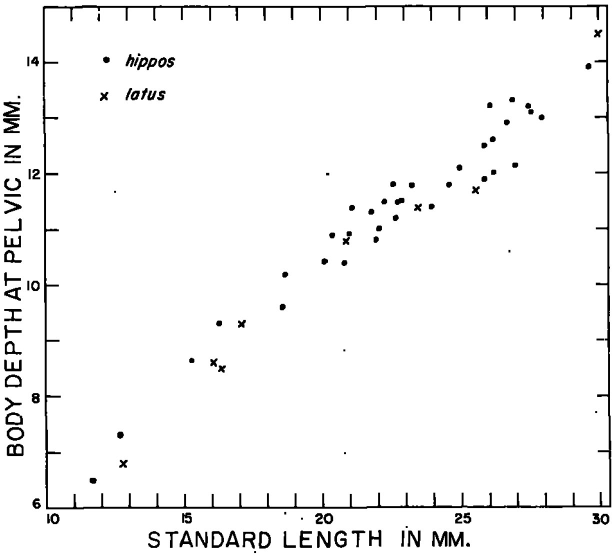

FIGURE 8.—*Caranx latus* and *C. hippos:* Relation of body depth at pelvic to standard length for specimens 30 mm. standard length and smaller.

Figure 9 illustrates differences in depth at pelvic of specimens below 10 mm.—the "*latus* and/or *hippos*" series averages a greater depth than *crysos* and *bartholomaei*.

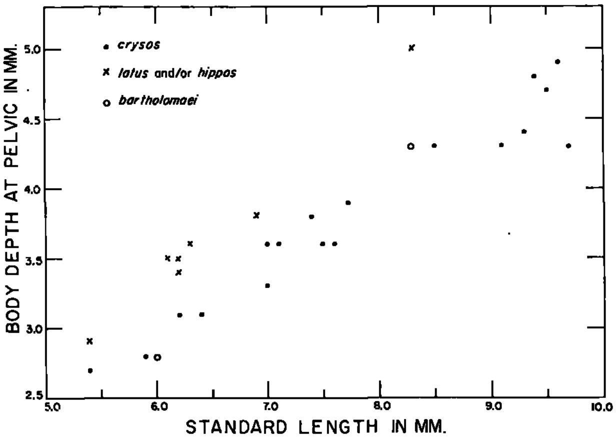

FIGURE 9.—*Caranx crysos*, *Caranx* sp. ("*latus* and/or *hippos*"), and *C. bartholomaei:* Relation of body depth at pelvic to standard length for specimens smaller than 10 mm. standard length.

Shapiro (1943: 94) graphically illustrated *hippos* (116 to 312 mm., measured from snout to least depth of peduncle) to be relatively heavier than *crysos* (96 to 203 mm., snout to least depth of peduncle) with a tendency for convergence of relative growth rates at larger sizes. He stated that these two species can be separated by their constant differential length-weight growth ratio, as well as by differences in weight at the same length.

Recorded maximum sizes of the species have not received much attention. The following maximum total lengths and weights represent a partial abstract of the literature:

crysos—about 28 in. (750 mm., Fowler 1953: 57); about 4 lb. (Bigelow and Schroeder, 1953: 376).

ruber—12.1 in. (308 mm., UF 3538).

bartholomaei—about 39 in. (1,000 mm., Fowler 1953: 57).

latus—to 22 in. (Beebe and Tee-Van, 1928: 108).

hippos—40 in. (1,020 mm., SAFI collection); maximum recorded weight 36 lb. (Bigelow and Schroeder, 1953: 376). Several eyewitness accounts of large jack crevalles of more than 5 feet in length from the Gulf of Mexico may have been this species. Stewart Springer reported (personal communication) having preserved and mounted a 41-lb. *hippos* caught off the Mississippi coast.

dentex—24 in. (Jordan and Evermann, 1896: 927).

lugubris—about 39 in. (about 1,000 mm., Fowler 1953: 58); 15.5 lb. (Woods and Kanazawa, 1951: 631).

Head length.—A composite graph of the regression lines for head length on standard length of the five common species is shown in figure 10. At approximately 22 mm. standard length, *crysos*

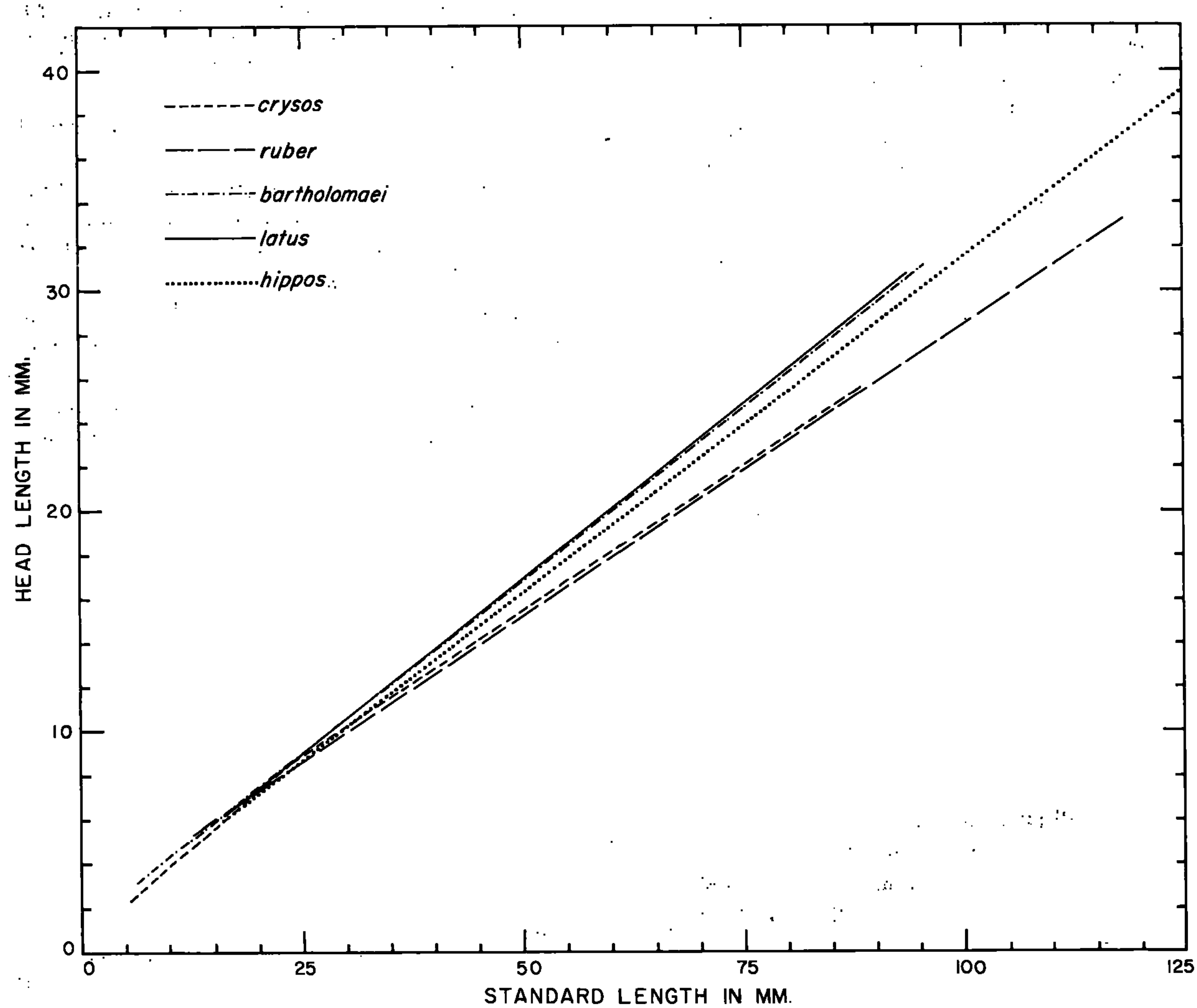

FIGURE 10.—Comparison of the regression lines for the relation of head length to standard length for five species of *Caranx*.

has an inflection followed by a decrease in head growth rate; and the other species evidenced a single regression line within the size ranges that were considered for each. The species can be adequately compared between about 25 mm. and 88 mm. standard length . *C. latus* apparently has the fastest head growth rate and *crysos* the slowest (0.32-and 0.26-mm. increase in head length per 1.0-mm. increase in standard length). *C. bartholomaei* and *latus* apparently average the greatest head lengths and *crysos* and *ruber* the least at comparable body lengths.

Eye diameter.—A composite graph of the regression lines for eye diameter on standard length for the five common species is shown in figure 11. Inflections occur in this relationship for *crysos*, *ruber*, and *hippos* at approximately 22 mm., 34 mm., and 55 mm. standard length; and *bartholomaei* and *latus* evidenced no inflections in the size range of each that was treated statistically. The species are adequately comparable between approximately 16 mm. and 83 mm. standard length. Above 22 mm., *bartholomaei* apparently has the fastest eye growth rate and above 34 mm., *ruber* apparently has the slowest (0.095-mm. and 0.058-mm. increase in eye diameter per 1.0-mm. increase in standard length). *C. bartholomaei* and *latus* apparently average the greatest eye diameter and *crysos* and *ruber* the least at comparable body lengths.

A decrease in the eye growth rate of *bartholomaei*, as suggested later, causes *latus* to average the greatest eye diameter above approximately 100 mm.; and the large eye size of *latus* has earned for it the common name of "horse-eye jack."

Snout length.—A composite graph of the regression lines for snout length on standard length of the five common species is shown in figure 12. The species can be adequately compared between 16 mm. and 89 mm. standard length. *C. bartholomaei* apparently has the fastest snout growth rate and *crysos* and *hippos* the slowest (0.11-mm. and 0.08-mm. increase in snout length per 1.0-mm. increase in standard length). Above approximately 20 mm. standard length, *bartholomaei* apparently averages the greatest snout length and *hippos* the least at comparable body lengths. *C. dentex* may average a snout length similar to that of *bartholomaei*.

Gill rakers.—The relation of the numbers of

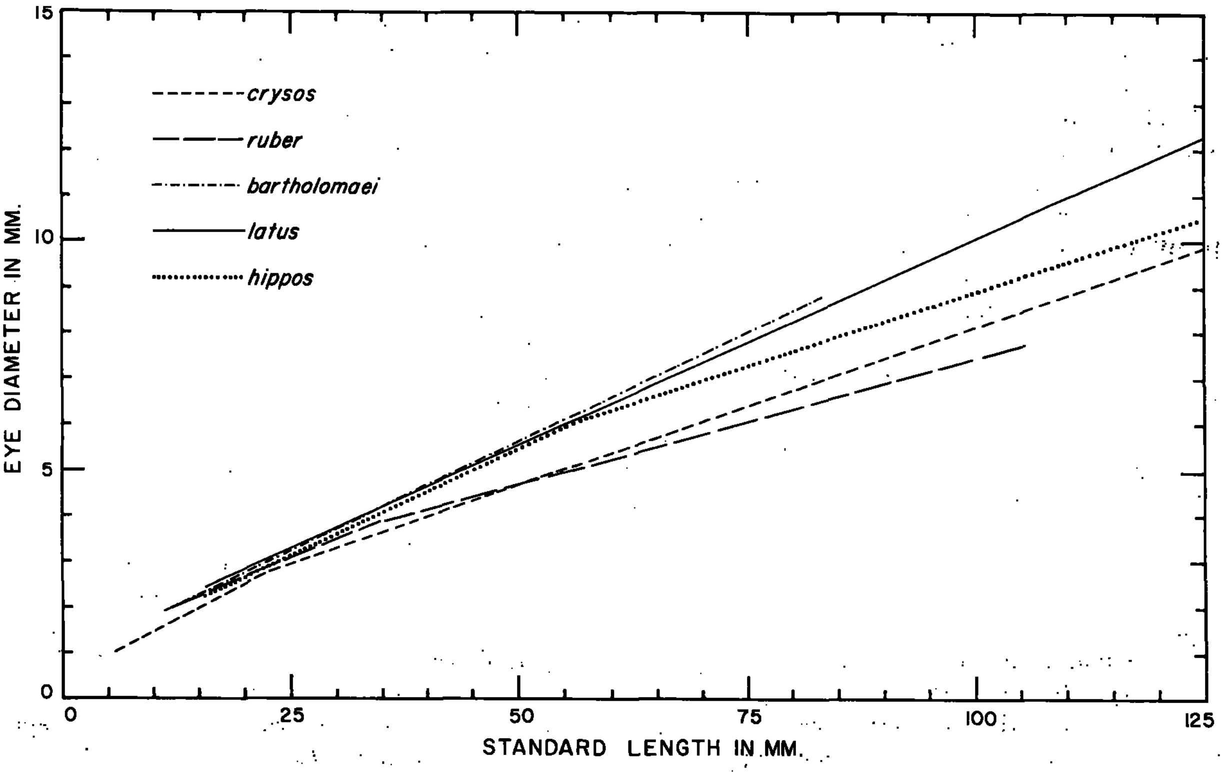

FIGURE 11.—Comparison of the regression lines for the relation of eye diameter to standard length for five species of *Caranx*.

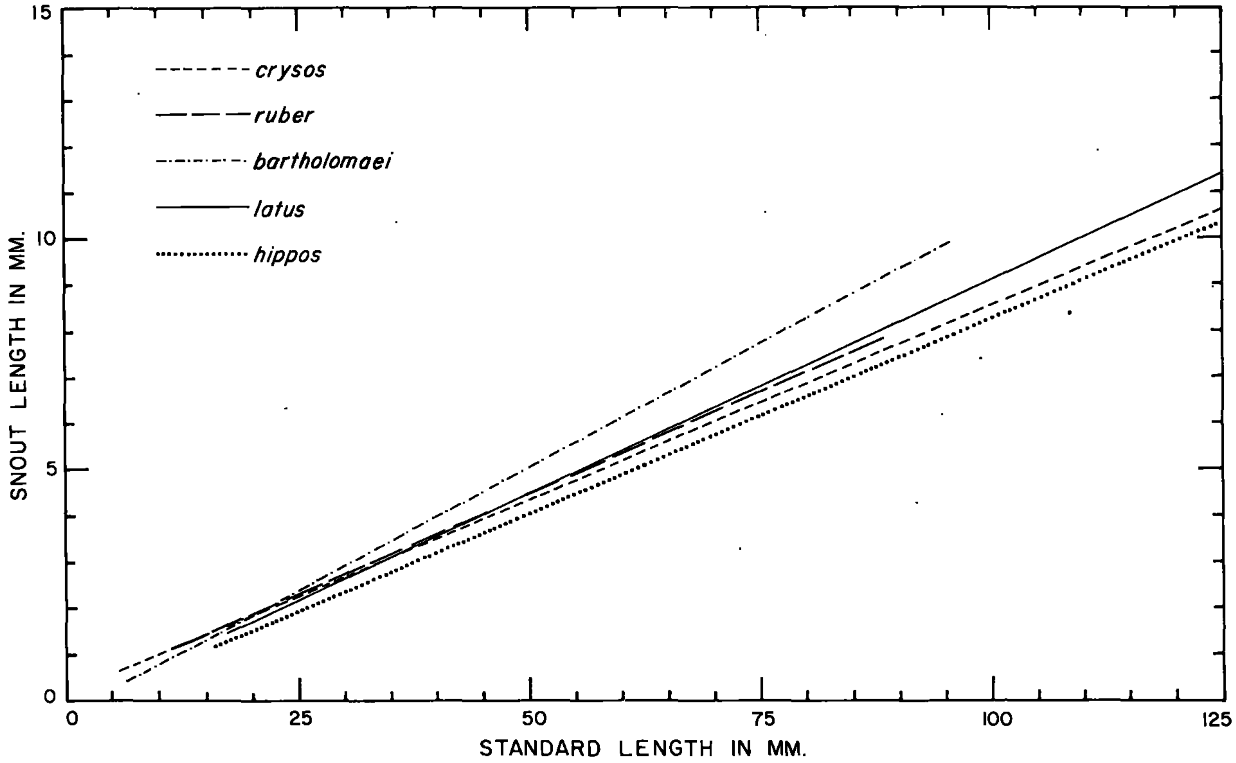

FIGURE 12.—Comparison of the regression lines for the relation of snout length to standard length for five species of *Caranx.*

lower-limb to upper-limb gill rakers (fig. 2) divides the seven species of *Caranx* into three distinct taxonomic groups: (1) *latus*, *hippos*, *bartholomaei*, and *lugubris;* (2) *crysos* and *dentex*; and (3) *ruber*. A general trend of a direct relation between upper-limb and lower-limb gill rakers is apparent, but this relation is not as sharply defined as is the dorsal ray–anal ray relation.

It is estimated from examination of many small specimens that the full complement of gill rakers for an individual fish will be formed by a size of 14 mm. Three of the species, *bartholomaei*, *latus*, and *hippos*, exhibit a tendency for gill rakers at the origins of both limbs to become smaller or rudimentary with growth, but *crysos* and *ruber* do not.

Branchiostegals.—Branchiostegal rays were counted on more than 300 specimens, representing all species examined. Seven rays were found on each side in all counts made—the number reported as generally characteristic of the family.

Scutes.—The estimated perimeters of the ranges of the mean number of scutes evidence appreciable overlapping in the individual species (fig. 13); but this character may be used for interspecific identification. A few scutes have completed their individual development on *hippos* and *latus* by 15.3 mm. and 16.1 mm., respectively. The smallest size at which completely developed scutes may be present on these two species is unknown; probably it is around 13.5 mm. The first scutes to complete their development on the other three common species do so between about 18 mm. and 24 mm. As predicted by the perimeters, the range of the mean number of scutes of *crysos* does not overlap that of *ruber* or *bartholomaei* above 25 mm., and does not overlap that of *hippos* above about 35 mm., and of *latus* above about 55 mm.; the range of *latus* does not overlap that of *ruber* or *bartholomaei* and averages a greater number of scutes, but it overlaps *hippos* at all sizes; the range of *hippos* does not overlap that of *ruber* or *bartholomaei* below about 25 mm., but does above this size; and the ranges of *ruber* and *bartholomaei* overlap at all sizes. The four specimens of *dentex* show an overlap in this character with *hippos*, *ruber*, and *bartholomaei*, but the true range for the species may be below that of *latus*. An estimated range of 26 to 33 scutes for *lugubris* (from the specimen examined and published accounts) is similar to that of *hippos* and overlaps all but *crysos* in this character.

The relationship of the number of scutes and length of fish has been dealt with for another member of the family. Blegvad (1944) suggested that the number of scutes of *Selar kalla* (Cuvier) increased with the total length. Bapat and Prasad (1952: 114) combined their observations with Blegvad's and showed a scute increase from 21 to 22 at 35 mm. total length to about 40 at about 128 to 134 mm. total length.

Lateral line.—As shown by the estimated perimeters of the ranges of the mean lateral-line ratios (fig. 14), a slight overlap of *crysos* and *latus* with *hippos* occurs in this character. The interspecific relationships of the mean lateral-line ratios are similar to those of the mean number of scutes for the five common species of *Caranx*; i. e., the longer the length of the straight lateral line relative to the length of the curved lateral line, the greater the number of scutes. The specimens of *dentex* and *lugubris* do not conform to this—the range of the

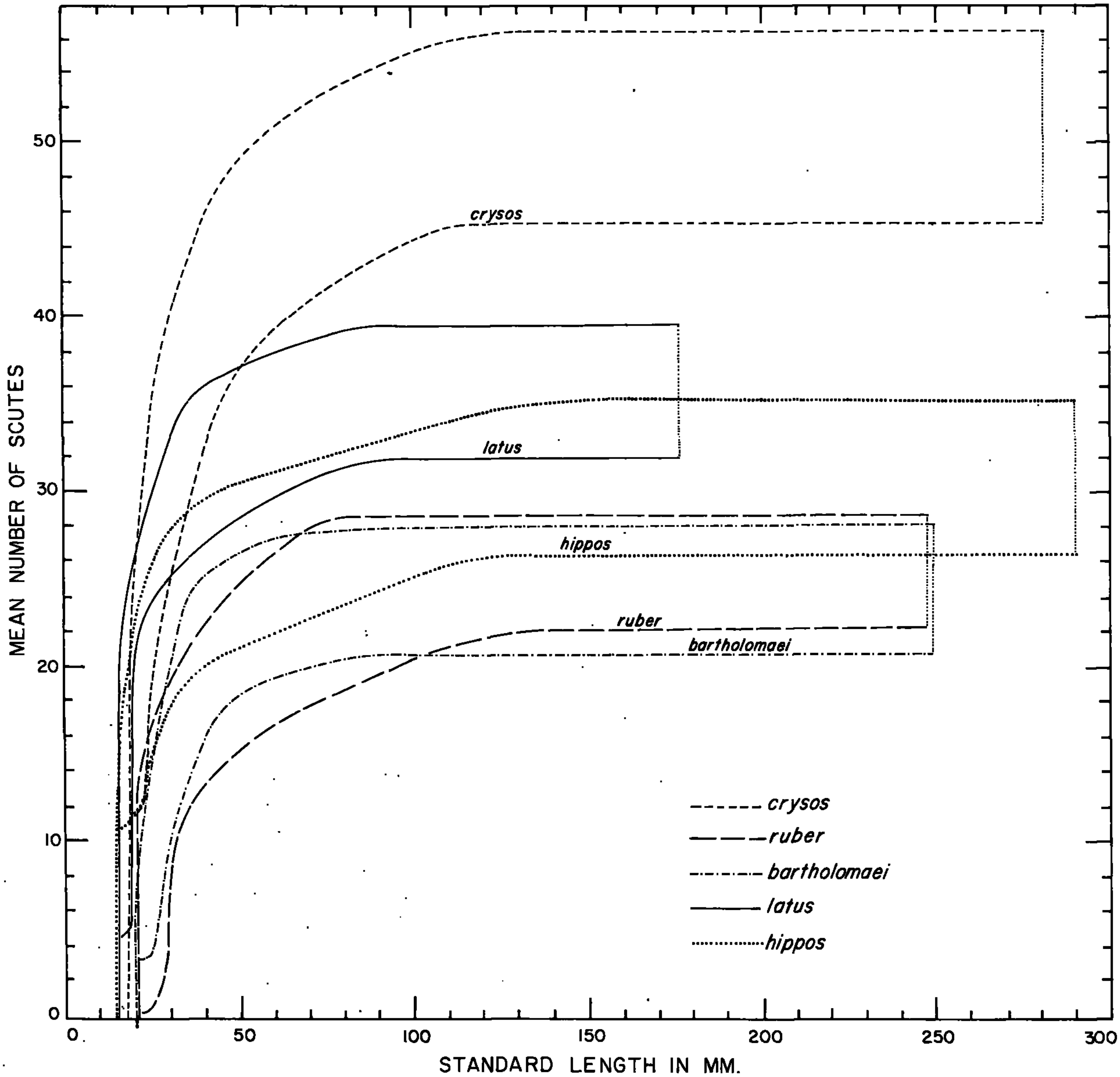

FIGURE 13.—Comparison of the variations of the mean number of scutes with respect to standard length for five species of *Caranx*.

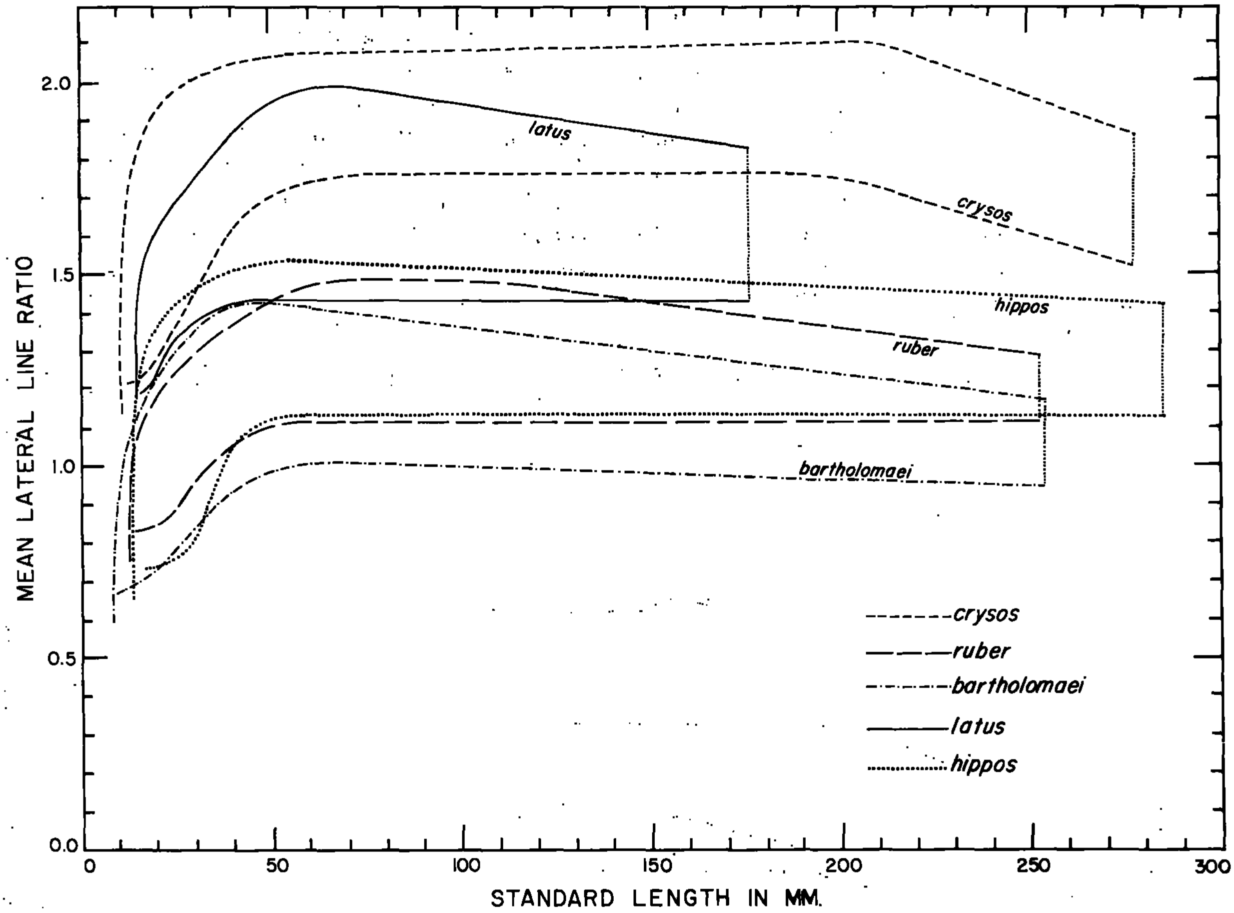

FIGURE 14.—Comparison of the variations of the mean lateral-line ratio with respect to standard length for five species of *Caranx*.

mean number of scutes in *dentex* overlaps the upper portion of this range in *bartholomaei*, while the range of the mean lateral-line ratio falls below that in *bartholomaei;* and the mean number of scutes of the one specimen of *lugubris* falls within the scute range of *hippos* while the lateral-line ratio of *lugubris* is well above the range of the lateral-line ratio of *hippos*. However, intraspecifically no obvious correlation between the mean number of scutes and the mean lateral-line ratio occurs in specimens larger than about 70 mm. standard length.

Preopercular spines.—There are indications that the preopercular-angle spines cease to grow between about 5.4 mm. and 7 mm. standard length in *crysos* and the "*latus* and/or *hippos*" series, and they begin to decrease in length between this size range and 10 mm. (fig. 15). The angle spines of *ruber* and *bartholomaei* apparently begin to decrease in length at sizes smaller than 18 mm. and 12 mm., respectively. The angle spines, the last remaining spines, have been absorbed or overgrown by the expanding margin of the preoperculum between 16 to 20 mm. in *latus*, 21 to 22.5 mm. in *hippos*, about 38 mm. in *bartholomaei*, and about 44 mm. in *crysos* and *ruber*. The number of preopercular upper-limb and lower-limb spines varies to such a great degree intraspecifically that only slight interspecific differences can be adjudged (table 1). *C. crysos* averages a higher number of spines on both limbs than do the other species. The lower limb of all species averages more spines than the upper. The number of spines on both limbs decreases above about 15 mm.—the spines on both limbs nearest the angle spine are the last to disappear.

Pigmentation.—Comparative reference to the illustrations will point out most of the interspecific differences in pigmentation of larval and juvenile forms. A few distinctions are listed here.

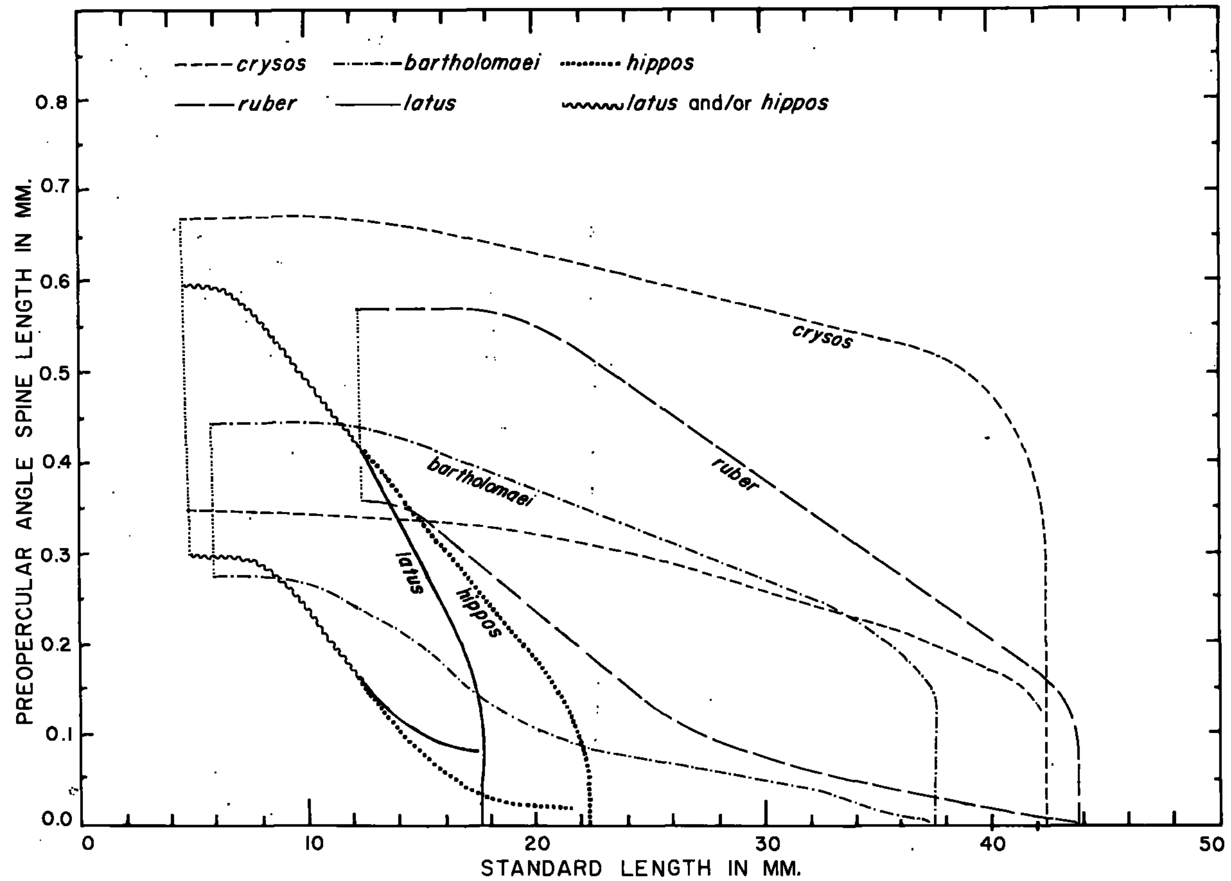

FIGURE 15.—Comparison of the variations of length of the preopercular-angle spine with respect to standard length for five species of *Caranx*.

TABLE 1.—*Ranges in numbers of spines on the upper and lower limbs of the preoperculum, by 5-mm. intervals, for five species of* Caranx

Standard length of fish	Number of preopercular spines on—									
	Lower limb					Upper limb				
	crysos	*ruber*	*bartholomaei*	*latus*	*hippos*	*crysos*	*ruber*	*bartholomaei*	*latus*	*hippos*
0.0–4.9 mm	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5.0–9.9 mm	4–6	-----	5	4–6		2–5	-----	3–4	3–4	
10.0–14.9 mm	5–7	4–6	4–6	5	?	4–5	4–5	3–5	1	?
15.0–19.9 mm	4–7	1–5	0–7	4–5	4–6	4–6	0–4	0–6	0	0
20.0–24.9 mm	2–8	1–3	3–6	0	3–5	2–7	0–4	0–3	0	0
25.0–29.9 mm	2-6	0–3	2-5	0	0	0–5	0–1	0–3	0	0
30.0–34.9 mm	0–3	0–1	3–5	0	0	0–2	0	1	0	0
35.0–39.9 mm	0–3	0	0–1	0	0	0–2	0	0	0	0
40.0–44.9 mm	2	0–3	0	0	0	0	0–1	0	0	0

(1) Specimens of *hippos* from about 20 to 45 mm. have intense pigmentation over most of the first dorsal fin; in comparable sizes of *latus* this is associated primarily with the second, third, and fourth spines.

(2) On *hippos* of 15.3 to 60 mm., the pigment of the posterior 3 bars extends nearly to the base of the anal fin; on most specimens of *latus* of more than 20 mm., these bars terminate ventrally on or slightly below the straight lateral line.

(3) The bars of juvenile *latus* larger than 26 mm. are wider than those of *hippos* of comparable size, but this character is most difficult to measure.

(4) Commonly, 5 body bars occur on *latus, hippos*, and *bartholomaei*, 6 on *ruber*, and 7 on *crysos*.

(5) The presence of body bars (and blotches on *bartholomaei*) is probably characteristic only of the juvenile stage. These bars persist to the largest sizes on *hippos*, disappearing at some size between 164 mm. and 248 mm. The bars of *latus* disappear at some size between 90.5 mm. and 116 mm., those of *ruber* at probably a little over 105 mm., and those of *crysos* at about 110 mm. The bars of *bartholomaei* begin to break up at about 28 mm.,

and its juvenile blotches persist to a little over 95 mm.

(6) The opercular spot of *hippos* is much more prominent and is definitive at a smaller body size than is that of *crysos*. The opercular spot of *latus* is less prominent than in both of the preceding species. *C. ruber* and *bartholomaei* lack an opercular spot.

(7) *C. dentex* may be distinguishable from other species by a dark-tipped upper caudal lobe at certain sizes.

(8) *C. lugubris* seems distinguishable from the other species, at least above 240 mm., by a sooty black or brownish body color.

DISTRIBUTION OF WESTERN ATLANTIC SPECIES OF *CARANX*

General Distribution

crysos: Western Atlantic—Cananeia, Sao Paulo, Brazil (Carvalho 1941: 53) to Herring Cove, Nova Scotia (Vladykov 1935: 4). ?Eastern Atlantic. ?Mediterranean.

ruber: Western Atlantic—Rio de Janeiro, Brazil (Fowler 1940: 766, as *Caranx crysos*, locality questioned), Union Island, British West Indies (Beebe and Hollister, 1935: 214), and Caledonia Bay, Panama (Breder 1925: 153) to Cape Hatteras, N. C. (text, p. 468; USNM 53109), and 39°13′ N., 71°13′ W. (Mather 1954: 293).

bartholomaei: Western Atlantic—Maceio, Brazil (Gilbert 1900: 167) to Woods Hole, Mass. (Smith 1898: 98).

latus: Western Atlantic—Rio de Janeiro, Brazil (Castelnau 1855) to Squan River (Manasquan River), N. J. (Fowler 1905b: 258).

hippos: Western Atlantic—35°30′ W. off Uruguay (Pozzi and Bordale, 1935: 164) to Musquodoboit Harbor, Nova Scotia (Vladykov 1935: 4). Eastern Atlantic. Eastern and Western Pacific. Indian Ocean.

dentex: Western Atlantic—Rio de Janeiro, Brazil (Cuvier, *in* Cuvier and Valenciennes, 1833: 87) to Bermuda (Bean 1906: 47); not on United States coast. Eastern Atlantic. Eastern and Western Pacific. Indian Ocean.

lugubris: Western Atlantic—Santos, Brazil (Miranda Ribeiro 1918: 52) to Bermuda (Woods and Kanazawa, 1951: 631); not on United States coast. Eastern Atlantic. Eastern and Western Pacific. Indian Ocean.

Distribution off Southeastern Atlantic Coast of the United States

Early juveniles of *crysos*, *ruber*, and *bartholomaei* have pelagic offshore habitats, probably directly associated with the Gulf Stream. As late juveniles, at least part of the populations of *crysos* and *bartholomaei* move into inshore waters—*crysos* is the most common *Caranx* in inshore waters along the Atlantic coast. Juveniles and adults of *ruber* maintain a pelagic offshore habitat, and the rare inshore records probably represent stray specimens. Larvae and early juveniles of *latus* and *hippos* apparently have an initial pelagic offshore habitat, but at least some of the early and older juveniles and the adults of these two species occur in inshore and even brackish-water habitats—*hippos* is the second most common *Caranx* in inshore waters along the Atlantic coast. There are no reliable records of *dentex* and *lugubris* from inshore waters along the Atlantic and Gulf coasts of the United States, but both might be expected as strays. Records of *dentex* and *lugubris* denote them to be offshore, or at least insular species.

The occurrence of young of the five common species in this area is seasonal, and the larvae of all species and the juveniles of at least *crysos*, *ruber*, and *bartholomaei* probably comprise populations which move northward in the Gulf Stream each year from about March to December. Some of the annual recruitment of these populations may result from spawning within this area, but the major recruitment to each probably comes from more southern waters that contribute to the Gulf Stream off the southeastern United States (around southern Florida, Cuba, and the Bahamas and from the eastern Gulf and the northern Caribbean). Larval and juvenile *crysos* and juvenile *ruber* are most abundant in this part of the Stream from June through August.

The factors that promote an association of larvae and juveniles of *Caranx* species with the offshore waters of the Gulf Stream are unknown. The relation of their food habits to organisms that might be associated with these waters and a tropism to the currents may be involved, and there are indications that temperature and salinity may be influencing factors. Larvae and juveniles were collected at *Gill* stations where surface temperatures ranged from 20.4° to 29.4° C. and surface salinity values ranged from 35.2 to 36.7 parts per thousand; however, at two-thirds of the stations where they were taken, the temperature range was only 27.4° to 29.4° C. and the salinity range 36.0 to 36.3 parts per thousand. Generally, the *Gill* stations closest to inshore waters at which *Caranx* specimens were taken had higher temperature and/or salinity values than successive stations closer to shore where *Caranx* were not taken. The minimum temperature and salinity values of these stations closest to inshore waters at which *Caranx* species were taken varied with each cruise, however.

Data from the dip-net collections of the *Gill* cruises are interpreted to indicate the relative distribution and abundance of the larval and juvenile stages of the five common species in this area by comparison of the number of occurrences in the collections and the total number of specimens of each species:

	Number of occurrences	*Number of specimens*
crysos	31	307
ruber	45	231
bartholomaei	20	35
latus	4	8
hippos	1	1

C. ruber is most widely distributed, but *crysos* is most abundant. *C. bartholomaei* is more restricted in both occurrence and numbers than *crysos* and *ruber*. The scarcity of *latus* and *hippos* is attributed to their apparent tendency to migrate to inshore waters at about 21 to 50 mm. standard length. The majority of these dip-net collections were made in association with floating sargassum. The collections were about evenly divided between day and night hours.

The juveniles of the five common species are frequently found in the same locality. Two or three species were taken together in 28 of the 67 dip-net collections of the *Gill* cruises that contained *Caranx* species. The following combinations occurred (number of occurrences in parentheses): *ruber-bartholomaei* (9), *crysos-ruber* (11), *crysos-ruber-bartholomaei* (5), *crysos-bartholomaei* (1), *crysos-latus* (1), *crysos-ruber-latus* (1). Records of a few stations of the M/V *Oregon* from the Gulf of Mexico, of a few collections of the U. S. National Museum, and collections of the *Combat* from the Western Atlantic added the following combinations: *bartholomaei-latus*, *bartholomaei-hippos*, *latus-hippos*, *crysos-hippos*, *crysos-latus-hippos*, *ruber-bartholomaei-hippos*, *crysos-ruber-bartholomaei-hippos*, and *crysos-ruber-latus-hippos*. In all of these collections the sizes or size ranges of concurrent species were nearly equal or overlapping.

The stomach contents of 26 fish taken by trolling on the *Gill* cruises collectively contained all five of the common species of *Caranx*. Data on these *Caranx* specimens are given in table 2. These specimens have not been included in the tables of individual species locations.

TABLE 2.—*Occurrence of* Caranx *species in the stomachs of 26 fish caught by trolling on* Gill *cruises, listed by predator species*

[An asterisk (*) indicates estimated size]

Caranx species	Standard length (mm.)	Location		Date
		N. latitude	W. longitude	
Sphyraena barracuda (Walbaum):				
ruber	*167	25°53′	77°51′	Oct. 11, 1953
hippos	21.2	26°05′	78°12′	Nov. 11, 1953
hippos (?)	12.7			
hippos (?)	*15			
hippos (?)	*18			
hippos (?)	*21			
hippos (?)	*22			
Scriola dumerili Risso: crysos(?).	*90	32°42′	78°52′	Aug. 15, 1953
Coryphaena hippurus Linnaeus:				
ruber	*76	23°40.5′	76°50′	June 19, 1954
bartholomaei	*38	23°40.5′	76°50′	June 19, 1954
bartholomaei	*40			
bartholomaei	*52			
bartholomaei	*56			
Caranx sp	*55	23°40.5′	76°50′	June 19, 1954
bartholomaei	*55	23°44′	76°54′	June 18, 1954
bartholomaei	*58			
crysos	*98	27°02′	79°23′	July 25, 1953
crysos	*115	28°04′	79°09′	July 26, 1953
ruber	*85			
bartholomaei	*83			
crysos	*100	28°04′	79°09′	July 26, 1953
crysos	*110			
ruber	*23	29°01′	80°02′	Apr. 27, 1954
ruber	33			
crysos	*51	31°33′	79°00′	Aug. 5, 1953
crysos	*52			
latus or *hippos*	*62			
crysos	*45	31°34′	79°27′	Aug. 5, 1953
crysos	*50			
ruber	*65	34°15′	74°28′	May 12, 1953
bartholomaei	*140			
Lobotes surinamensis (Bloch):[1]				
ruber	*31	26°21.2′	76°46.5′	July 19, 1953
ruber	*32			
ruber	*32			
ruber	*32			
ruber	*44			
ruber	*45			
ruber	*45			
ruber	*50			
ruber	*55			
ruber	65			
Katsuwonus pelamis (Linnaeus):				
latus	*31	25°56.5′	77°54′	June 22, 1954
latus	32			
latus	*36	25°57′	77°55′	June 22, 1954
crysos	77	26°09.5′	78°13.5′	June 22, 1954
crysos	----------			
Euthynnus alletteratus (Rafinesque):				
crysos	*25	29°07′	80°25′	Aug. 28, 1954
latus	*28	32°09′	79°28′	Oct. 25, 1953
Thunnus atlanticus (Lesson):				
hippos	28.5	26°06′	78°08′	June 22, 1954
crysos (?)	*12.3	30°20′	80°01′	June 26, 1954
Thunnus albacares (Bonnaterre):				
Caranx sp	*28	25°57.5′	77°56′	June 22, 1954
crysos	*33	26°01.5′	78°01.5′	June 22, 1954
crysos	*39			
crysos	*48			
ruber	58			
ruber	61			
ruber	73			
ruber	74			
ruber	*87			
ruber	89			
bartholomaei (?)	*51			
Caranx sp	*25			
Caranx sp	----------			
Caranx sp	*90			
ruber	49	26°06′	78°08′	June 22, 1954
ruber	60			
latus	36	28°16′	77°01′	Nov. 5, 1954

[1] About 450 mm. standard length; taken at night by dip net.

Records of Eggs, Larvae, and Early Juveniles of *Caranx* Species that Occur in the Western North Atlantic

Apparently the only published record of eggs and larvae of species of *Caranx* that occur in the Western Atlantic is by Chacko (1950: 171) in his account of plankton around the Krusadi Island in the Gulf of Mannar, India. For *Caranx hippos* (Linnaeus) he gave the following information: Spawning season, August to September; diameter of egg, 0.7 to 0.9 mm.; chief characters of egg, segmented yolk and one yellowish oil globule of 0.18 mm. diameter with dark pigments; chief characters of larva, 1.6 to 1.8 mm. in length, brown pigments on dorsal side of body, and 12 preanal myotomes. In citing this reference in his bibliography of the development of Indian fishes, Jones (1950: 129) assigned it to the synonymy of *C. sexfasciatus* Quoy and Gaimard; but his reasons for doing this are not given, and the correct identity of Chacko's specimens is uncertain.

Schnakenbeck (1931: 17, fig. 12) illustrated a 20-mm. total length specimen taken south of Crete, which he questionably identified as *Caranx fusus* Geoffroy. The illustration and soft-ray counts are very similar to the closely related, if not identical, Atlantic *crysos*. According to this observation and Tortonese's (1952) review of the Mediterranean Carangidae, the specimen is *fusus*.

Schnakenbeck (1931: 18, figs. 13 to 16) illustrated a 6-mm. total length specimen questionably identified as *C. dentex* taken between Crete and North Africa, and recorded the same identity to a 5-mm. total length specimen from around Corsica. He stated that the identification was based upon supposition. Although the specimen illustrated may belong to the genus *Caranx*, it would be better unassociated with any species designation pending the acquisition and study of identifiable series of the Mediterranean species.

Nichols (1938b: 1) illustrated and gave proportions of a 22-mm. juvenile *crysos* taken in the Gulf Stream off Bimini, Bahamas; and illustrated a 30-mm. juvenile *ruber*.

Nichols (1939) gave proportions and pigment descriptions for juveniles of five species of *Caranx* from the West Indies: *crysos*, 12 to 72 mm.; *ruber*, 13 to 62 mm.; *bartholomaei*, 16 to 51 mm.; *latus* (=*sexfasciatus*), 12 to 25 mm.; and *hippos*, 13 mm. His key to young *Caranx* of the West Indian region does not allow for changes in ratios with changes in relationships of body parts or the intraspecific variation and interspecific overlap that is characteristic of these species.

Fowler (1945: 292) misidentified a juvenile from Boca Chica, Key West, Fla., as *dentex* (under the name of *guara*)—the specimen is a 24.4-mm. *bartholomaei*.

Fowler (1950: 70) misidentified a juvenile *bartholomaei*, 17.4 mm., from northwest of Cay Sal Bank, as *latus*.

Fowler (1950: 70, fig. 3) misidentified 2 juvenile specimens of *bartholomaei*, 15.8 and 17.2 mm., from northwest of Cay Sal Bank, as *dentex* (under the name of *guara*).

Padoa, *in* Padoa et al. (1956: 54–5) reproduced the illustrations of *Caranx* which Schnakenbeck (1931) had identified as *dentex* and *fusus*, and expressed doubt on the identity of the former and concurred with the identity of the latter.

Lütken (1880: 535) briefly described differences in comparative measurements (body depth, head and pectoral lengths) between small and large sizes of three species of *Caranx: C. ruber*, under the name of *C. blochii* Cuvier; *C. hippos;* and *C. crysos*, under the name of *C. pisquetus* Cuvier. He mentioned minimum lengths of 13 mm. for *ruber* and 34 mm. for *crysos*. He (*op. cit.:* 538) said that the body bars of young *C. latus* (under the name of *C. fallax* Cuvier) disappeared comparatively early.

SPAWNING

Published data relating to the spawning of *hippos* and *crysos* are very meager, and apparently are nonexistent for the other species of *Caranx*. Spawning may occur in waters off the southeastern Atlantic coast of the United States for *latus* and *hippos* (whether this applies to one or both species is dependent in part on the specific identity of the "*latus* and/or *hippos*" series of specimens), for *crysos* and *ruber*, and possibly for *bartholomaei*. The major areas of spawning are probably to the south of this area. Since the larvae and early juveniles are associated with the Gulf Stream, spawning must occur in offshore waters of the Gulf Stream or in currents contributing to it.

The spawning season that contributes *Caranx* to this area is estimated to extend from February into September.

DESCRIPTION OF SPECIES

Numbers preceeding discussion of each meristic character are the counts or ranges found in adult fish, unless otherwise indicated. Body lengths are given in standard length unless otherwise noted. The development of all characters is described as a continuous series as far as is practical, following the "dynamic approach" used by Ahlstrom and Ball (1954: 215).

Caranx crysos (Mitchill)

(Figures 17–24)

Scomber crysos Mitchill, 1815, p. 424, pl. IV, fig. 2 (New York Bay).

Scomber chrysos, Cuvier, *in* Cuvier and Valenciennes, 1833, p. 98 (listed as synonymous with *Scomber hippos* Linnaeus; New York).

Caranx pisquetus Cuvier, *in* Cuvier and Valenciennes, 1833, p. 97 (Saint-Domingue; Cuba; Brazil).

Caranx crysos, DeKay, 1842, p. 121, pl. XVII, fig. 85 (New York).

Trachurus squamosus Gronow, *in* Gray, 1854, p. 125 (Carolina).

Caranx chrysos, Gill, 1857, p. 262 (New York market).

Caranx hippos (*non* Linnaeus), Holbrook, 1860, p. 90, pl. XII, fig. 2 (Massachusetts to Florida).

Paratractus pisquetus, Gill, 1863, p. 432 (eastern coast of United States).

Carangus chrysos, Gill, 1873, p. 803 (Cape Cod to Florida).

Paratractus pisquetos, Gill, 1873, p. 803 (Cape Cod to Florida).

Paratractus chrysos, Poey, 1875, p. 76 (Cuba).

Carangus chrysus, Jordan and Gilbert, 1879, p. 376 (Beaufort Harbor, N. C.).

Carangus pisquetos, Jordan and Gilbert, 1879, p. 376 (Beaufort, N. C.).

Carangus pisquetus, Goode and Bean, 1880, p. 339 (West Florida).

Caranx caballus (*non* Günther), Günther, 1880, p. 10 (Bermuda).

Caranx pisquetus, Goode and Bean, 1882, p. 237 (Gulf of Mexico).

Caranx chrysus, Jordan and Gilbert, 1882b, p. 970 (in key).

Carangus crysos, Kendall, 1908, p. 81 (Massachusetts, Rhode Island).

Paratractus crysos, Jordan, Evermann, and Clark, 1930, p. 272 (Cape Cod to Brazil).

Paratractos chrysos, Gunter, 1935, p. 40 (off Louisiana).

Nomenclature

Caranx crysos (Mitchill 1815) of the Western Atlantic should be recorded as distinct from the closely related, if not identical, *C. caballus* Günther (1869) of the Eastern Pacific and *C. fusus* Geoffroy-Saint-Hilaire (1809) of the Mediterranean until the true relationships of the three forms become known. This will distinguish the three populations and conform to more common usage until adequate comparisons of the three have been made.

Conflicting opinions on the relationship of *C. caballus* and *C. crysos* have been given by Nichols (1920a: 29; 1921b: 45) and Nichols and Breder (1927: 113), who considered the two forms conspecific; by Evermann and Jenkins (1891: 138) and Nichols and Murphy (1944: 243) who considered them to be subspecies; and by Jordan and Evermann (1896) and Meek and Hildebrand (1925: 348) who considered them to be distinct species.

Caranx fusus has been regarded as a distinct species endemic to the Mediterranean. Recently, Enrico Tortonese suggested (personal communication) that *C. fusus* and *C. crysos* might be the same. Ben-Tuvia (1953: 19), whose specimens from the Mediterranean off Israel were identified by Dr. J. T. Nichols, placed *C. fusus* in the synonymy of *C. crysos*. If they are the same, *C. crysos* will become a synonym of *C. fusus*. *C. crysos*, abundant in the Western Atlantic, has also been recorded from the Eastern Atlantic and West Africa (Steindachner 1894: 20; Metzelaar 1919: 265; Fowler 1936: 698; Nichols 1939: 4). If these latter records are valid, the currently enforced concept that *C. fusus* is distinct from *C. crysos* and is endemic to the Mediterranean is improbable.

Material

Measurements and counts were taken on a series of 120 specimens from 5.4 to 267 mm. standard length and meristic values were recorded for an additional 122 specimens within this size range. The 683 specimens identified are listed in table 6.

A specimen, measuring 3.8 mm. from snout to a vertical from the tip of the urostyle, tentatively identified as *Caranx* sp., and illustrated in figure 16 may be this species. The specimen has a depth at pelvic of 1.6 mm. and a preopercular-angle spine length of 0.35 mm. It was taken with several other specimens of *crysos* (USNM 164486) ranging from 5.7 to 7.7 mm. standard length, 33 miles south of Lookout Lightship in the Gulf Stream.

Four specimens of *dentex* are included and distinguished on the graphs with *crysos*.

FIGURE 16.—*Caranx* sp. larva, 3.8 mm. standard length, measured from tip of snout to vertical from tip of urostyle (USNM 164486). It is suspected to be *C. crysos.*

Characters

Dorsal spines.—VIII and I. All spines are well formed at 5.4 mm. standard length (fig. 17). The fourth spine averages the greatest length to about 37 mm.; above 37 mm., the third spine is longest. An interspinous membrane connects the first and second dorsal fins (eighth and ninth spines) to about 90 mm.

The regression of length of third dorsal spine on standard length is shown in figure 25 and table 3. A line fitted to this regression for specimens from 5.4 to 88.0 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.13-mm. increase in spine length per 1.0-mm. increase in standard length). The majority of the coordinates of specimens larger than 88 mm. fall above the extension of the calculated regression line, indicating an increase in the spine growth rate above this size.

Anal spines.—II and I. All spines are well

FIGURE 17.—*Caranx crysos* larva, 5.4 mm. standard length (*Gill* 3, Reg. 38).

TABLE 3.—Caranx crysos: *Statistics describing regressions of body parts on standard length*

$\bar{x}$=mean of independent variable x
$\bar{y}$=mean of dependent variable y
N=number of specimens
b=rate of increase of y
a=y-intercept of regression line
$Sy{\cdot}x$=standard deviation from regression (standard error of estimate)

Independent variable x	Dependent variable y	Size range of specimens (mm.)	$\bar{x}$	$\bar{y}$	N	b	a	$Sy{\cdot}x$
Standard length	Dorsal-fin spine length (3d)	5.4–88.0	30.56	3.73	97	0.126	−0.124	0.358
Do	Dorsal soft-ray length (1st)	5.6–83.5	30.65	3.98	93	.129	.038	.261
Do	Pectoral length	7.0–58.5	20.94	4.25	74	.195	.160	.244
Do	do	58.5–266	124.51	35.88	37	.406	−14.664	2.321
Do	Body depth	5.4–22.9	12.95	6.03	55	.413	.683	.289
Do	do	22.9–88.0	50.27	18.03	46	.293	3.292	.565
Do	Head length	5.4–22.9	12.95	4.93	55	.354	.349	.238
Do	do	22.9–88.0	50.27	15.56	46	.263	2.362	.332
Do	Eye diameter	5.4–30.3	15.51	2.04	67	.108	.359	.123
Do	do	30.3–145	74.23	6.34	43	.069	1.188	.414
Do	Snout length	5.4–145	38.54	3.40	109	.084	.170	.247

formed at 5.4 mm. standard length (fig. 17). The second spine is longer than the first. An interspinous membrane connects the second and third spines to about 45 mm. The relation of second anal spine length to standard length for specimens smaller than 10 mm. is shown in figure 4.

Dorsal soft-rays.—22 to 25 (table 4). The full complement is formed between about 7.5 and 8.5 mm. standard length. Segment marks are present above 6.5 mm. (fig. 18). Branching of the last ray occurs at about 8.5 mm. and of the other rays at about 17 to 20 mm. (fig. 22). The extension of the anterior 5 or 6 rays to produce the lobe begins at about 14 mm. (fig. 21). The second ray averages the greatest length to about 35 mm.; above 35 mm., the first ray is longest. The longest ray averages a greater length than the longest spine.

The regression of first dorsal soft-ray length on standard length is shown in figure 25 and table 3. A line fitted to this regression for specimens from 5.6 to 83.5 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.13-mm. increase in soft-ray length per 1.0-mm. increase in standard length). The coordinates larger than 83.5 mm. fall above the extension of the calculated regression line,

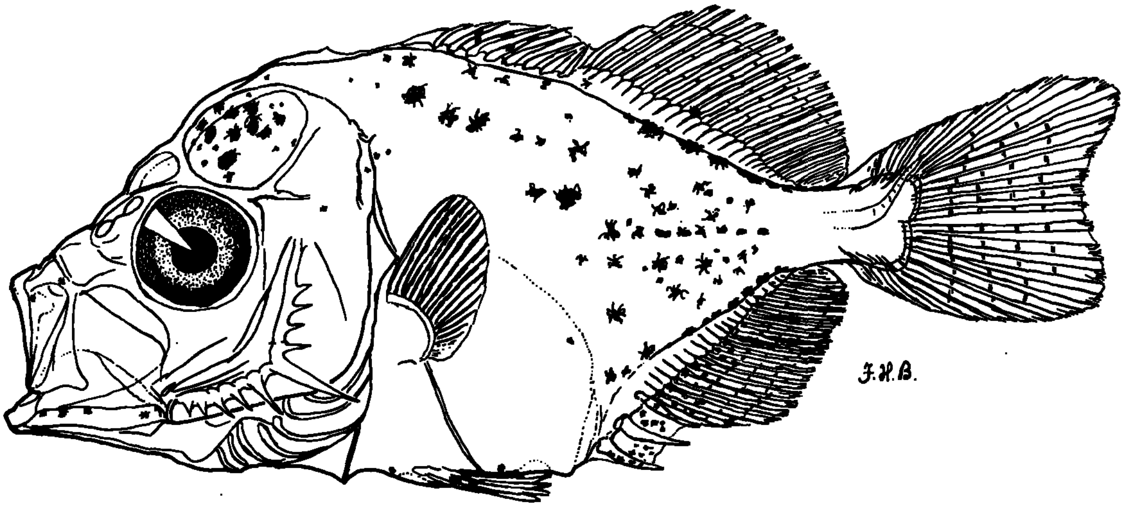

FIGURE 18.—*Caranx crysos* larva, 7.0 mm. standard length (*Gill* 3, Reg. 60).

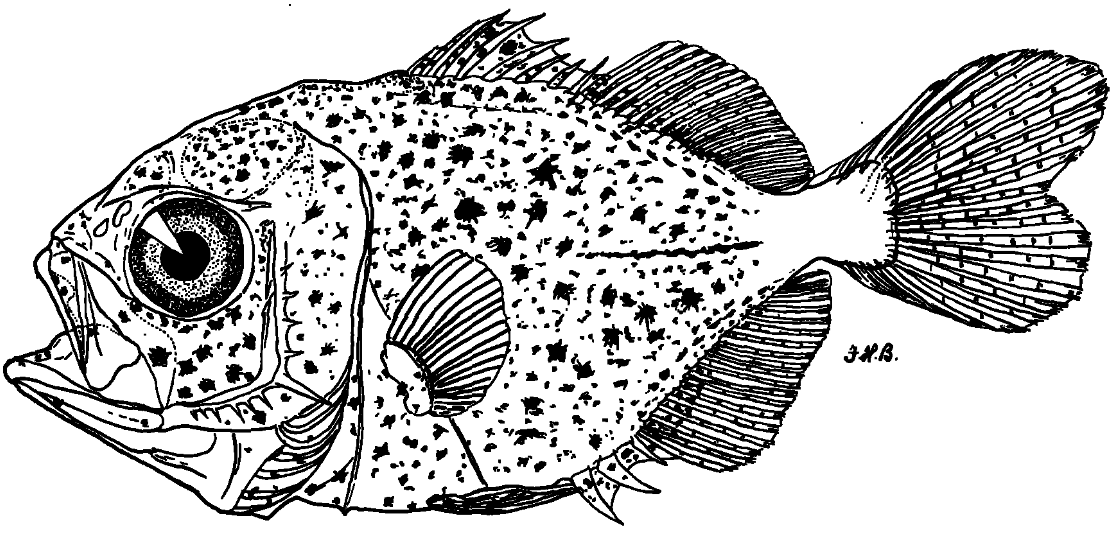

FIGURE 19.—*Caranx crysos* juvenile, 8.5 mm. standard length (*Gill* 3, Reg. 52).

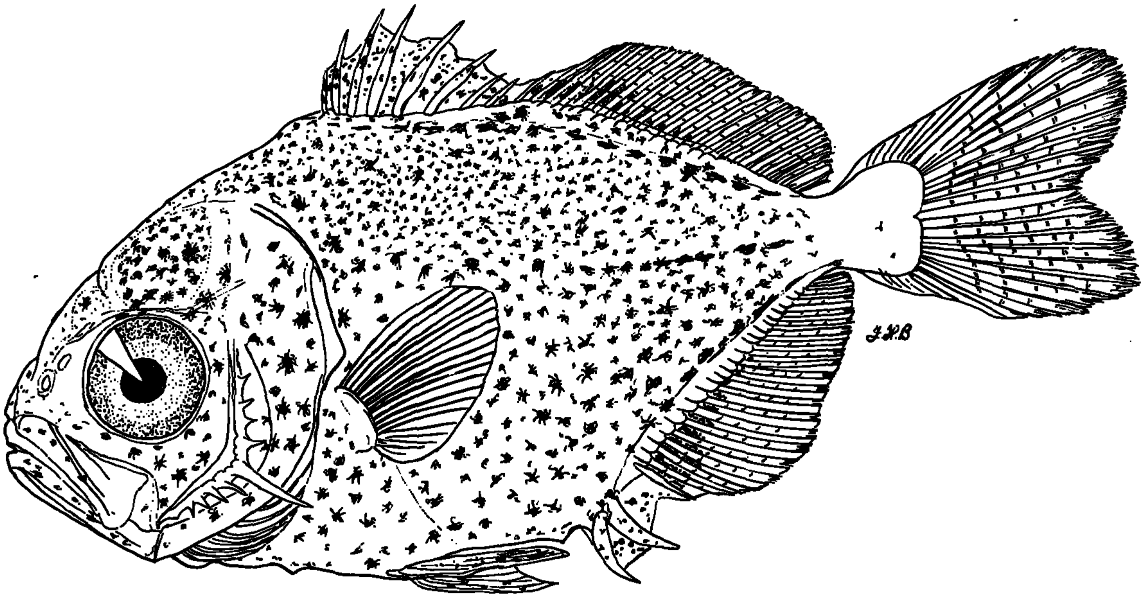

FIGURE 20.—*Caranx crysos* juvenile, 10.6 mm. standard length (*Gill* 3, Reg. 61).

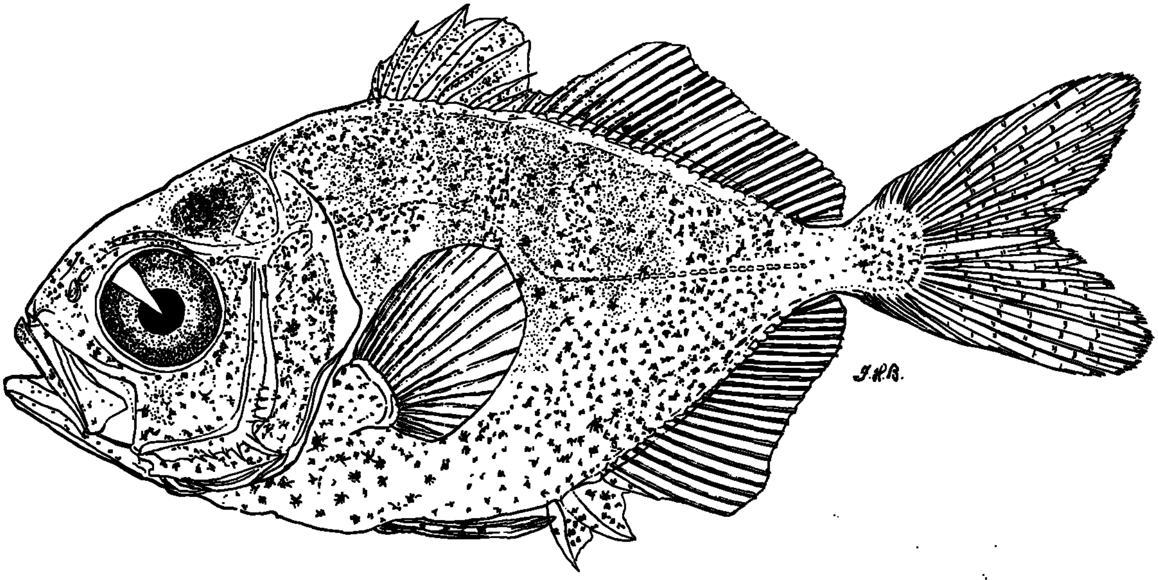

FIGURE 21.—*Caranx crysos* juvenile, 15.6 mm. standard length (*Gill* 8, Reg. 29 to 30).

indicating an increase in soft-ray growth rate at about this size.

Anal soft-rays.—19 to 21 (table 4). Formation, segmentation, branching, and lobation occur about as in the dorsal rays The second ray averages the greatest length to about 22 mm. standard length; above 22 mm., the first ray is longest. The longest dorsal and anal rays are of approximately equal length to about 31 mm.; above this size the dorsal averages slightly longer. The second anal spine is slightly shorter than the longest anal ray on specimens below 8 mm., is only one-half as long from 40 to 70 mm., and one-third as long at 219 mm.

Interneural and interhemal spines.—The posterior lateral projections of these spines are not extended above the body surface (as occurs in *latus* and *hippos*).

TABLE 4.—Caranx crysos: *Correlation of the numbers of dorsal and anal soft-rays of 231 specimens*

[The upper number in each block is the count obtained for that combination and the number in parentheses below is the approximate percentage of that count in the total sample]

ANAL SOFT-RAYS	DORSAL SOFT-RAYS			
	22	23	24	25
19	2 (.9)	51 (22.1)	12 (5.2)	
20		69 (30.0)	91 (39.4)	1 (.4)
21			3 (1.3)	2 (.9)

Caudal.—9+8 principal rays; 9 or 8+8 or 9 secondary rays. The principal rays are all present and segmentation has begun at 5.4 mm. standard length (fig. 17). The secondary rays are all present at 8.5 mm., but not at 7.5 mm. Branching begins at about 10 mm. (fig. 20), and is pronounced at about 15 mm. (fig. 21). Forking of the tail is represented by a slight indentation at 5.4 mm. (fig. 17) and is pronounced by about 8 mm. (fig. 19).

The urostyle is visible in preserved specimens to about 9 mm. (figs. 17 to 19).

Pectoral.—I–19 to 23. The full complement of rays is present at 8.5 mm. standard length (fig. 19). Branching has begun by 25 mm. The distal end of the fin is rounded from 5.4 to about 35 mm., above which it becomes pointed and falcation begins (figs. 17 to 23). Falcation is pronounced by 100 mm.

The regression of pectoral length on standard

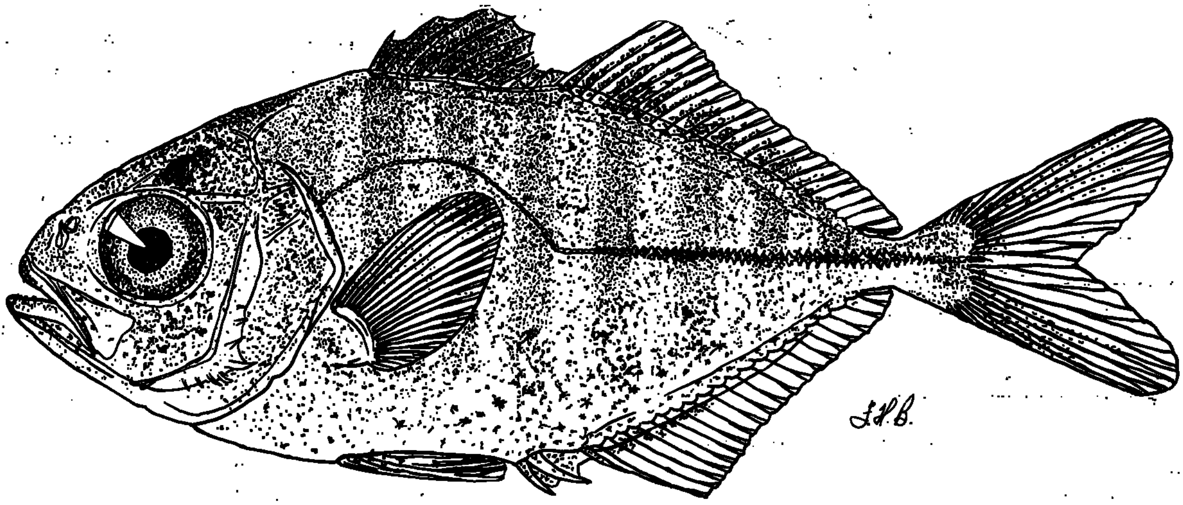

FIGURE 22.—*Caranx crysos* juvenile. 29.1 mm. standard length (*Gill* 4, Reg. 61).

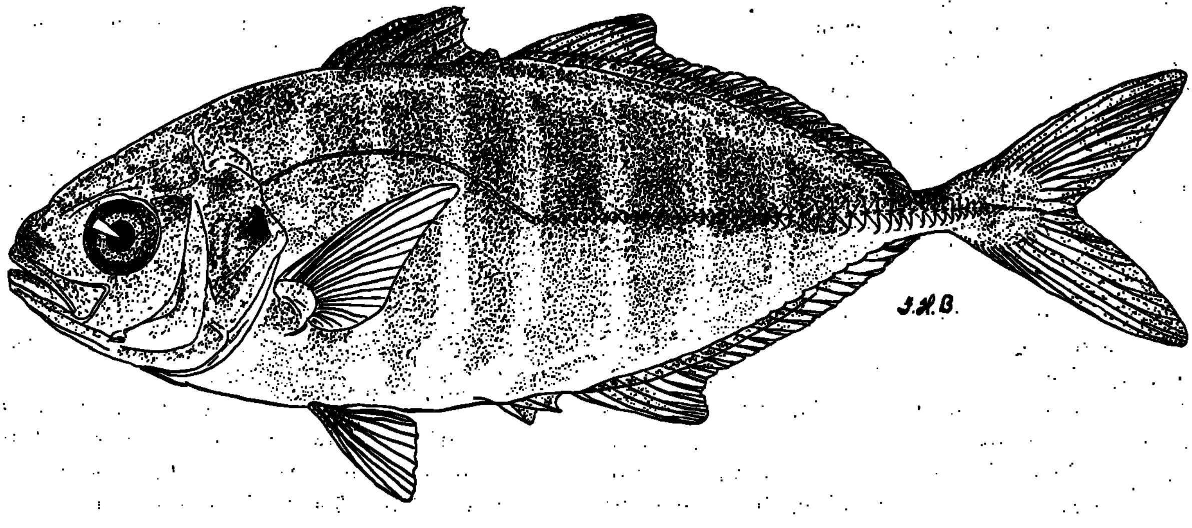

FIGURE 23.—*Caranx crysos* juvenile, 82 mm. standard length (*Gill* 3, Reg. 62).

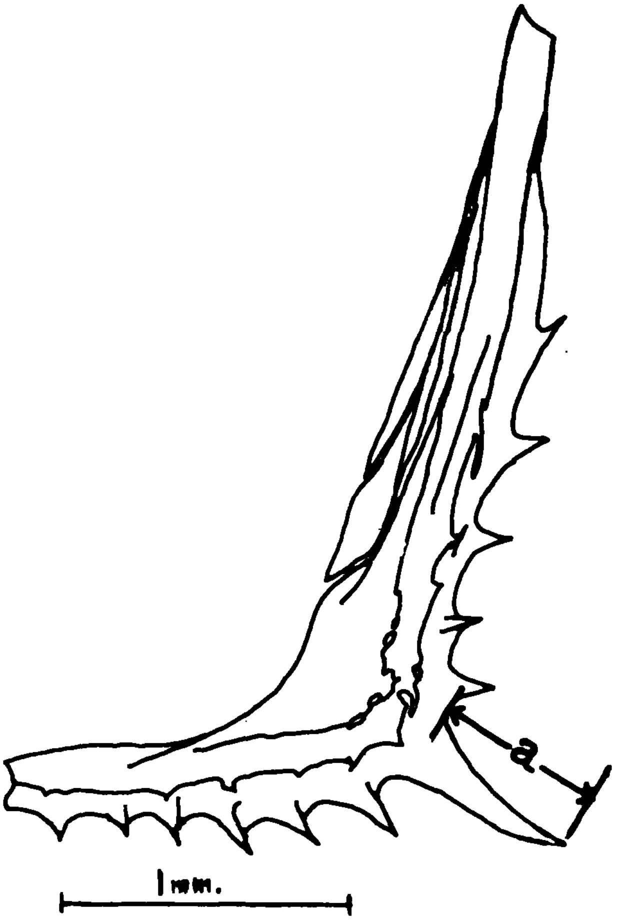

FIGURE 24.—*Caranx crysos*: Preopercular spines of a 14-mm. specimen, showing measurement (a) of the length of the preopercular-angle spine.

length is shown in figure 26 and table 3. Two lines were fitted to this regression: for specimens from 7.0 to 58.5 mm. and from 58.5 to 266 mm. standard length. An extension of the lower line intersects the upper line at approximately 70 mm., indicating that an inflection occurs at about that size and that a faster pectoral growth rate prevails above that size. The proportional rates of increase for the two variates are 0.195-mm. (below 70 mm.) and 0.41-mm. (above 70 mm.) increase in pectoral length per 1.0-mm. increase in standard length.

Pelvic.—I–5. The pelvic fin has formed by 5.4 mm. standard length (fig. 17), but the 6 rays are not distinguishable below about 6.2 mm. (fig. 18). Branching has begun by about 15 mm.

Body depth.—At corresponding body lengths the depth at first anal spine averages less than the depth at pelvic from 16.1 to about 40 mm. standard length, approximately equals the latter to about 75 mm., and averages greater above 75 mm. The body depth at pelvic for specimens smaller than 10 mm. is illustrated in figure 9.

The regression of body depth at pelvic on standard length is shown in figure 27 and table 3. Two lines were fitted to this regression: for specimens from 5.4 to 22.9 mm. and from 22.9 to 88.0 mm. standard length. The lines intersect at 23 mm., indicating that an inflection occurs at about that size and that a slower body-depth growth rate prevails above that size. The proportional rates of increase for the two variates are 0.41-mm. (below 23 mm.) and 0.29-mm. (above 23 mm.) increase in body depth per 1.0-mm. increase in standard length. The majority of the coordinates larger than 150 mm. fall below the extension of the calculated regression line, indicating a possible further decrease in body-depth growth rate somewhere above that size.

Head.—The nostril becomes divided at about 8 mm. standard length (figs. 17 to 19). The serrations on the supraoccipital crest persist to about 7 mm. (figs. 17 and 18). Three posterolaterally projecting spines are located on the cleithrum just below its junction with the operculum at 5.4 mm. (fig. 17); 1 to 2 similar spines occur on specimens 5.6 to 7.5 mm.; and none is present at 8.5 mm. or above.

The regression of head length on standard length is shown in figure 27 and table 3. Two lines were fitted to this regression: for specimens from 5.4 to 22.9 mm. and from 22.9 to 88.0 mm. standard length. The lines intersect at approximately 22 mm., indicating that an inflection occurs at about that size and that a slower head growth rate prevails above that size. The proportional rates of increase for the two variates are 0.35-mm. (below 22 mm.) and 0.26-mm. (above 22 mm.) increase in head length per 1.0-mm. increase in standard length. The coordinates of specimens larger than 88 mm. fall above the extension of the calculated regression line, indicating an increase in the head growth rate at around that size.

Eye.—The regression of eye diameter on standard length is shown in figure 28 and table 3. Two lines were fitted to this regression: for specimens from 5.4 to 30.3 mm. and from 30.3 to 145 mm. standard length. An extension of

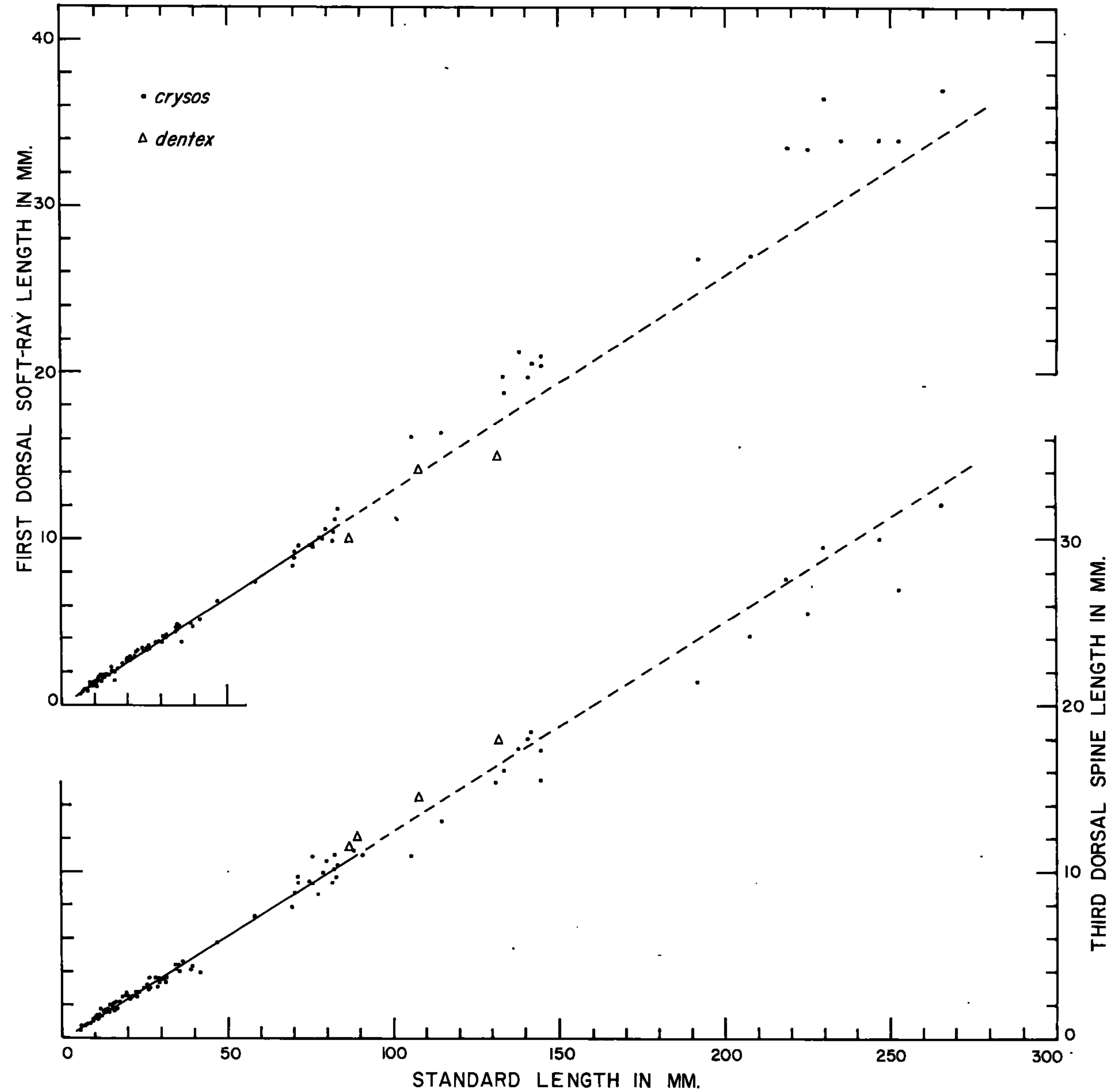

FIGURE 25.—*Caranx crysos* and *C. dentex:* Relation of length of first dorsal soft-ray and of third dorsal spine to standard length.

the upper line intersects the lower line at approximately 22 mm., indicating that an inflection occurs at about that size and that a slower eye growth rate prevails above that size. The proportional rates of increase for the two variates are 0.11-mm. (below 22 mm.) and 0.07-mm. (above 22 mm.) increase in eye diameter per 1.0-mm. increase in standard length. The spread of the coordinates of specimens larger than 145 mm. around the extension of the calculated regression line is variable, but suggests that eye diameter growth may continue at the same proportional rate.

Snout.—The regression of snout length on standard length is shown in figure 28 and table 3. A line fitted to this regression for specimens from 5.4 to 145 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.08-mm. increase in snout length per 1.0-mm. increase in standard length). The

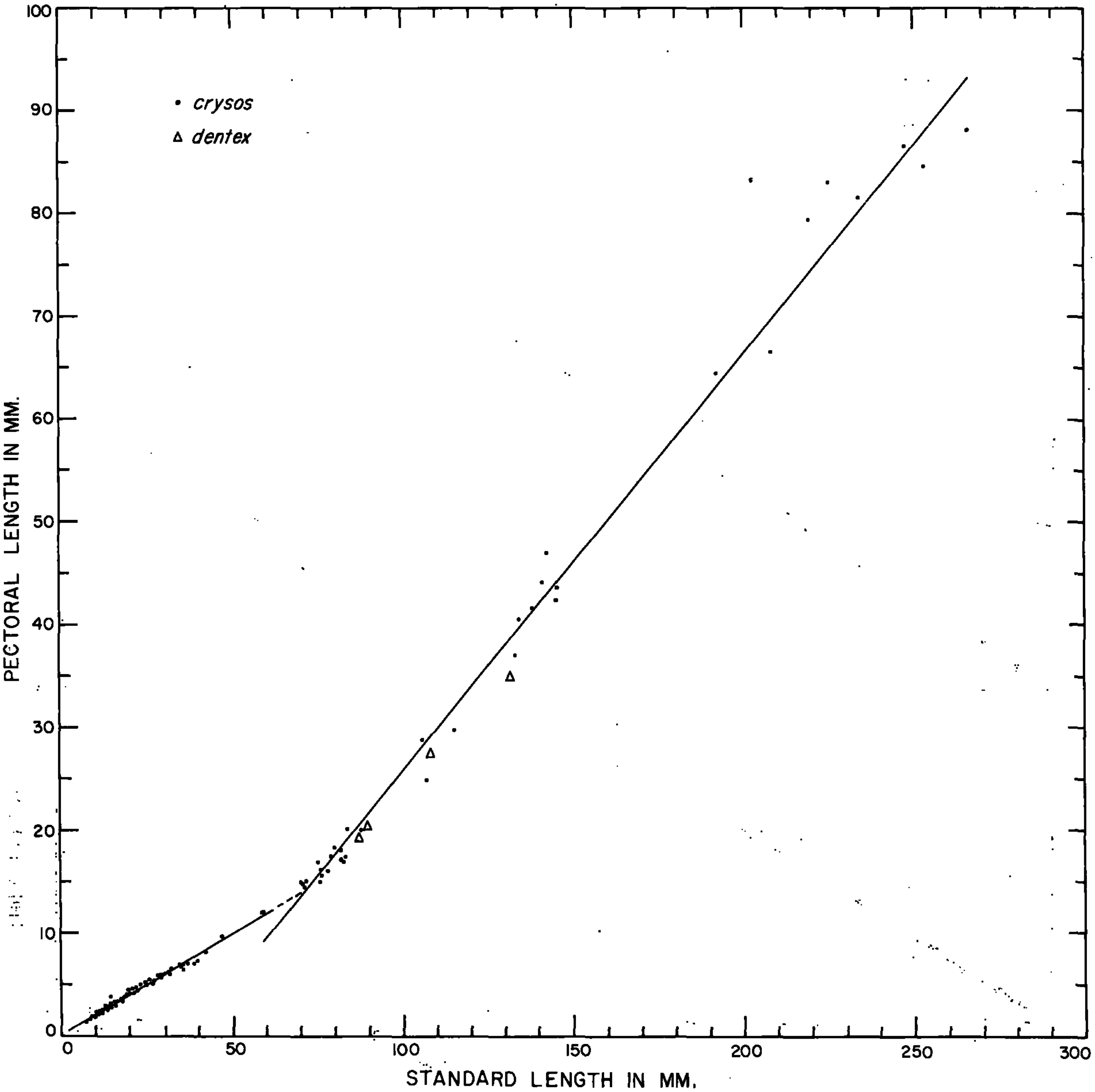

FIGURE 26.—*Caranx crysos* and *C. dentex*: Relation of pectoral length to standard length.

coordinates of specimens larger than 145 mm. fall along the extension of the calculated regression line, indicating that snout growth may continue at the same proportional rate.

Gill rakers.—Lower limb, 23 to 28; upper limb, 10 to 14; total, 35 to 42 (table 5). Nichols (1938b: 2) listed a range on the lower limb of 25 to 33 (his average, 27.9) for 28 specimens. In view of the maximum number on the lower limb (28) obtained by Ginsburg (1952: 97) and myself, abnormal specimens might account for the high number reported by Nichols.

About 20 percent of the specimens above 20 mm. had 1 or 2 rudimentary gill rakers at the origin of the lower limb; none on the upper limb. The presence or absence of these rudiments is apparently independent of body size relationship, as the specimens possessing rudiments were interspersed throughout the range of sizes examined.

Scutes.—Range of the mean number of scutes above 100 mm. standard length: about 46 to 56 (fig. 29). Ginsburg (1952: 97), working with specimens up to about 426 mm. (converted), gave an upper limit of 54 scutes. Nichols (1938b: 2), examining 28 specimens ranging from 103 to 311 mm. standard length, found scutes to vary from 40 to 50. The developing scutes appear between 12 and 13 mm. (figs. 20 and 21). The first scutes to complete their individual development do so at about 19 mm. All scutes of fish above 100 mm. have completed, or nearly completed, their individual development (fig. 29).

Lateral line.—Range of mean lateral-line ratio

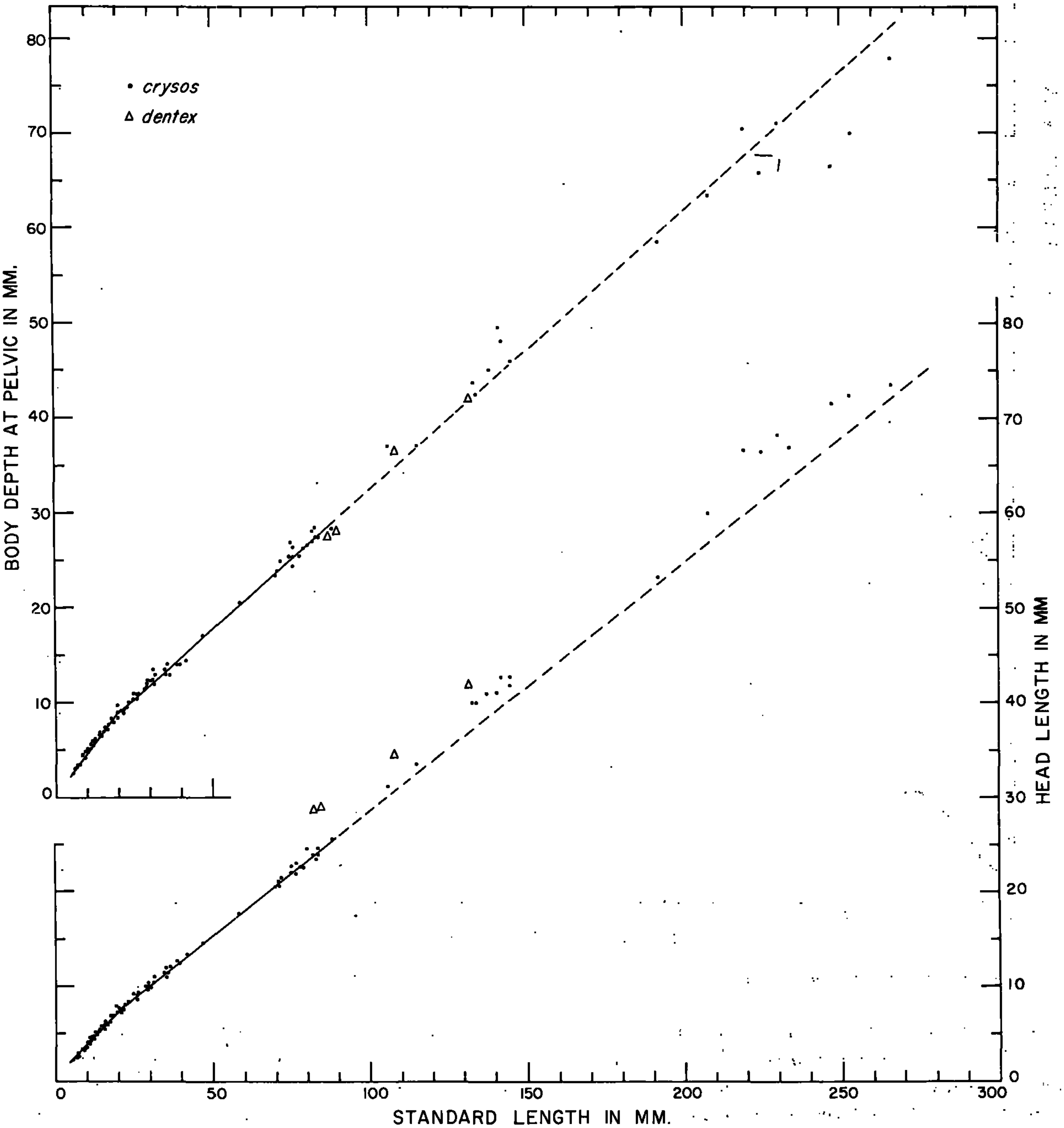

FIGURE 27.—*Caranx crysos* and *C. dentex:* Relation of body depth at pelvic and of head length to standard length.

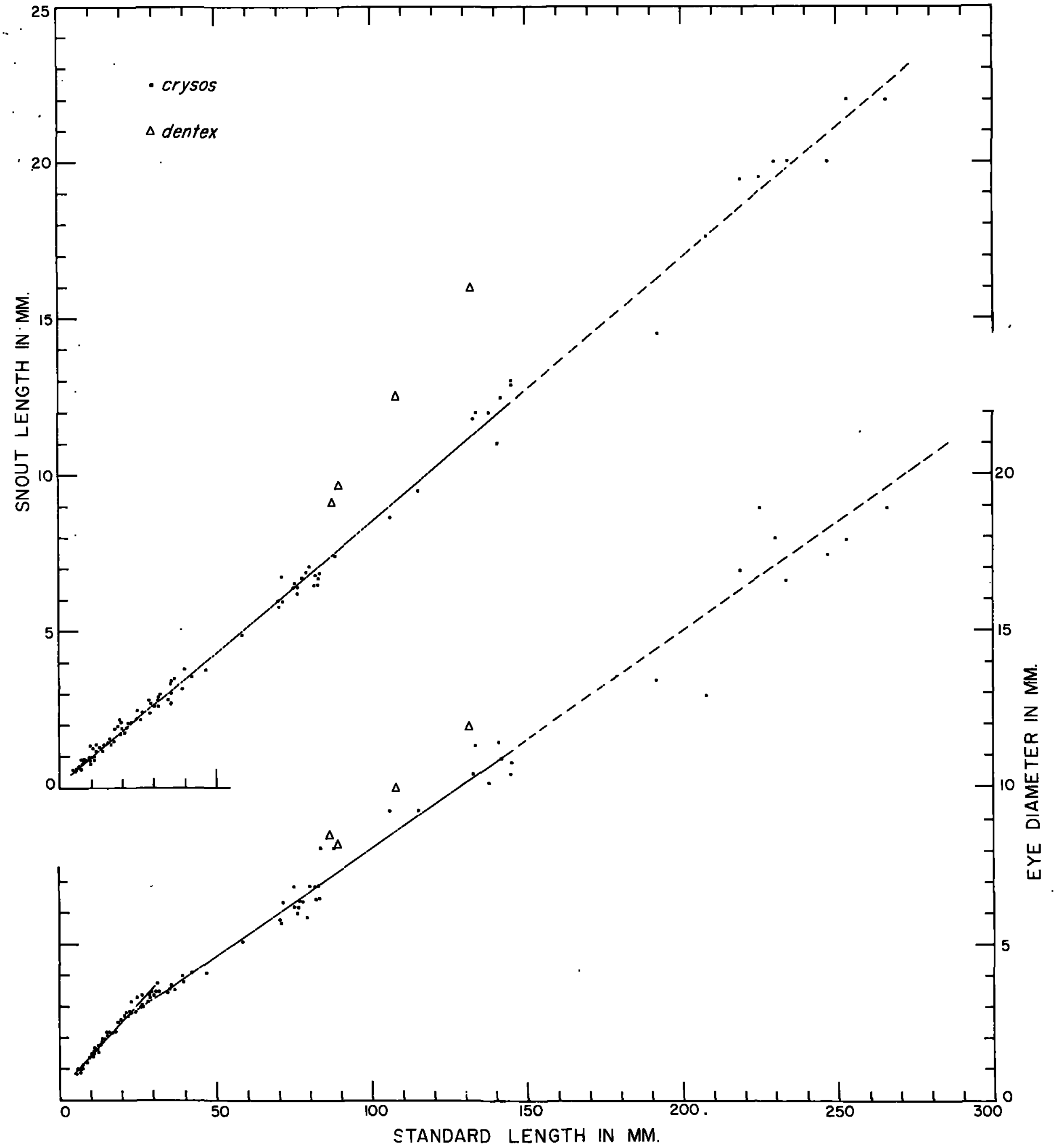

FIGURE 28.—*Caranx crysos* and *C. dentex*: Relation of snout length and of eye diameter to standard length.

from 70 to 200 mm. standard length: 1.75 to 2.1 (fig. 30). The relationship is highly variable, but the ratio shows a trend of increase up to about 50 or 60 mm. and a decrease above 200 mm. The ratio of 1.7 given by Nichols (1938b: 1) for a 22-mm. standard length specimen is within the range I have established. However, the majority of the ratios he gives for 103- to 311-mm. specimens are too low to fall within the perimeters established by my specimens. This may be due to variations in our methods. The values of 1.5 to 1.8 given by Nichols (1939: 5, 6) for specimens 12 mm. and

72 mm. fall within my predicted range, but in the lower portion and with less variation that I encountered.

Preopercular spines.—Because of the appreciable individual variation in this character, it is not possible from the specimens examined to predict accurately at what size the preopercular-angle spine ceases to increase in length—this probably occurs at some size around 7 mm. standard length. Above approximately 10 mm. the length of this spine decreases due to expansion of the posterior margin of the preoperculum (fig. 31). This spine is completely absorbed within the preopercular margin between 42 and 47 mm. The numbers of preopercular upper- and lower-limb spines are variable but tend to decrease with an increase in standard length (table 1). The preoperculum and the preopercular spines of an alizarin-stained 14-mm. specimen are illustrated in figure 24.

Pigmentation.—There are three rows of elongated melanophores on the body of the 5.4-mm. specimen—below the base of the dorsal fin, above

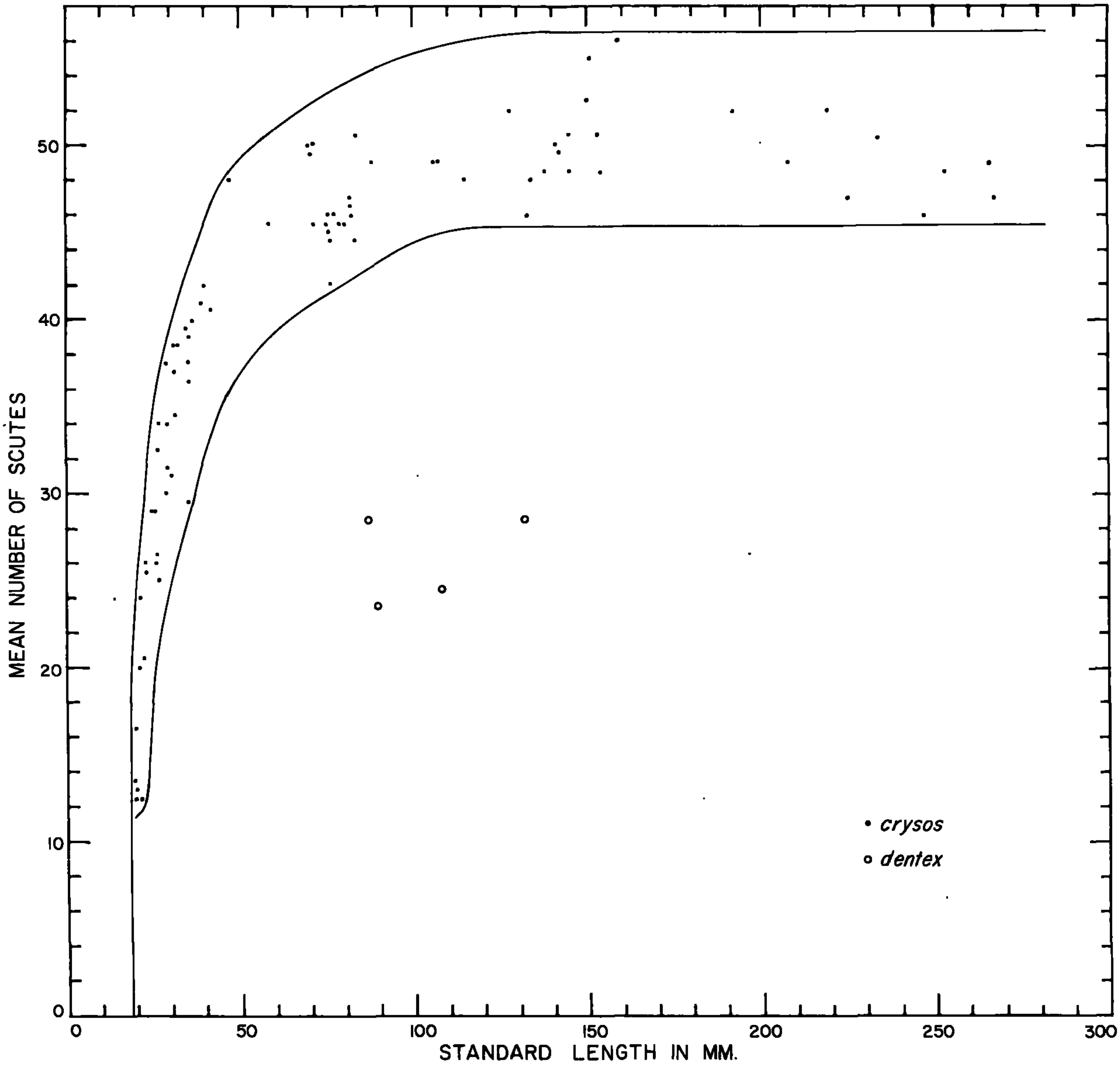

FIGURE 29.—*Caranx crysos* and *C. dentex:* Relation of the mean number of scutes to standard length.

TABLE 5.—*Caranx crysos: Correlation of the numbers of lower-limb to upper-limb gill rakers of 73 specimens*

[The upper number in each block is the count obtained for that combination and the number in parentheses below is the approximate percentage of that count in the total sample]

UPPER-LIMB GILL RAKERS	LOWER-LIMB GILL RAKERS					
	23	24	25	26	27	28
10			4 (5.5)	11 (15.1)	2 (2.7)	
11			6 (8.2)	14 (19.2)	11 (15.1)	1 (1.4)
12	1 (1.4)		2 (2.7)	7 (9.7)	6 (8.2)	4 (5.5)
13				2 (2.7)		1 (1.4)
14						1 (1.4)

the base of the anal fin, and on the midline posteriorly. A few melanophores are scattered over the body, upper and lower jaws, and operculum. A group of larger melanophores occurs over the eye on the transparent portion of the head. A few pigment spots are on the interspinous membranes of the dorsal and anal fins, and a row of melanophores occurs along the base of the anal soft-rays (fig. 17).

By about 12 mm. standard length the 3 rows of elongated melanophores begin to intergrade with the other body pigmentation (figs. 18 to 21). The body bars begin to form between 15 mm. and 19 mm.—the rudiments of 5 bars are present in the 15.6-mm. specimen (fig. 21). The number of bars increases to the normal complement of 7 by about 23 mm. (fig. 22). Rarely 6 or 8 bars may be counted on one or both sides of fish above 23 mm. The bars are not distinct on some specimens above 60 mm., but on six freshly preserved specimens from Brunswick, Ga., bars were present on specimens of 105 mm., 105 mm., 111 mm., and 134 mm., but not on specimens of 110 mm. and 124 mm. The caudal peduncle is unpigmented to about 13 mm. (figs. 17 to 20). A dense mass of pigment begins to develop on the upper portion of the peduncle at about 28 mm. (figs. 22 and 23).

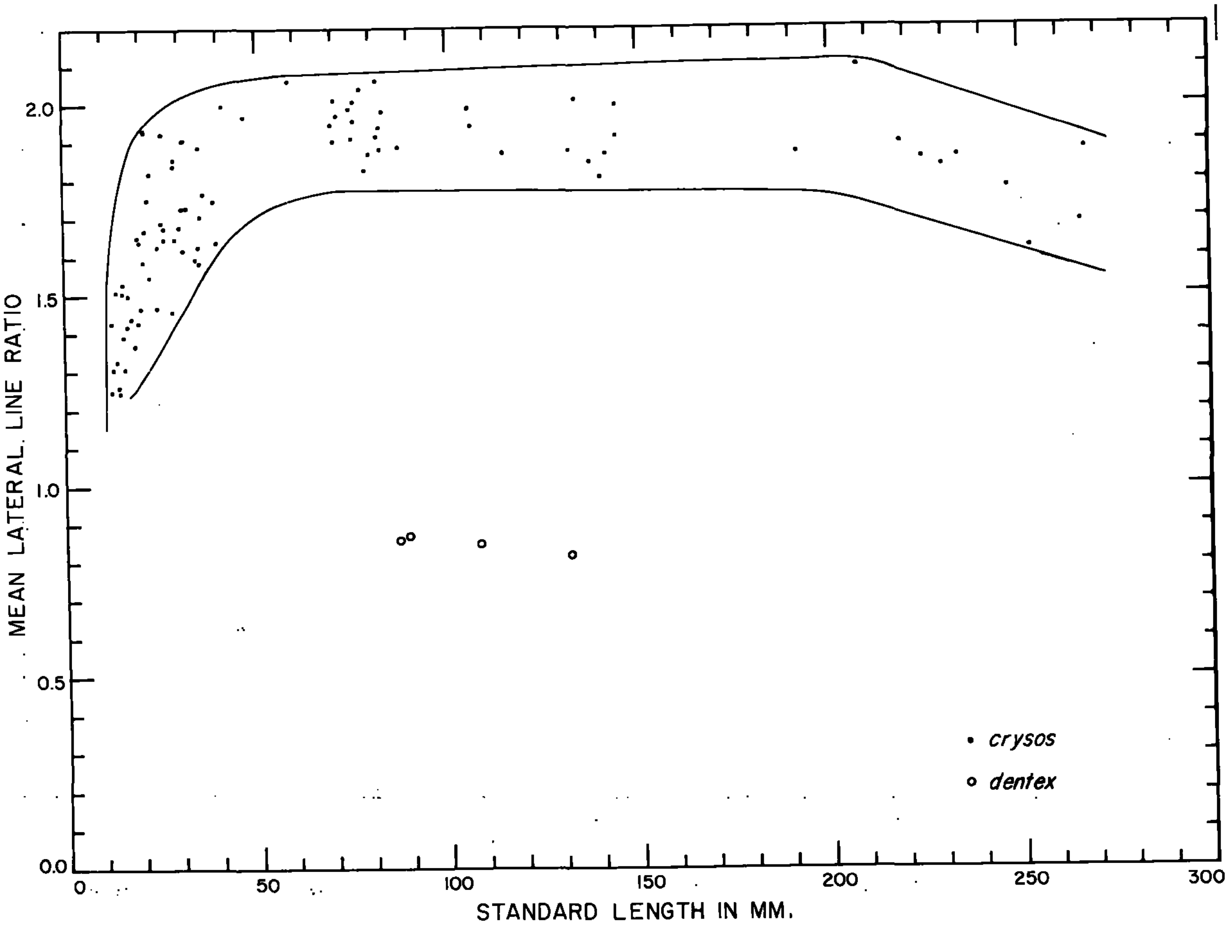

FIGURE 30.—*Caranx crysos* and *C. dentex*: Relation of the mean lateral-line ratio to standard length.

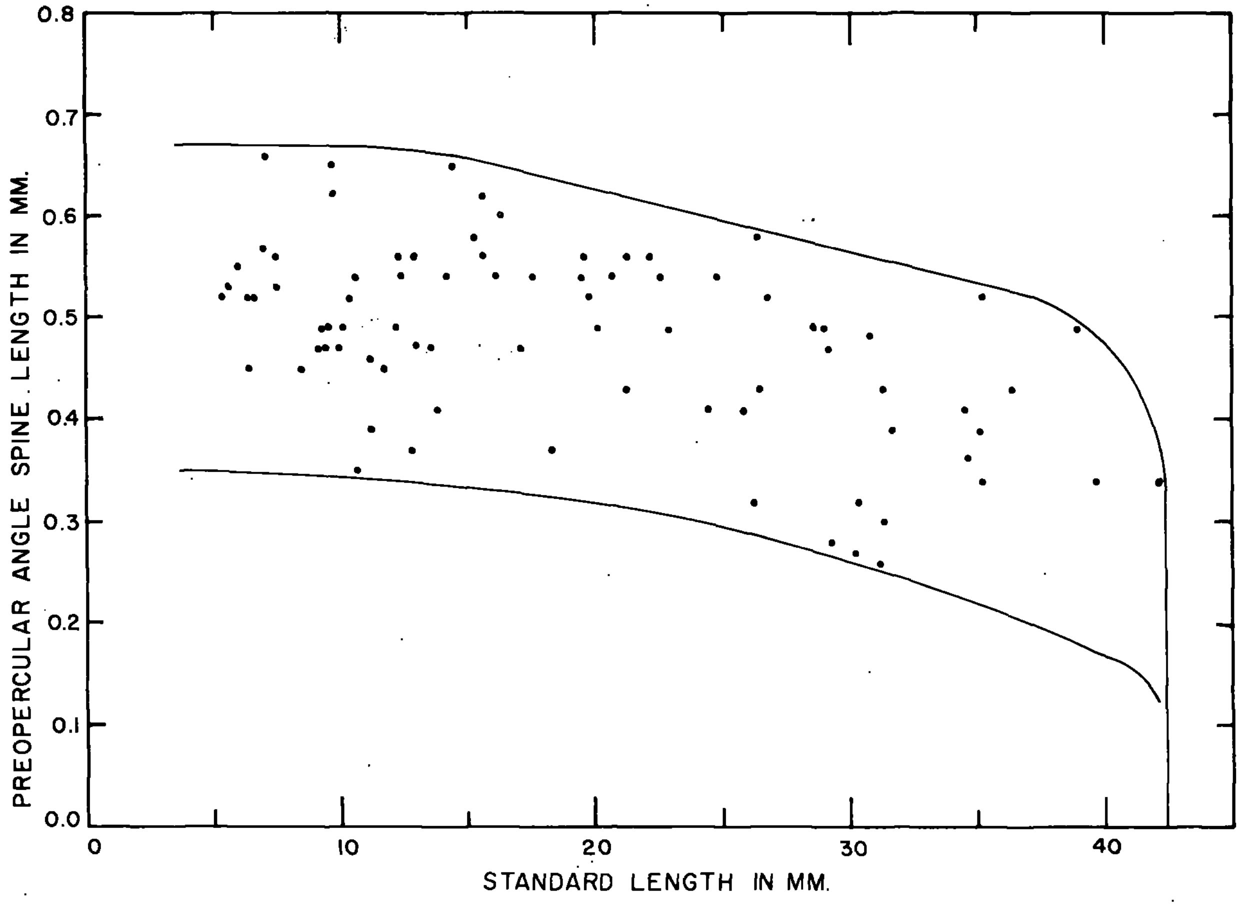

FIGURE 31.—*Caranx crysos:* Relation of length of the preopercular-angle spine to standard length.

This may have been referred to as an additional body bar by Nichols (1939: 6), Beebe and Tee-Van (1928: 110), Fowler (1936: 699), and possibly others.

The pigmentation on the brain case changes from a few large melanophores on the transparent portion to a pigment mass which is projected posterodorsally and which forms the nuchal band by about 29 mm. (figs. 17 to 21). The brain case becomes opaque between 10 mm. and 15 mm. (figs. 20 and 21). Concentrations of pigment below the eye and on the eye above and below the pupil give the impression that the nuchal band bends downward and continues through the eye. A vertically elongated spot forms on the operculum from about 30 to 40 mm., becomes prominent at about 60 mm., and is reduced in size and located on the upper and outer margin of the operculum by about 100 mm.

Pigment on the first dorsal fin intensifies to about 82 mm. standard length and diminishes at larger sizes; that of the anal interspinous membranes is similar but never as concentrated as on the first dorsal (figs. 17 to 23). Pigmentation on the second dorsal and anal fins is pronounced at 8.5 mm. (fig. 19) and intensifies to above 82 mm. (figs. 20 to 23). Pigment spots are present on the pelvics by 7.0 mm. (fig. 18) and on the caudal and pectorals by 29 mm. (fig. 22), but these fins are never heavily pigmented.

Five specimens with enlarged gonads, which were approaching spawning condition, were darker than other specimens examined. Described from preservation in isopropyl alcohol: the 4 females (247 to 267 mm.) were dark above and light below the lateral line, with clear pelvics and slightly dusky anal fins; the 225-mm. male was black above and leaden below the lateral line, and all the fins were dark with the pelvics very black.

Distribution off Southeastern Atlantic Coast of the United States

Caranx crysos has been reported from the following specific localities within this area: Nassau, Bahamas, by Lee (1889: 670), Bean (1905: 302), Parr (1930: 45), and Ginsburg (1952: 96); the Gulf Stream off Bimini, Bahamas, by Nichols (1938b: 1); Biscayne Bay, Fla., by McCormick, *in* Smith (1896: 174); Boca Raton, Fla., by Fowler (1945: 292); St. Johns River, Fla., by Goode (1879: 112; 1882: 35); Fort Macon, N. C., by Goode (1882: 32); Cape Romain and Charleston, S. C., by Fowler (1945: 191); and Beaufort, N. C., by Goode (1882: 35), Jordan (1886a: 27), Yarrow (1877: 208), Jordan and Gilbert (1879: 376), Smith (1907: 84), and Nichols (1938a: 1).

Figure 32 shows the locations of specimens taken on the *Gill* cruises, specimens taken by the *Combat* off Florida, other specimens in the SAFI collection (Brunswick, Ga.), USNM specimens examined (33 miles south of the Lookout Light Ship in Gulf Stream), and ChM specimens examined (Charleston and Cape Romain, S. C.) (tables 2 and 6); and specimens reported by Nichols (1938a: 1; in the Gulf Stream off Bimini, Bahamas, 22 mm.) and Fowler (1945: 292; Boca Raton, Fla., about 63 mm., converted). The specimens recorded on this chart are larvae and juveniles with the exception of the inshore records of larger specimens from South Carolina which may have been adult. The locations of capture of the larvae and juveniles were generally near or beyond the 100-fathom line and indicate an association with the Gulf Stream, as depicted by the approximate axis of the Stream in figure 32. Because of the relatively less-concentrated collecting by the *Gill* east of the axis of the Gulf Stream, it is not possible to estimate accurately the relative abundance of these forms for that area. This occurrence of young in the Gulf Stream extends from about May into November, but in heaviest concentration from mid-June to mid-August (fig. 33).

Specimens of *crysos* above 100 mm. standard length have commonly been taken inshore along the Atlantic coast of the United States. Specimens below this size occasionally occur inshore on the Atlantic coast of southern Florida and at Cape Lookout and Cape Hatteras, N. C. (where the Gulf Stream moves in relatively close to the shore). I have found few published inshore records of *crysos* less than 100 mm. other than from these two localities: Smith (1898: 98) reported specimens of about 36 mm. and 51 mm. (converted) from Woods Hole, Mass., in summer. Breder's (1926: 124) record of "a small example of about 30 mm." identified as *crysos* from Sandy Hook Bay, N. Y., is not convincing because he describes the body as banded with five intense black vertical bars, which description normally applies to *hippos* or possibly *latus*. The larvae and juveniles evidently have an affinity for the Gulf Stream and offshore waters to a size of 80 to 100 mm., above which size at least a part of the Stream population moves inshore. Records of *crysos* taken inshore north of North Carolina support this: Bean (1891: 87) reported specimens of about 105 to 145 mm. (converted) from Cape Charles City, Va., September 16 to October 3; Murphy and Harper (1915: 41), specimens of about 135 mm. (converted) from Long Island, N. Y., in September; Latham (1918: 55), specimens about 115 mm. (converted) on October 23 and about 141 mm. (converted) on November 4 from Long Island, N. Y.; Latham (1920: 92), specimens about 95.5 mm. (converted) from Long Island, N. Y., July 26; Bigelow and Schroeder (1953: 377), specimens about 115 to 155 mm. (converted) from Cape Cod Bay, Mass., in September; Leim (1930: xlvi, *fide* Bigelow and Schroeder, 1953: 377), specimens about 95 mm. (converted) from Halifax, Nova Scotia; and Vladykov (1935: 4), a specimen about 141 mm. (converted) from Pubnico, Nova Scotia, September 1.

I believe that the larvae and young juveniles in the Gulf Stream are carried northward by the Stream currents—a northward movement of young is also probably effected by the Antilles Current. At a juvenile size of 80 to 100 mm. a portion of this developing population migrates to Atlantic coast inshore waters, but another portion may, at least temporarily, continue its movement eastward with the Stream. A continuation in movement with the Stream to Africa is also possible. Nichols (1939: 5) hypothesized, "a regular interchange between the continents of America and Africa, eastward in the north and westward in the south." Records of *crysos* from the Azores and West Africa sponsored this theory, but the inadequately known relations of this species with *C. fusus* of the Mediterranean limit its acceptability. If young *crysos* taken in the Gulf Stream off the southeastern United States

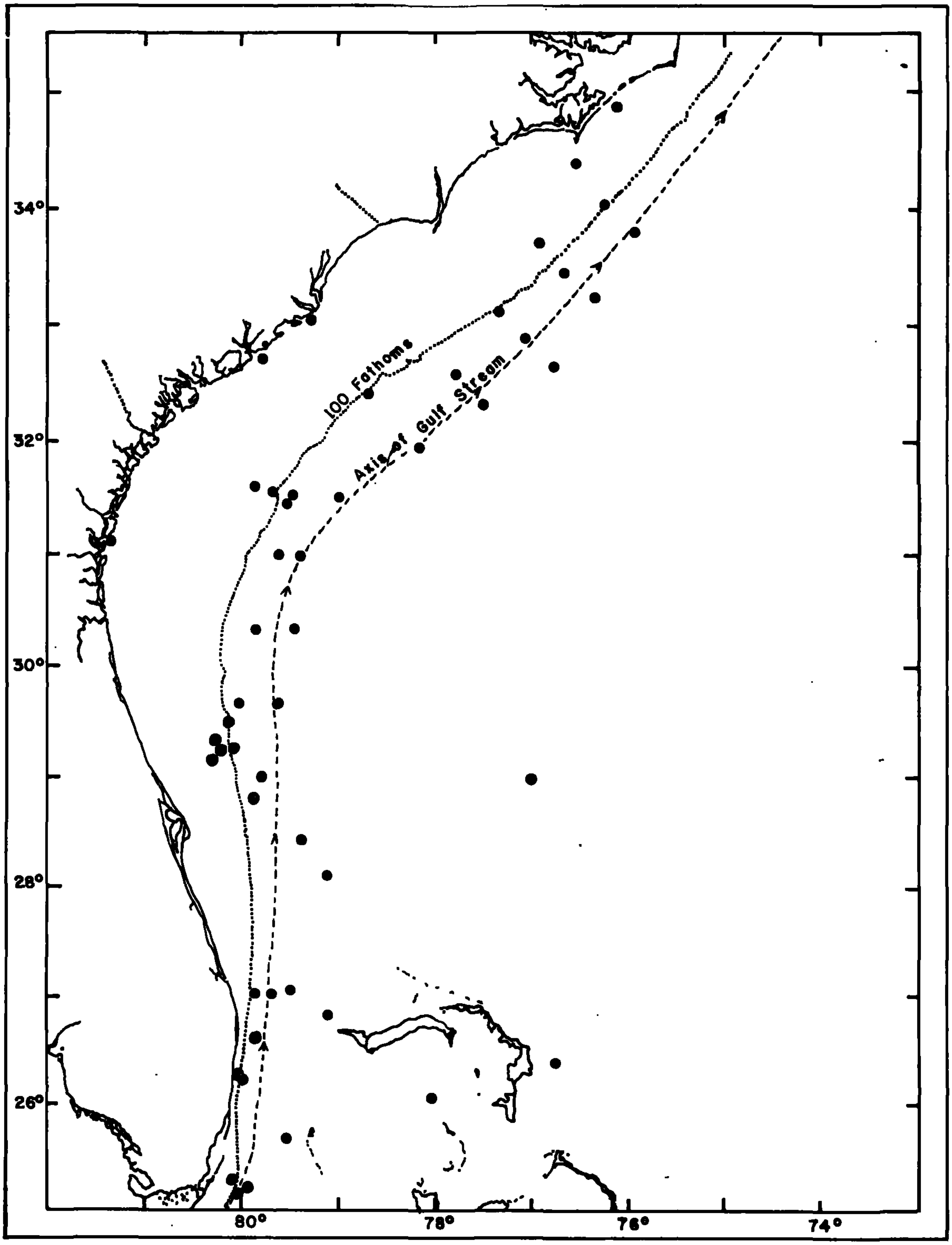

Figure 32.—*Caranx crysos:* Locations of capture off the southeastern Atlantic coast of the United States.

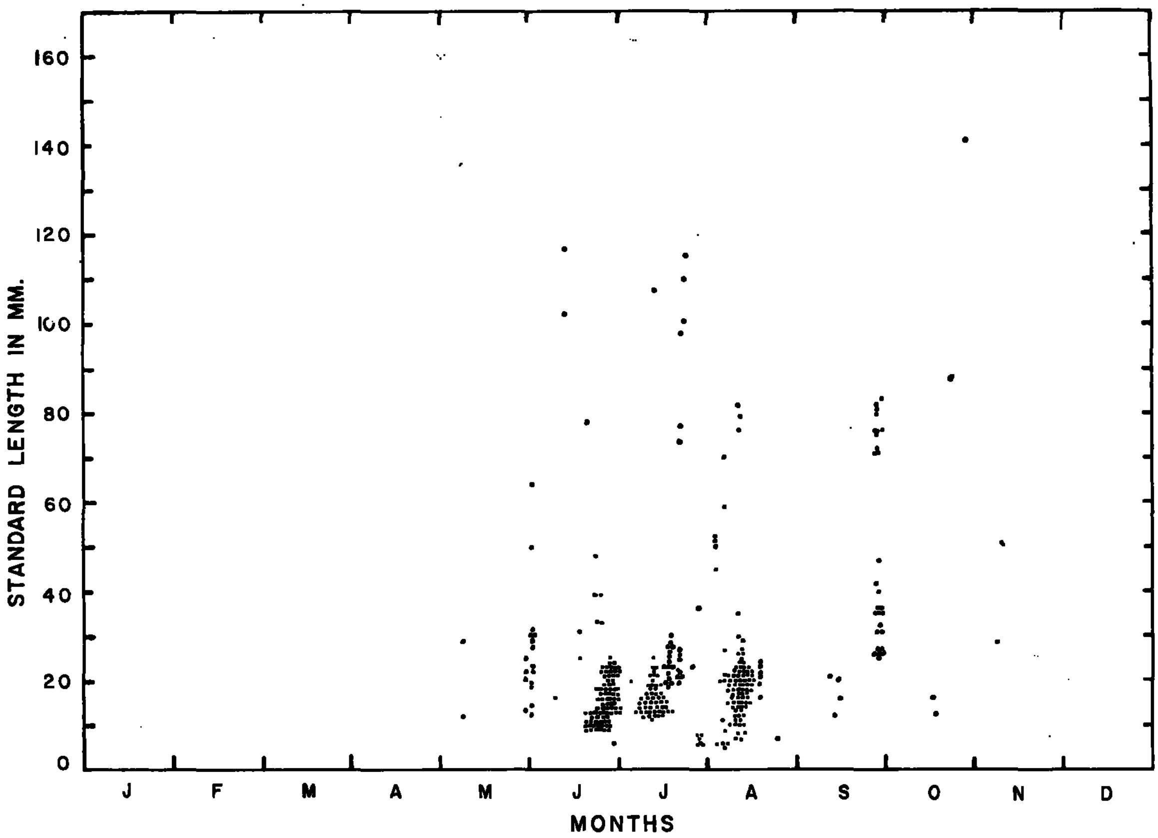

FIGURE 33.—*Caranx crysos:* Size distribution, by months, of specimens taken off the southeastern Atlantic coast of the United States.

represent a population that occurs each year from summer to fall and moves northward in the Stream and the Antilles Current, then much of this population must be recruited from areas that contribute to this portion of the Stream, although some part of the population may be the result of reproduction within the area.

On the basis of two collections of *crysos* from 12 to 72 mm., Nichols (1939: 5 and 8) predicted a "nursery ground" for the species in the Gulf Stream off Maryland (37°12′ N., 67°39′ W. to 38°59′ N., 69°46′ W.) in late August. These fish probably represented a northward continuation of the population which occurs yearly off the coast of the Southeastern States.

The absence of records of *crysos* from inshore waters along the Atlantic coast from December through June indicates that the larger fish which have been reported from the coast during July through November either migrate to the south or move offshore to the warmer waters of the Stream during the colder months.

Spawning

The spawning season that contributes young *crysos* to this area may be estimated, from the smallest specimens taken in May (12.4 mm.) and in October (13.2 mm.), to extend from early April to early September (fig. 33).

The only specimens of *Caranx* with developed gonads that were examined during this study were five *crysos* taken by the *Oregon* from about 50 to 60 miles east-southeast of South Pass, La., July 20–26, 1956. None of these fish were running-ripe; but the four females (247 mm., 253 mm., 266 mm., and 267 mm. standard length) had enlarged ovaries about 50 mm. long containing macroscopically visible eggs, and the one male (225 mm.) had enlarged testes about 50 mm. long. The pigmentation of these specimens was unusual, and is described under the section on Pigmentation, page 453.

Erdman (1956: 230) noted *crysos* in spawning condition in May at Puerto Rico. Holbrook (1860: 93) described the testes of *crysos* from

South Carolina—possibly indicating the presence of ripening males from that locality, but he gave no season or definite locality.

Referring to *crysos* that appeared at Pensacola, Fla., in April and May, Stearns, *in* Goode (1882: 32), stated—

> On their arrival the larger fish contain spawn, which in July and August becomes quite full, after which none are seen but the young fish of about 10 inches in length, until there is a general movement towards the sea. It is believed that the adult fish spawn in the bays, but the only evidence to support that belief is that they come inside with spawn, go away without it, and that very young fish are found there.

This reasoning is analogous to that which for many years was applied to the Atlantic coast species of *Mugil*. Anderson (1957), however, has shown that spawning of *M. curema* occurs in offshore waters, and that the young do not come into the coast and bays until after attaining a certain size. Since larvae of *crysos* were abundant offshore and smaller larvae have never been recorded inshore, it is probable that *crysos* also spawns offshore.

If, as suggested, there is a motile, northward-moving population of developing young, the majority of the specimens taken by the *Gill* would have been the result of spawning that occurred to the south of this area. Some of the smaller specimens (5.4 to 7.5 mm.) taken by the *Gill* off Georgia to North Carolina and the 5.7 to 7.7-mm. specimens taken by the *Fish Hawk* from near the Lookout Light Ship (table 6) may have been spawned within this area.

TABLE 6.—Caranx crysos: *Location and date of capture, number and size range (in mm.) of 683 specimens examined*

[See pp. 417 and 419 for explanation of abbreviations used; measurements in standard length]

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN:				
24°04′ N., 79°15′ W	July 24, 1957	SAFI, *Combat* 448	28	18.5–35
24°13′ N., 81°42′ W	July 21, 1957	SAFI, *Combat* 436	4	26–64
25°10′ N., 80°02′ W	July 22, 1957	SAFI, *Combat* 438	17	18.5–30
25°11′ N., 79°56′ W	do	SAFI, *Combat* 443	10	19.5–77
25°16′ N., 80°07′ W	July 26, 1956	SAFI, *Combat* 457	1	23
26°21.2′ N., 76°46.5′ W	July 19, 1953	SAFI, *Gill* 3, Std	1	77.5
Do	July 23, 1953 July 24, 1953	do	1	17.6
26°37′ N., 79°51′ W	July 28, 1957	SAFI, *Combat* 458	1	36.5
26°54′ N., 79°07′ W	Aug. 29, 1954	SAFI, *Gill* 8, Settlement Point, Bahamas	18	24.5–70.5
27°01′ N., 79°45′ W	June 23, 1954	SAFI, *Gill* 7, leaving Reg. 2	30	9.1–14.4
27°11′ N., 79°55′ W	July 23, 1953	SAFI, *Gill* 3, Reg. 2 to Reg. 3	1	6.6
28°17.5′ N., 79°28′ W	Sept. 12, 1954	SAFI, *Gill* 8, Reg. 8	1	20.7
28°18.5′ N., 79°26′ W	July 26, 1953	SAFI, *Gill* 3, Reg. 8	9	17–25
28°48′ N., 79°53′ W	June 13, 1956	SAFI, *Pelican* 67	2	102–117
28°56.3′ N., 79°45.6′ W	July 27, 1953	SAFI, *Gill* 3, Reg. 15	1	20.1
29°00′ N., 77°00′ W	July 17, 1953	SAFI, *Gill* 3, Spc. 6	2	24.8–31.3
29°10′ N., 80°19′ W	June 1, 1957	SAFI, *Combat* 336	2	28.5–31.5
29°10′ N., 80°19′ W. to 29°19′ N., 80°15′ W	do	SAFI, *Combat* 336 to 337	4	22.5–31.5
29°16′ N., 80°04′ W	May 30, 1957	SAFI, *Combat* 328	1	25
29°19′ N., 80°18′ W	June 1, 1957	SAFI, *Combat* 339	4	12.5–19.5
Do	do	SAFI, *Combat* 343	2	50–64
29°28′ N., 80°09′ W	May 30, 1957	SAFI, *Combat* 326	3	13.4–22
29°29′ N., 80°09′ W	Aug. 18, 1957	SAFI, *Combat* 485	7	16.5–24
29°36.2′ N., 79°59.8′ W	July 28, 1953	SAFI, *Gill* 3, Reg. 18	1	6.4
29°38′ N., 79°36.5′ W	June 25, 1954	SAFI, *Gill* 7, Reg. 17	1	33
29°40′ N., 80°00′ W	do	SAFI, *Gill* 7, Reg. 18	1	39
Do	Sept. 13, 1954	SAFI, *Gill* 8, Reg. 18	1	12.2
30°20′ N., 79°50′ W	June 26, 1954	SAFI, *Gill* 7, Reg. 27	1	22.9
30°20.5′ N., 79°27′ W	Sept. 14, 1954	SAFI, *Gill* 8, Reg. 28	1	19.6
30°56.8′ N., 79°37.4′ W	July 29, 1953	SAFI, *Gill* 3, Reg. 30	1	22.6
30°58′ N., 79°37.5′ W	June 27, 1954	SAFI, *Gill* 7, Reg. 30	62	12–24
30°59′ N., 79°14′ W. to 30°59.5′ N., 79°36.5′ W	Sept. 15, 1954	SAFI, *Gill* 8, Reg. 29 to Reg. 30	1	15.6
Commercial trawling area, Brunswick, Ga	Sept. 14, 1956	SAFI	4	105–124
Do	Sept. 16, 1956	do	1	111
Do	Oct. 9–10, 1956	do	1	135
Do	Nov. 9, 1956	SAFI	4	151–158
Do	Nov. 13, 1956	do	10	128–154
31°32′ N., 79°28′ W	Aug. 5, 1953	SAFI, *Gill* 3, Reg. 39	1	10.7
31°33′ N., 79°39.5′ W	do	SAFI, *Gill* 3, Reg. 38 to Reg. 39	1	6.0
31°35′ N., 79°51′ W	do	SAFI, *Gill* 3, Reg. 38	3	5.4–6.4
31°56′ N., 75°08.5′ W	July 4, 1954	SAFI, *Gill* 7, Reg. 50	1	20.0
31°57′ N., 78°09′ W	Aug. 6, 1953	SAFI, *Gill* 3, Reg. 50	2	19.5–26.7
32°19′ N., 77°34′ W	Aug. 7, 1953	SAFI, *Gill* 3, Reg. 51	3	21.2–70
32°24′ N., 78°44′ W	Aug. 6, 1953	SAFI, *Gill* 3, Reg. 48	1	19.8
32°35′ N., 77°46′ W	Aug. 7, 1953	SAFI, *Gill* 3, Reg. 52	1	8.5
32°39′ N., 76°46′ W	Aug. 10, 1953	SAFI, *Gill* 3, Reg. 62	7	22.2–82
Charleston Harbor, S. C	Aug. 11, 1937	ChM 38.181	1	234
Off Charleston, S. C	July 3, 1934	ChM 34.174	1	208
Do	Oct. 28, 1940	ChM 40.200	1	141
Off Blackfish Bank, Charleston, S. C	May 19, 1939	ChM 39.93.1	1	192
32°53′ N., 77°03.5′ W	Nov. 8, 1953	SAFI, *Gill* 4, Reg. 61	1	29.1
32°54′ N., 77°04′ W	Aug. 10, 1953	SAFI, *Gill* 3, Reg. 61	2	7.1–7.5
Do	do	do	8	9.5–12.3

TABLE 6.—Caranx crysos: *Location and date of capture, number and size range (in mm.) of 683 specimens examined*—Con.

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN—Continued				
Cape Romain, S. C.	July 11, 1933	ChM 33.176.3	1	107
33°07′ N., 77°20′ W	Aug. 10, 1953	SAFI, *Gill* 3, Reg. 60	1	7.0
33°14.7′ N., 76°23′ W	May 8, 1953	SAFI, *Gill* 2, Reg. 63	2	12.4–29.3
33°24′ N., 76°25′ W	Aug. 11, 1953	do	1	79
33°29′ N., 76°40′ W	do	SAFI, *Gill* 3, Reg. 64	68	12–29
33°43.5′ N., 76°56′ W	Sept. 28, 1954	SAFI, *Gill* 8, Reg. 65	7	71–82
33°44′ N., 77°00′ W	Aug. 11, 1953	SAFI, *Gill* 3, Reg. 65	1	13.8
33°50′ N., 75°58′ W	Aug. 12, 1953	SAFI, *Gill* 3, Reg. 72	1	7.5
33°50′ N., 75°59′ W	July 10, 1954	SAFI, *Gill* 7, Reg. 72	14	17–24.5
34°02.5′ N., 76°15.5′ W	Sept. 28, 1954	SAFI, *Gill* 8, Reg. 71	1	82.5
34°03.7′ N., 76°14.5′ W	July 10, 1954	SAFI, *Gill* 7, Reg. 71	53	11–19
Gulf Stream, 33 mi. south Lookout Lightship	July 28, 1915	USNM 164486, *Fish Hawk*	6	5.7–7.7
35°01′ N., 75°45′ W	Sept. 29, 1954	SAFI, *Gill* 8, Reg. 77	2	76–83
35°08′30″ N., 75°10′ W	Oct. 17, 1885	USNM 164536, *Albatross* Sta. 2596	2	13.2–16.5
Edge of Gulf Stream, off Cape Hatteras	June 6, 1903	USNM 53106	1	16.6
Mouth of York River, Va	July 8, 1953	UF 884	2	106–115
37°48′30″ N., 69°43′30″ W	Sept. 7, 1884	USNM 131600, *Albatross* Sta. 2223	2	21.0–24.2
38°49.3′ N., 71°37′ W	Aug. 3, 1952	SAFI, *Caryn*	9	90–105
39°26′ N., 68°03′30″ W	Aug. 31, 1885	USNM 92618, *Albatross* Sta. 2569	1	25.5
39°58′30″ N., 70°16′ W	Sept. 1, 1899	USNM 73248, *Fish Hawk* Sta. 7070	1	52.5
GULF OF MEXICO:				
Dry Tortugas, Fla		USNM 38597	1	88
Bonefish Bank, Fla	Nov. 27, 1906	USNM 57312, *Orian*	1	83.5
28°17′ N., 88°27′ W	July 22, 1956	UF 3914, *Oregon* 1587	3	80–145
28°17′ N., 88°35′ W	do	UF 3911, *Oregon* 1586	3	225–266
28°17′ N., 88°37′ W	Aug. 22, 1955	GFEGR, *Oregon* 1380	5	19–23
28°20′ N., 88°37′ W	July 21, 1956	UF 3917, *Oregon* 1585	9	34.5–49.5
150 mi. South of Mobile Bay	Aug. 1955	GFEGR, *Oregon*	7	54.5–72
Bayport, Fla	Sept. 25, 1954	UF 3744	6	133–219
28°45′ N., 88°03′ W	July 24, 1956	UF 3920, *Oregon* 1590	2	37.5–41.5
28°47′ N., 87°56′ W	July 23, 1956	UF 3915, *Oregon* 1589	5	12–37.5
28°47′ N., 87°57′ W	Aug. 15, 1955	GFEGR, *Oregon* 1367	4	20.5–44
28°48′ N., 87°50′ W	Aug. 14, 1955	GFEGR, *Oregon* 1365	3	23.5–44
28°50′ N., 87°58′ W	July 24, 1956	UF 3918, *Oregon* 1591	29	17.59
Do	July 26, 1956	UF 3912, *Oregon* 1593	2	247–267
Do	do	UF 3919, *Oregon* 1593	57	14.5–37.5
28°50′ N., 87°50′ W	Aug. 13, 1955	GFI, *Oregon* 1363	1	14
28°55′ N., 87°50′ W	Aug. 10, 1955	GFEGR, *Oregon* 1356	15	22.5–86
28°55′ N., 87°30′ W	June 21, 1957	SAFI, *Oregon* 1835	1	15.5
28°55′ N., 87°57′ W	Aug. 21, 1955	GFEGR, *Oregon* 1372	25	15–72
28°55′ N., 88°00′ W	Aug. 20, 1955	GFEGR, *Oregon* 1370	15	20–49
28°58′ N., 87°55′ W	July 20, 1956	UF 3916, *Oregon* 1582	2	27.5–33
29°01′ N., 87°48′ W	Aug. 22, 1955	GFEGR, *Oregon* 1374	29	17.5–53
Do	do	GFI, *Oregon* 1374	2	27.5–41
Do		do	1	17
Yankeetown, Fla	Oct. 26, 1930	UF 1420	1	142
Cedar Key, Fla	Sept. 1956	SAFI	1	191
Do	Oct. 28, 1956	do	1	193
CARIBBEAN SEA:				
Rocky Point, Jamaica	June 23, 1957	UF (uncataloged)	1	230

Caranx ruber (Bloch)

(Figures 34–38)

Scomber ruber Bloch, 1793, p. 75, pl. CCCXLII (St. Croix, West Indies).

Caranx ruber, Bloch and Schneider, 1801, p. 29.

Caranx blochii Cuvier, *in* Cuvier and Valenciennes, 1833, p. 69 (St. Croix, West Indies; Gulf of Mexico).

?*Caranx dentex* (*non* Bloch and Schneider), Günther, 1860, p. 441 (New Orleans).

Caranx iridinus Poey, 1860, p. 266 (Cuba).

Carangoides iridinus, Poey, 1868, p. 366.

Caranx (*Elaphrotoxon*) *ruber*, Fowler, 1905a, p. 76 (new subgenus).

Elaphotoxon ruber, Jordan, Evermann, and Clark, 1930, p. 271 (altered orthography; West Indies and coast of the Carolinas).

Caranx crysos (*non* Mitchill), Fowler, 1940, p. 766 (Rio de Janeiro, Brazil, but locality questioned).

Nomenclature

The nomenclature of *Caranx ruber* (Bloch) has been decisive since Jordan and Gilbert (1884: 32) amended their earlier synonymization (1883: 198) of this species with *C. bartholomaei* Cuvier.

Material

Measurements and counts were taken on a series of 76 fish from 12.4 to 246 mm. standard length, and meristic values were recorded for an additional 78 specimens within this size range. The 426 specimens identified are listed in table 10.

Three young specimens from New Orleans (presumably Louisiana) that are in the British Museum (Natural History) and were recorded by Günther (1860: 441) as *dentex* are not that species, but apparently are *ruber*. G. Palmer of the Museum has kindly furnished information on these specimens: 41 mm., 51 mm., and 59 mm. standard length; dorsal soft-rays 27 (2), and 28 (1); anal soft-rays 24 (3); lower-limb gill rakers 33 (3); lateral-line ratio 1.31 (1), and 1.37 (2); no pigmentation is apparent; and paired caudal keels above and below the lateral line are present. In the family Carangidae, this combination of characters is attributable only to *ruber*.

Characters

Dorsal spines.—VIII and I. All spines are well formed at 12.4 mm. standard length (fig. 34). The fourth spine averages the greatest length to about 33 mm.; above 33 mm., the third spine is longest. An interspinous membrane connects the first and second dorsal fins (eighth and ninth spines) to about 75 mm. On specimens 230 mm. and 246 mm., the membrane connecting the seventh and eighth spines has disappeared.

The regression of length of the third dorsal spine on standard length is shown in figure 39 and table 7. A line fitted to this regression for specimens from 12.4 to 118 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.10-mm. increase in spine length per 1.0-mm. increase in standard length). The coordinates of the four specimens larger than 118 mm. fall along the extension of the calculated regression line, indicating that the spine growth may continue at the same proportional rate.

Anal spines.—II and I. All spines are well formed at 12.4 mm. standard length (fig. 34). The second spine is longer than the first at all sizes. An interspinous membrane connects the second and third spines to about 42 mm.

Dorsal soft-rays.—26 to 30 (table 8). Counts of 2 specimens with only 24 soft-rays given by Nichols and Roemhild (1946, fig. 1) could repre-

TABLE 7.—Caranx ruber: *Statistics describing regressions of body parts on standard length*

$\bar{x}$=mean of independent variable x
$\bar{y}$=mean of dependent variable y
N=number of specimens
b=rate of increase of y
a=y-intercept of regression line
$Sy{\cdot}x$)=standard deviation from regression (standard error of estimate)

Independent variable x	Dependent variable y	Size range of specimens (mm.)	$\bar{x}$	$\bar{y}$	N	b	a	$Sy{\cdot}x$
Standard length	Dorsal-fin spine length (3d)	12.4–118	44.70	4.61	68	0.098	1.708	0.435
Do	Dorsal soft-ray length (1st)	12.4–118	45.72	5.72	66	.121	.174	.376
Do	Pectoral length	12.4–74.5	34.44	7.01	57	.201	.094	.336
Do	do	74.5–230	106.27	26.90	15	.381	−13.588	1.961
Do	Body depth	12.4–23.1	18.61	8.67	23	.406	1.107	.302
Do	do	23.1–106	52.82	19.30	47	.294	3.776	.638
Do	Head length	12.4–118	43.91	13.65	71	.265	2.014	.523
Do	Eye diameter	12.4–34.1	22.84	2.90	39	.080	1.080	.143
Do	do	34.1–106	65.50	5.55	31	.058	1.736	.165
Do	Snout length	12.4–88.5	38.31	3.45	65	.088	.087	.219

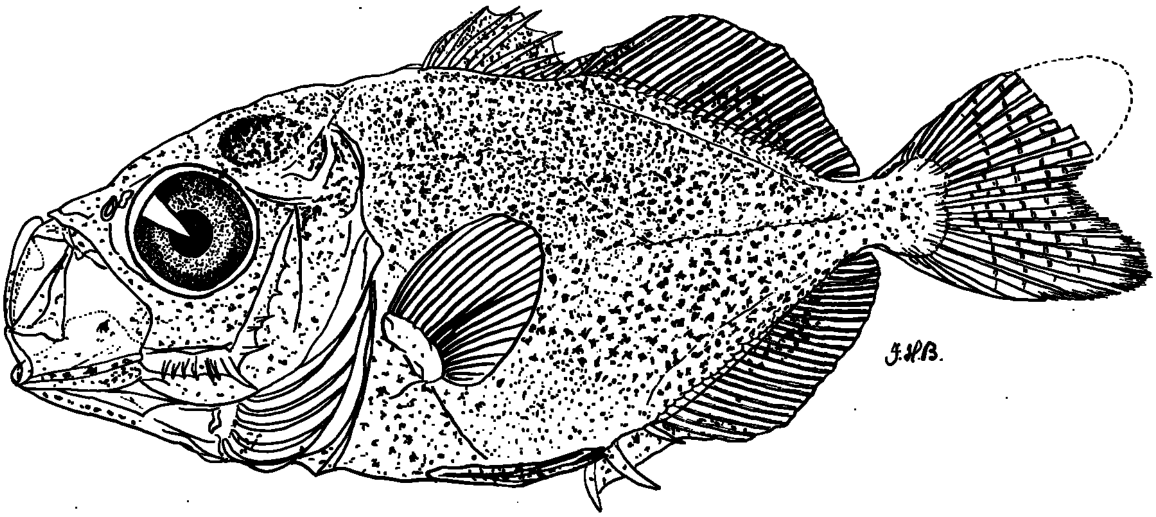

FIGURE 34.—*Caranx ruber* juvenile, 12.4 mm. standard length (*Gill* 7, Reg. 71).

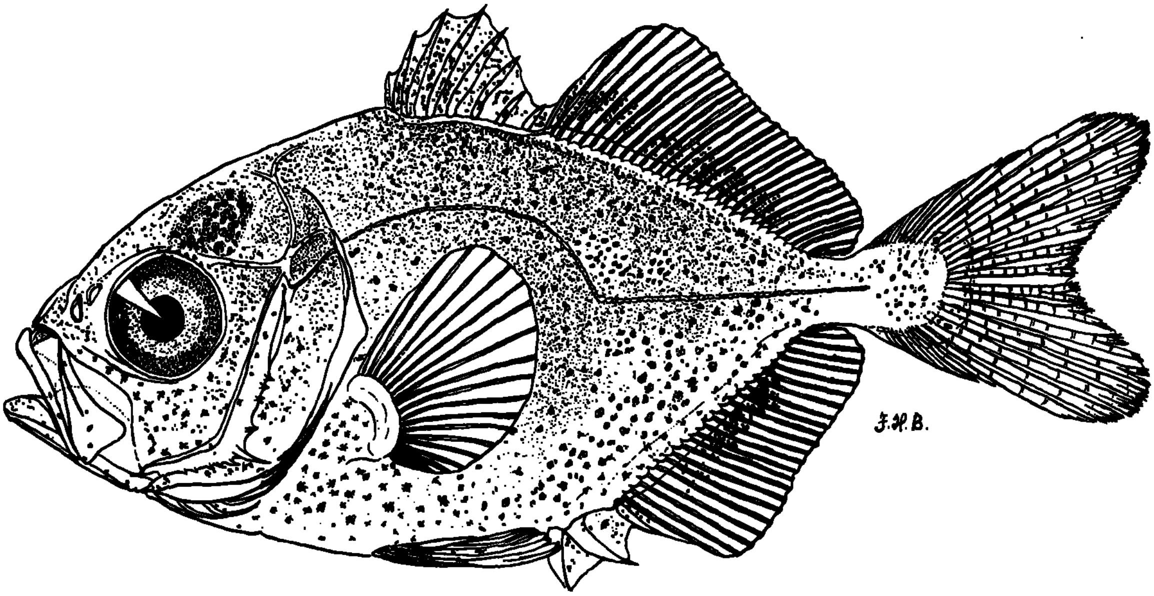

FIGURE 35.—*Caranx ruber* juvenile, 14.9 mm. standard length (*Gill* 7, Reg. 71).

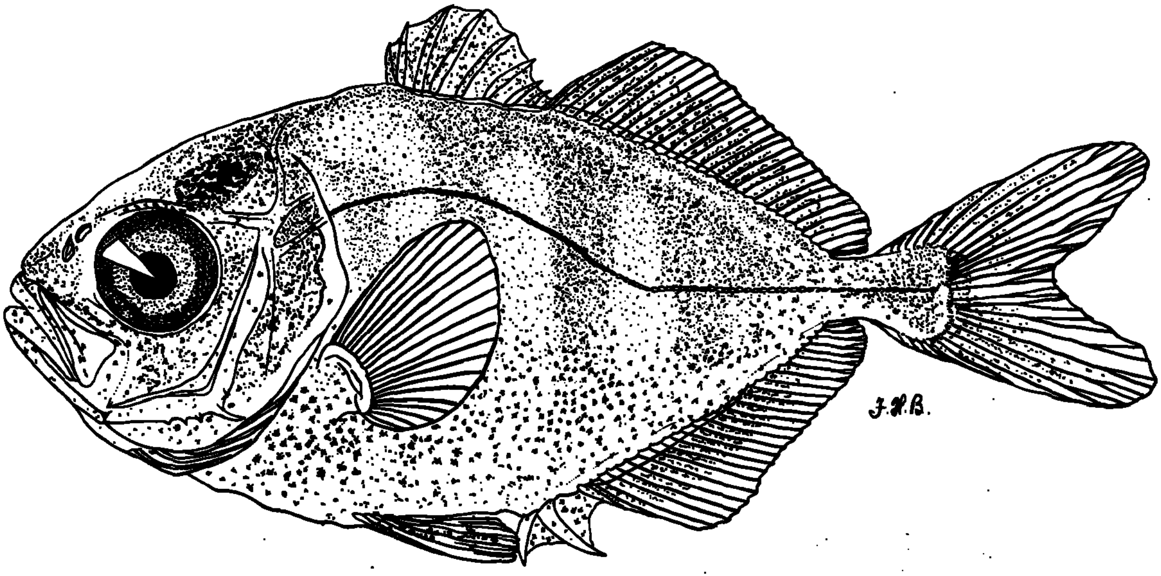

FIGURE 36.—*Caranx ruber* juvenile, 18.0 mm. standard length (*Gill* 4, Reg. 2).

sent specimens with missing rays (see Comparison of Species, p. 428). They gave a modal value (comprising 40 percent of their specimens) of 26 dorsal soft-rays, while 62 percent of my specimens had a bimodality of 27 and 28 soft-rays. All soft-rays are well formed, segmentation has begun, and the terminal ray is branched to its base at 12.4 mm. (fig. 34). Several other posterior rays are branched at 18 mm. (fig. 36), and all soft-rays are branched at 31.9 mm. (fig. 37). Extension of the anterior 5 or 6 rays to produce the fin lobe begins at about 20 mm. (fig. 37). The second ray averages the greatest length to about 28 mm.; above 28 mm., the first ray is longest. The longest ray averages a greater length than the longest spine (fig. 39).

The regression of length of the dorsal soft-ray on standard length is shown in figure 39 and table 7. A line fitted to this regression for specimens from 12.4 to 118 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.12-mm. increase

Table 8.—Caranx ruber: *Correlation of the numbers of dorsal and anal soft-rays of 152 specimens*

[The upper number in each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

	DORSAL SOFT-RAYS				
ANAL SOFT-RAYS	26	27	28	29	30
23	1 (.7)	11 (7.2)	3 (2.0)		
24	1 (.7)	48 (31.6)	48 (31.6)	1 (.7)	
25		3 (2.0)	25 (16.4)	9 (5.9)	1 (.7)
26			1 (.7)		

in soft-ray length per 1.0-mm. increase in standard length). The coordinates of the four specimens larger than 118 mm. fall along the extension of the calculated regression line, suggesting that soft-ray growth may continue at the same proportional rate.

Anal soft-rays.—23 to 26 (table 8). Formation, segmentation, branching, and lobation occur about as with the dorsal soft-rays. The second soft-ray averages the greatest length to about 22 mm. standard length; above 22 mm., the first ray is longest. The longest anal ray approximates the length of the longest dorsal ray to about 25 mm.

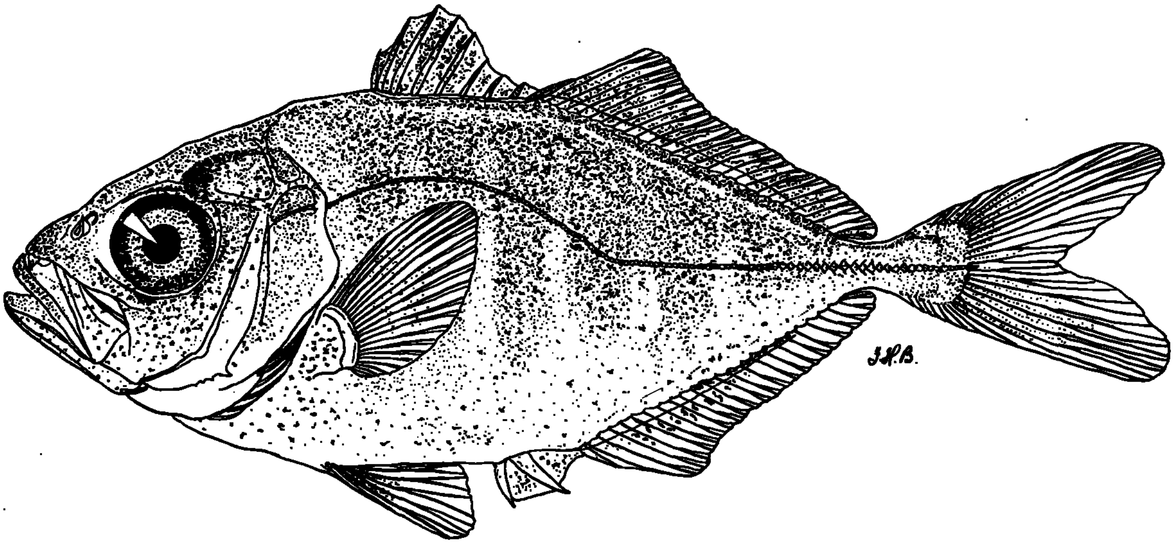

Figure 37.—*Caranx ruber* juvenile, 31.9 mm. standard length (*Gill* 6, Reg 14.).

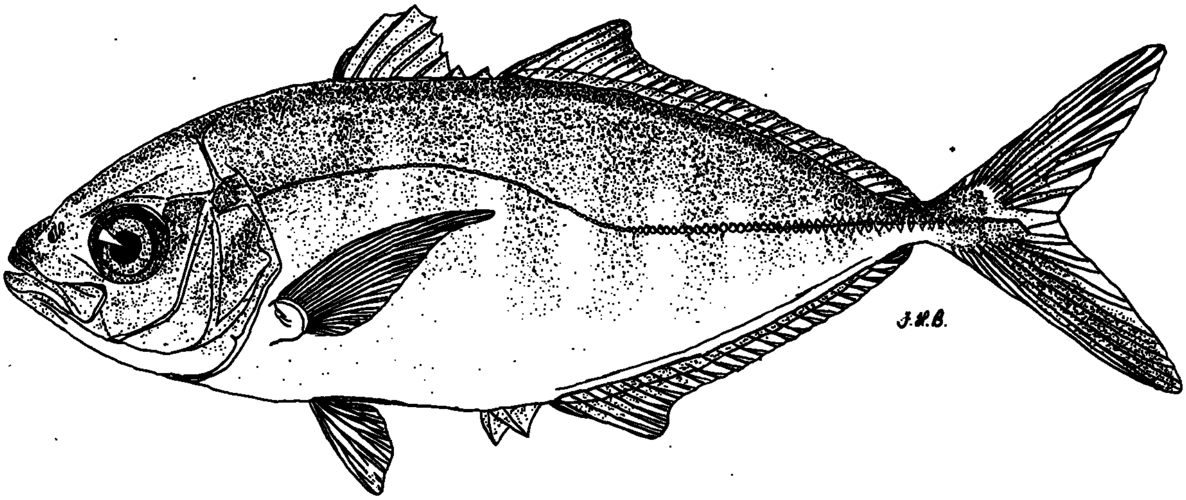

Figure 38.—*Caranx ruber* juvenile, 83.5 mm. standard length (*Gill* 3, Std., July 19, 1953; 0000–0400).

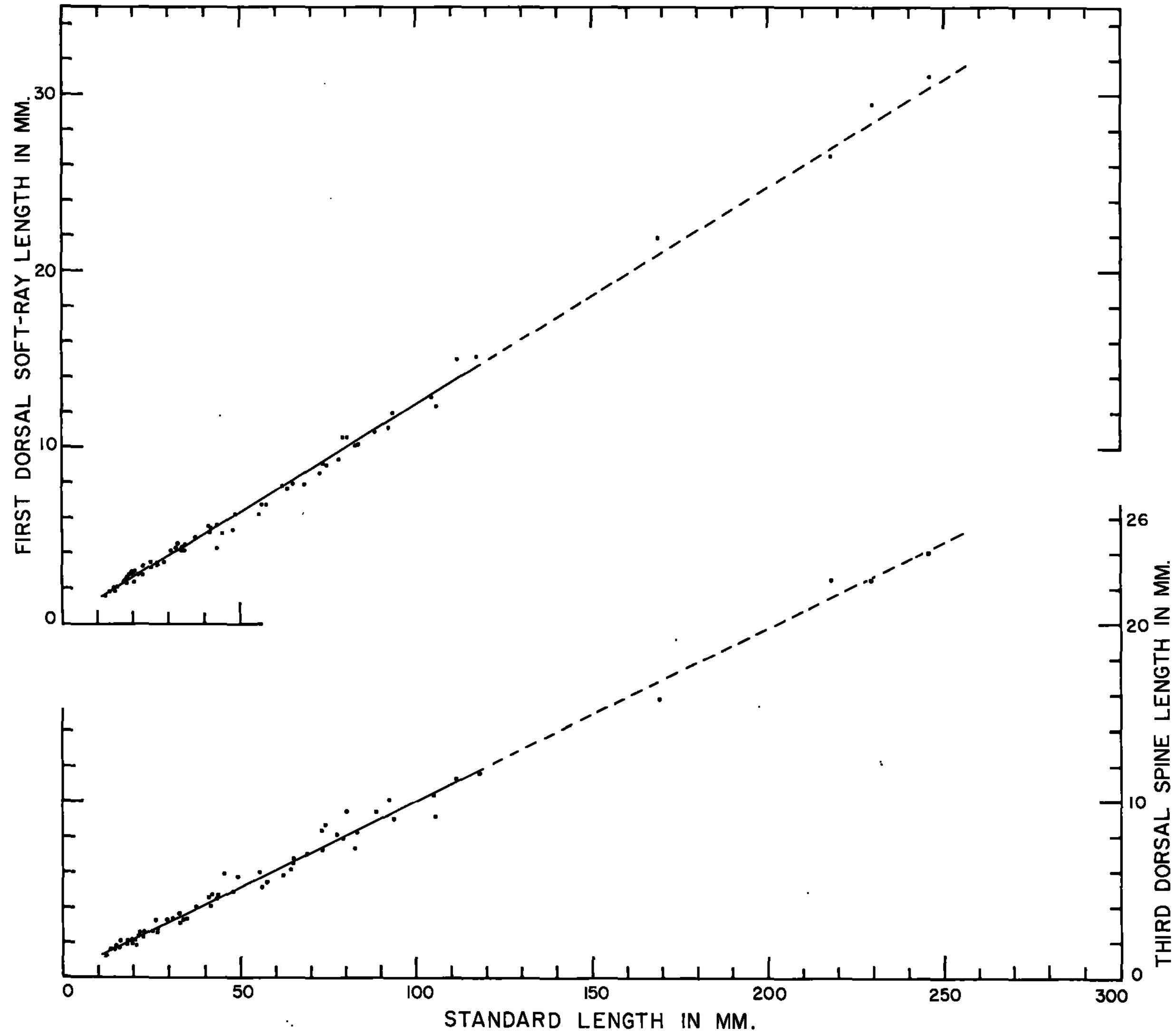

FIGURE 39.—*Caranx ruber:* Relation of length of the first dorsal soft-ray and of the third dorsal spine to standard length.

standard length; above 25 mm., the dorsal ray averages the greater length. The second anal spine averages slightly more than one-half the length of the longest anal ray to about 75 mm., and only about one-third at 169 mm. and 246 mm.

Interneural and interhemal spines.—Posterior lateral projections of these spines are not extended above the body surface (as occurs in *latus* and *hippos*).

Caudal.—9+8 principal rays; about 7 to 9+7 or 8 secondary rays. The principal rays are all segmented, branching has occurred, and forking of the tail is pronounced at 12.4 mm. (fig. 34). Branching is pronounced at about 15 mm. (figs. 35 and 36).

Pectoral.—I–18 to 21. The full complement of rays is formed at 12.4 mm. standard length (fig. 34). Branching has begun by 25 mm. The distal end of the fin is rounded from 12.4 mm. to about 35 mm., above which it becomes pointed and falcation begins (figs. 34 to 37). Falcation is pronounced by 83 mm.

The regression of pectoral length on standard length is shown in figure 40 and table 7. Two lines were fitted to this regression: for specimens from 12.4 to 74.5 mm. and from 74.5 to 230 mm. standard length. The lines intersect at approximately 75 mm., indicating that an inflection occurs at about that size and that a faster pectoral growth rate prevails above that size. The proportional rates of increase for the two variates are 0.20-mm. (below 75 mm.) and 0.38-mm. (above 75 mm.) increase in pectoral length per 1.0-mm. increase in standard length.

Pelvic.—I–5. The rays are well formed at 12.4 mm. standard length (fig. 34), and branching has begun by 15 mm. (fig. 35).

Body depth.—At corresponding body lengths the depth at first anal spine averages less than the depth at pelvic to about 35 mm. standard length, approximately equals the latter from 35 mm. to about 55 mm., and averages greater above 55 mm.

The regression of body depth at pelvic on standard length is shown in figure 41 and table 7. Two lines were fitted to this regression: for specimens from 12.4 to 23.1 mm. and from 23.1 to 106 mm. standard length. The lines intersect at approximately 24 mm., indicating that an inflection occurs at about that size and that a slower body-depth growth rate prevails above that size. The proportional rates of increase for the two variates are 0.41-mm. (below 24 mm.) and 0.29-mm. (above 24 mm.) increase in body depth per 1.0-mm. increase in standard length. The coordinates of the four specimens larger than 106 mm. fall slightly below the extension of the calculated regression line, but these data are insufficient to indicate a possible decrease in body-depth growth rate.

Head.—The regression of head length on standard length is shown in figure 41 and table 7. A line fitted to this regression for specimens from 12.4 to 118 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.27-mm. increase in head length per 1.0-mm. increase in standard length). The

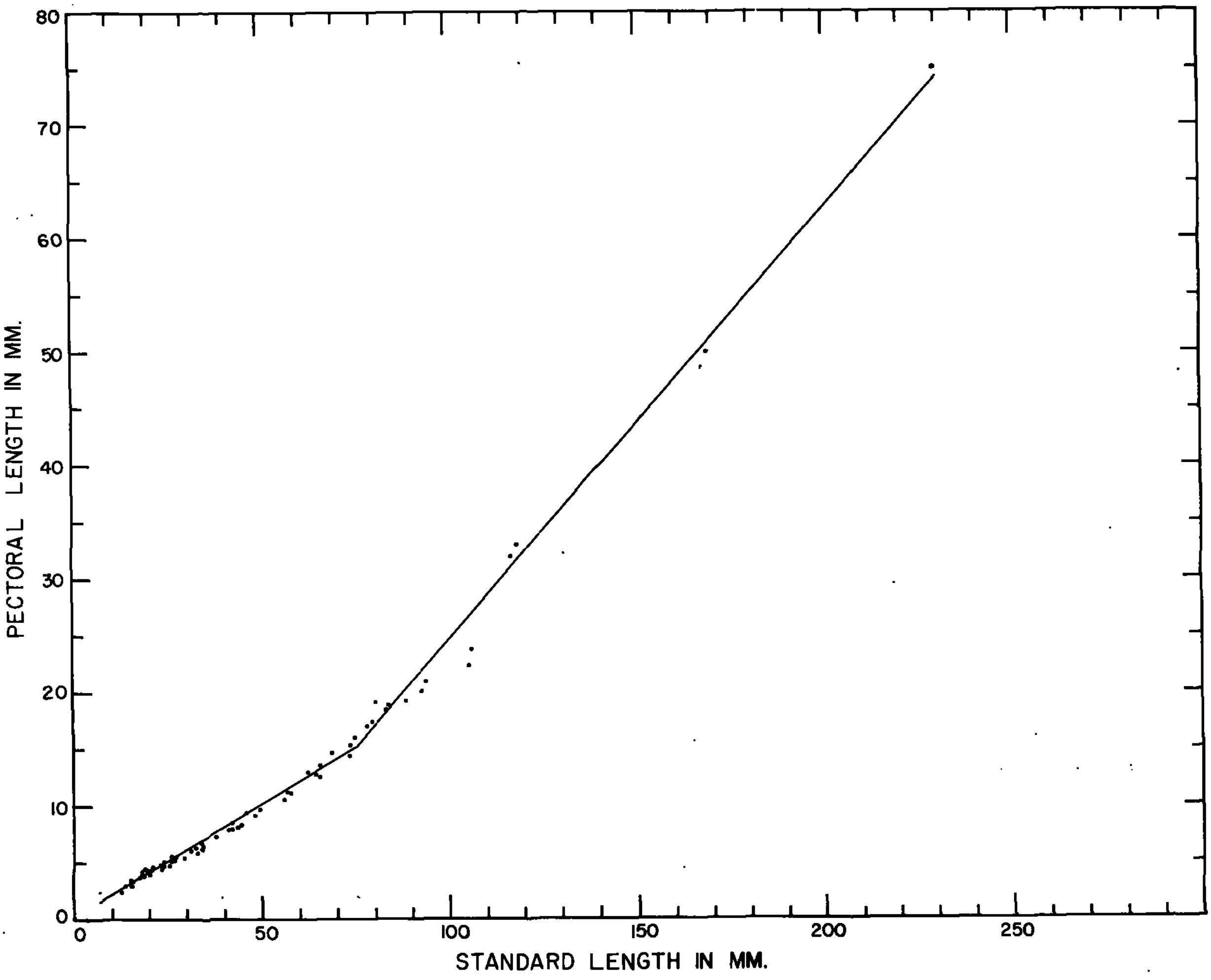

FIGURE 40.—*Caranx ruber:* Relation of pectoral length to standard length.

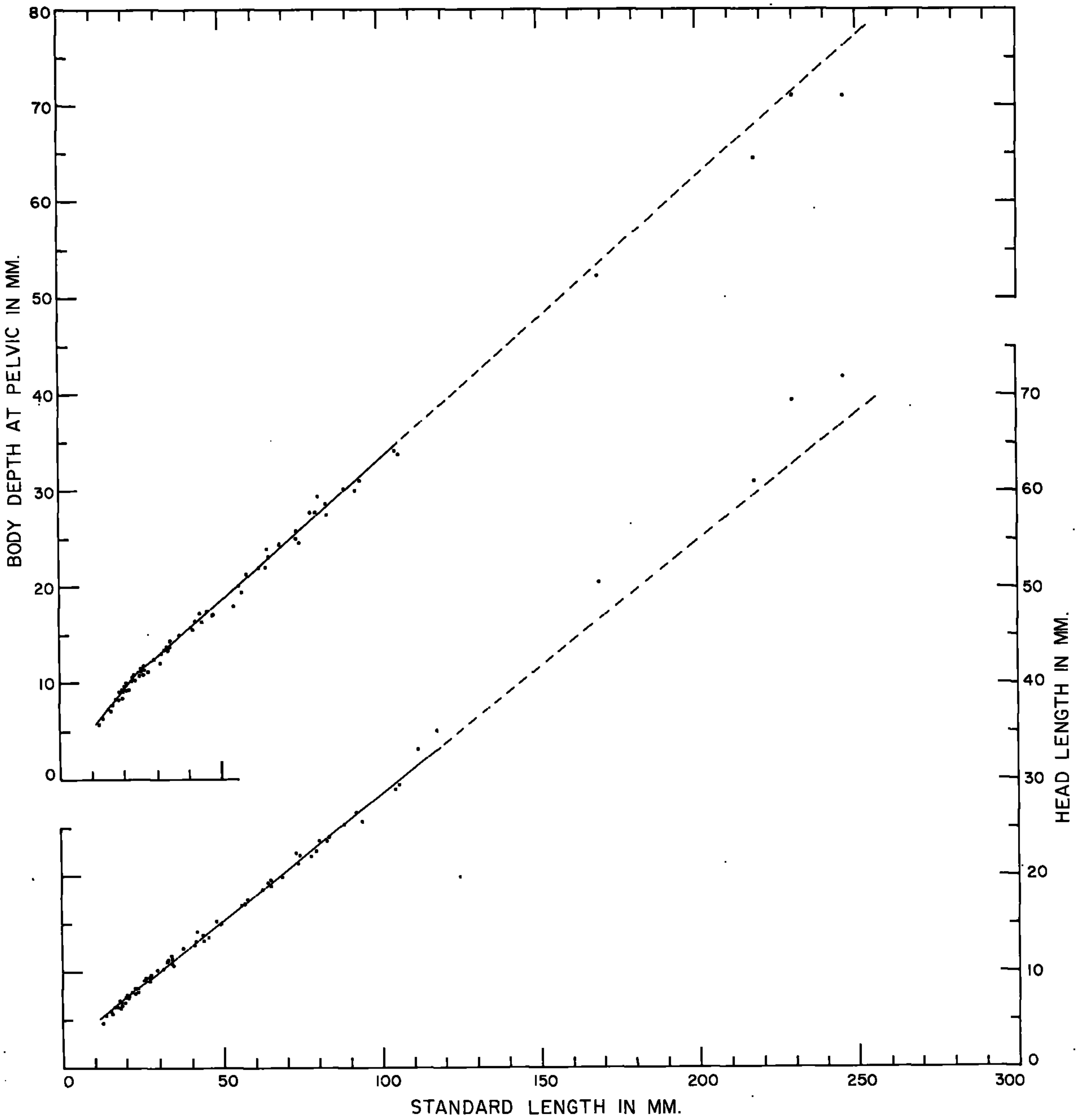

Figure 41.—*Caranx ruber:* Relation of body depth at pelvic and of head length to standard length.

alinement of the coordinates of the four largest specimens above the extension of the calculated regression line suggests an increase in head growth rate at some size around 118 mm.

Eye.—The regression of eye diameter on standard length is shown in figure 42 and table 7. Two lines were fitted to this regression: for specimens from 12.4 to 34.1 mm. and from 34.1 to 106 mm. standard length. The lines intersect at approximately 34 mm., indicating that an inflection occurs at about that size and that a slower growth rate prevails above that size. The proportional rates of increase for the two variates are 0.08-mm. (below 34 mm.) and 0.058-mm. (above 34 mm.) increase in eye diameter per 1.0-mm. increase in standard length. The coordinates of the six specimens larger than 106 mm. fall well above the extension of the calculated regression line, indicating an increase in eye growth rate around 106 mm.

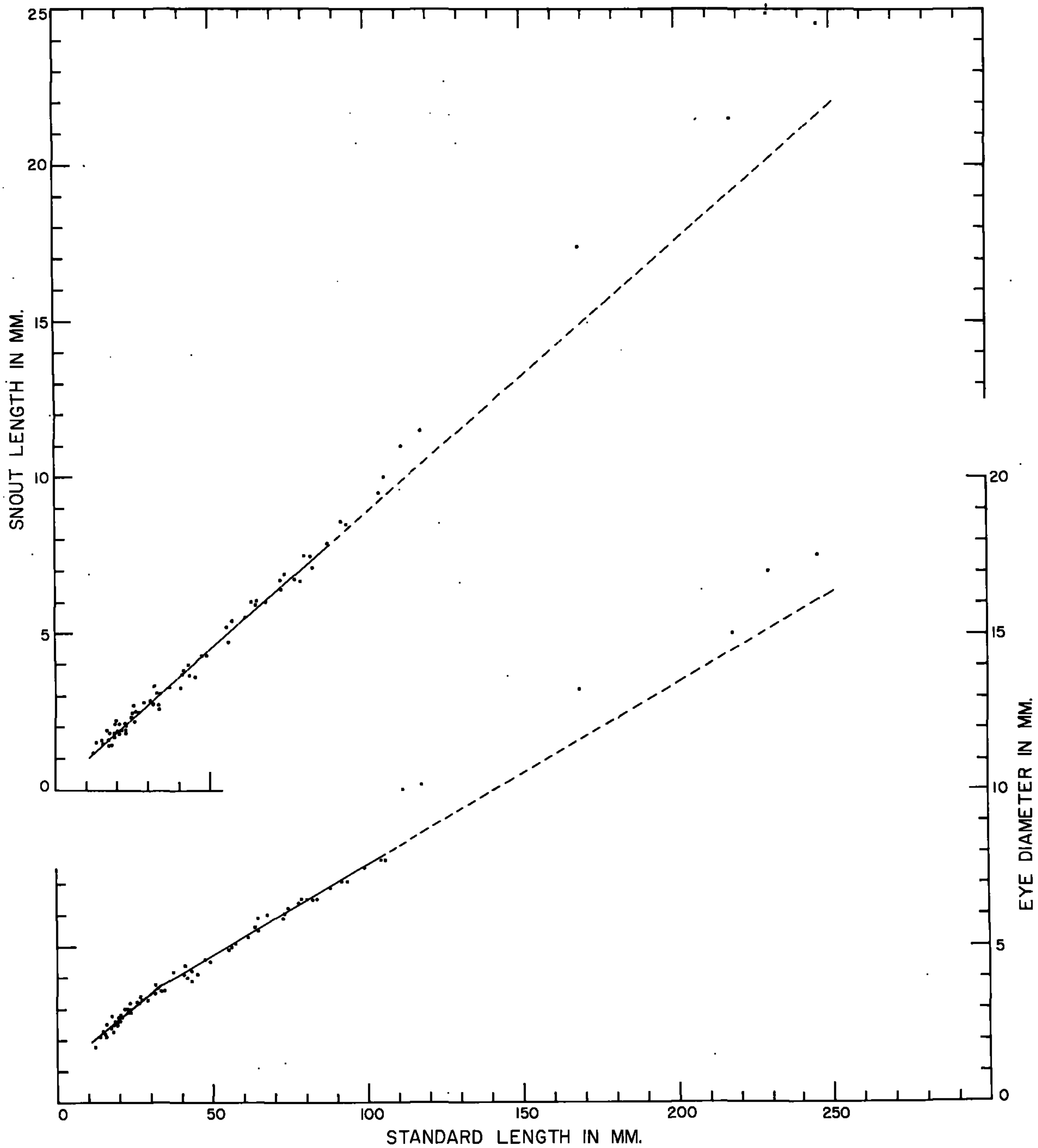

FIGURE 42.—*Caranx ruber:* Relation of snout length and of eye diameter to standard length.

Snout.—The regression of snout length on standard length is shown in figure 42 and table 7. A line fitted to this regression for specimens from 12.4 to 88.5 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.09-mm. increase in snout length per 1.0-mm. increase in standard length). The alinement of coordinates of specimens larger than 88.5 mm. above the extension of the calculated regression line indicates that an increase occurs in snout growth rate at about that size.

Gill rakers.—Lower limb, 31 to 35; upper limb, 10 to 14; total, 42 to 47 (table 9). About 15 percent of the specimens had one shortened or rudimentary gill raker at the origin of the lower limb; the 169-mm. specimen had two; and there was none on a 230-mm. specimen. Only one of the specimens had a shortened gill raker at the origin of the upper limb. There is no apparent correlation between body size and number of rudimentary gill rakers, at least up to 230 mm.

Scutes.—Range of the mean number of scutes at more than 100 mm. standard length: about 23 to 29 (fig. 43). The developing scutes appear below 15 mm. (fig. 35). The first scutes to complete their individual development do so at 22 to 24 mm. Development of all scutes of fish above 100 mm. is completed, or nearly completed (fig. 43).

Table 9.—Caranx ruber: *Correlation of the numbers of lower-limb to upper-limb gill rakers of 73 specimens*

[The upper number in each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

UPPER-LIMB GILL RAKERS	LOWER-LIMB GILL RAKERS				
	31	32	33	34	35
10		11 (15.1)	4 (5.5)	4 (5.5)	
11	4 (5.5)	5 (6.8)	7 (10.0)	4 (5.5)	
12		13 (17.8)	5 (6.8)	1 (1.4)	2 (2.7)
13	1 (1.4)	1 (1.4)	2 (2.7)	7 (10.0)	
14		1 (1.4)	1 (1.4)		

Lateral line.—Range of mean lateral-line ratio at more than 55 mm.: about 1.1 to 1.5 (fig. 44). Nichols (1939: 9) gave a ratio range for small specimens of 1.0 to 1.3. The mean ratio increases up to about 65 mm.

Preopercular spines.—The preopercular angle spine has apparently ceased to grow by 12.4 mm. standard length and to decrease in length at some size smaller than 18 mm. It is completely absorbed within the preopercular margin between 41 mm. and 44 mm. (fig. 45). The number of preopercular upper-limb and lower-limb spines is variable, but tends to decrease with an increase in body size (table 1).

Pigmentation.—The body, head, and mouth parts of the 12.4-mm. specimen are covered with pigment spots. A group of larger melanophores occurs on the transparent portion of the brain case. The pelvic fins and the dorsal and anal interspinous membranes are well pigmented, and

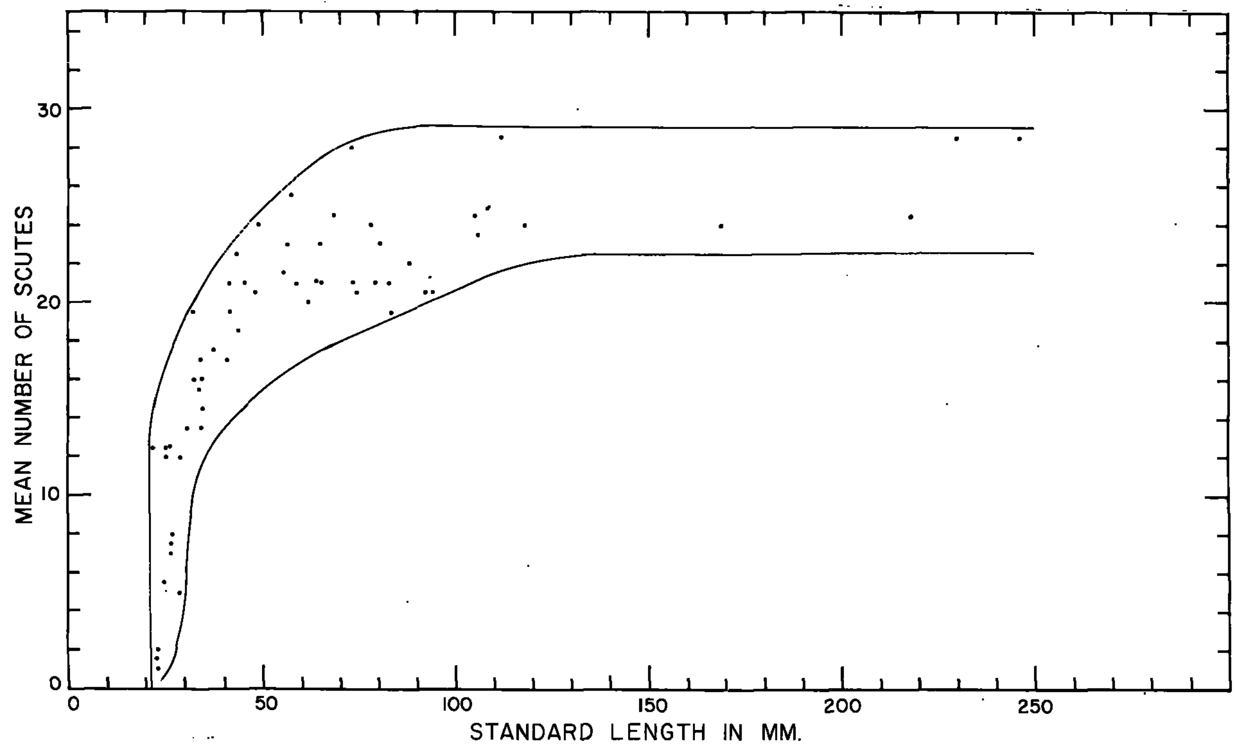

Figure 43.—*Caranx ruber:* Relation of the mean number of scutes to standard length.

a few pigment spots are present distal to the bases of the dorsal and anal soft-rays (fig. 34).

Pigmentation on the sides of the body intensifies and becomes blotched between about 15 mm. and 17 mm. standard length (fig. 35). Between about 17 mm. and 19 mm., from 3 to 5 indistinct bars are present on the sides (fig. 36). At sizes slightly over 19 mm., the full complement of 6 bars (infrequently, 5 or 7) is present (figs. 37 and 38). At about 40 mm. the lower parts of the bars below the straight part of the lateral line begin to fade, and the upper portions merge into a uniform pigmentation along the back. Indistinct traces of the bars remain on some specimens to over 105 mm., although they may have faded out or may be indistinct on some specimens as small as 30 mm. By 40 mm. a dense mass of pigment has developed on the upper portion of the caudal peduncle and the fleshy portion of the caudal fin. Above 60 mm. this pigmentation extends as a dark stripe to the tip of the lower caudal lobe (fig. 38).

The indistinct nuchal band is formed by about 30 mm. by the development of a posterodorsally projected pigment mass above and behind the eye (figs. 34 to 38). A slight concentration of pigment occurs directly below the eye on some specimens from about 18 to 40 mm. A vague vertically elongated spot is present on the operculum of some specimens between 40 mm. and 80 mm.

Pigment spots are present on the caudal and pectoral fins on some specimens by 16 mm. (fig. 35). The slight pigmentation found in the dorsal, anal, pectoral, and pelvic fins is illustrated in figures 34 to 38. The caudal pigmentation has been previously described.

Distribution off Southeastern Atlantic Coast of the United States

Caranx ruber has been reported from the following localities within this area: the northern Bahamas by Fowler (1919b: 150; 1944: 443), Bean (1905: 302), Lee (1889: 670), Meek and Hildebrand (1925: 357), and Ginsburg (1952: 91); the Gulf Stream off Bimini, Bahamas, by Nichols (1937b: 236; 1938b: 1); Cape Lookout and Beaufort, N. C., by Nichols (1912: 185; 1935: 268) and Smith (1907: 204); and from Charleston, S. C., by Nichols (1939: 1) and Fowler (1945: 189).

Figure 46 shows the location of specimens taken on the *Gill* cruises, by the *Combat* in the Gulf Stream off Florida and South Carolina, USNM specimens examined (Cape Hatteras and Cape Lookout, N. C.; on the 1,000-fathom line off Cape

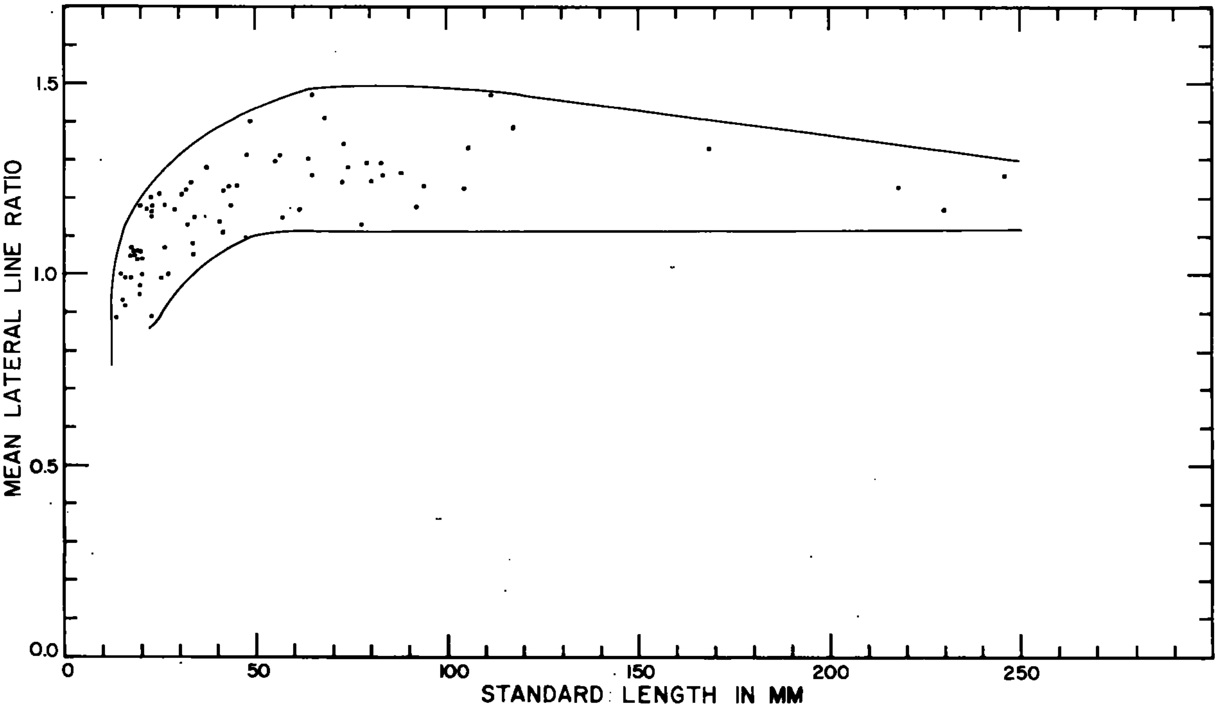

FIGURE 44.—*Caranx ruber:* Relation of the mean lateral-line ratio to standard length.

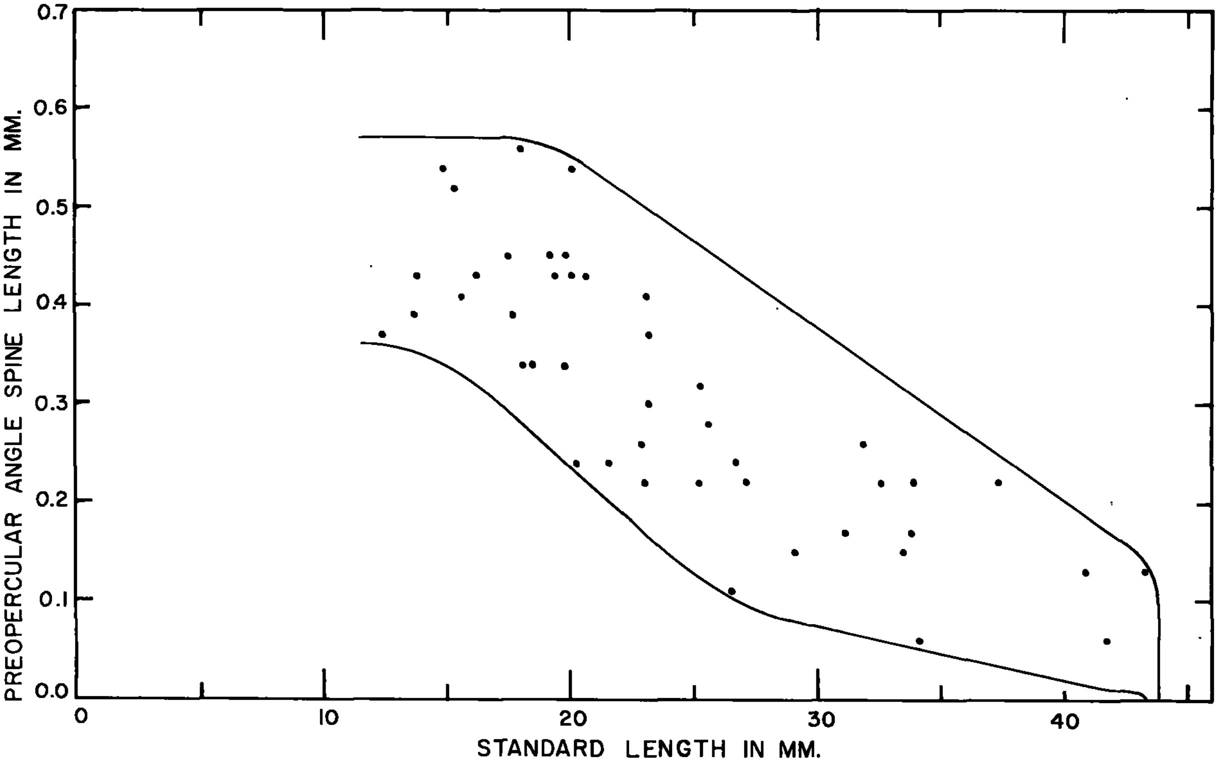

Figure 45.—*Caranx ruber:* Relation of the length of the preopercular-angle spine to standard length.

Lookout, N. C.; on the 100-fathom line off Cape Hatteras, N. C.; and east of the axis of the Gulf Stream off Cape Canaveral, Fla.), and a ChM specimen examined (Charleston, S. C.) (tables 2 and 10). The locations of capture recorded on this chart are for juvenile specimens. These juveniles were generally captured beyond the 100-fathom line and an association with the Gulf Stream (as depicted by the approximate axis of the Stream in figure 46) is indicated. Collections by the *Gill* were relatively less concentrated to the east of the Stream axis, and the occurrence of *ruber* is not as well depicted for this area, but the several deeper-water records indicate that the species is common there. Young *ruber* occur in the Gulf Stream from late April to November and are in greatest concentration from May through August (fig. 47).

The only published records of *ruber* that I have found from inshore waters of the United States are for Texas (Baughman 1947: 280); Tortugas, Fla. (Gudger 1929: 169; Longley and Hildebrand, 1941: 77; and Ginsburg 1952: 91); Charleston, S. C. (Fowler 1945: 189; Nichols 1939: 1); and Beaufort and Cape Lookout, N. C. (Smith 1907: 204; Nichols 1912: 185, 1935: 268). I have examined the Charleston, S. C., specimen reported by Fowler, and USNM specimens from Tortugas, Fla., and near Cape Hatteras, N. C. The USNM specimen, taken near Cape Hatteras, is the most northern inshore record for the species. The most-northern record is from 39°13′ N., 71°13′ W., in the Gulf Stream south of Georges Bank (Mather 1954: 293). This compilation indicates that *ruber* is rare in inshore waters. The North Carolina and South Carolina records are of specimens below 70 mm., which could have been drifted inshore by temporary currents.

The *Gill* collections indicate that juvenile forms of *ruber* are both widespread and abundant in the offshore waters of this area, primarily in association with the Gulf Stream and the merging Antilles Current. I believe that these developing young are carried northward by the currents. Absence of inshore records of the species north of North Carolina indicates that the Stream-grown juveniles and adults do not migrate in this direction, and absence of records from the Azores and waters farther east suggests that they discontinue their movement with the Stream to the east. It is possible

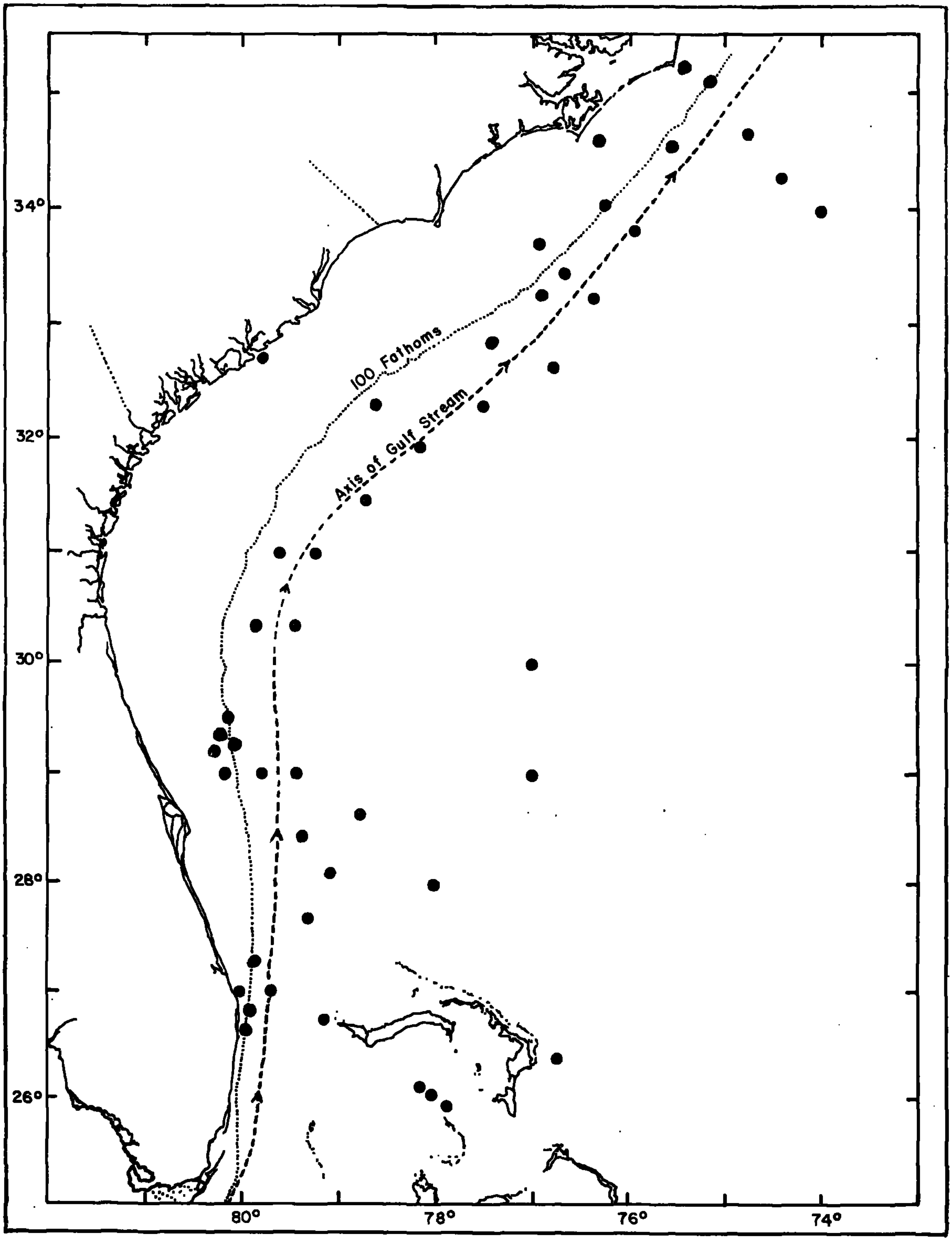

FIGURE 46.—*Caranx ruber:* Locations of capture off the southeastern Atlantic coast of the United States.

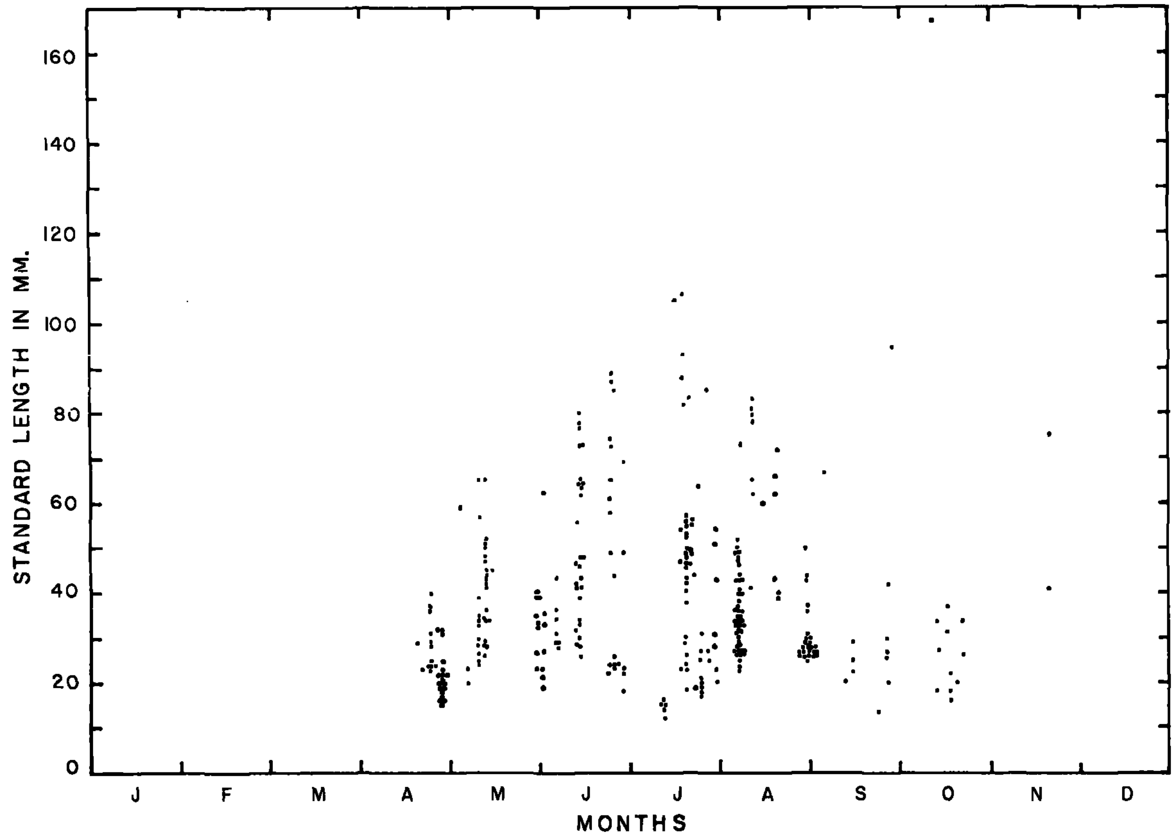

FIGURE 47.—*Caranx ruber:* Size distribution, by months, of specimens taken off the southeastern Atlantic coast of the United States.

that the major portion of this population returns southward, either against the currents of the Gulf Stream or through the Sargasso Sea, to supplement the adult population of the West Indies.

Although apparently very abundant off the Atlantic coast of the United States, *ruber* appears to be relatively rare in the northern Gulf of Mexico. It was reported from the Port Isabel area of Texas by Baughman (1947: 280). Ginsburg (1952: 91) found no specimens from the northern Gulf coast. The specimens reported by Günther (1860:441) as *dentex*, which probably were *ruber*, were listed ambiguously from New Orleans. I have examined two specimens of *ruber* taken by the *Silver Bay* about 11 miles southwest of Cedar Key, Fla., and specimens taken by the *Oregon* about 55 miles southeast and about 60 miles east of South Pass, La., and 150 miles south of Mobile Bay (table 10). Other than from around Havana and Torgugas, the only other records I have found for this species in the Gulf of Mexico are from five *Oregon* stations reported by Springer and Bullis (1956: 74).

On the basis of two collections of *ruber* from the Gulf Stream (off Bimini, Bahamas, and about 350 miles east of Virginia), Nichols (1939:2) postulated, "The Gulf Stream is obviously their Atlantic nursery ground." He suggested that the young might enter the Gulf Stream mainly from its easterly edge, "or perhaps they frequent the current rather than slack waters at the edges until large enough to migrate independently, when they must of necessity strike southward or be lost."

Spawning

The spawning season may be estimated, from the smallest specimens taken in April (15 mm.) and in October (18 mm.), to extend from mid-February to mid-August (fig. 47).

If, as suggested, there is a mobile, northward-moving population of developing young in the Gulf Stream, the majority of the specimens taken by the *Gill* would have developed from spawning that occurred to the south of this area. The small sizes of several specimens listed in table 10 suggest

TABLE 10.—Caranx ruber: *Location and date of capture, number and size range (in mm.) of 426 specimens examined*

[See pp. 417 and 419 for explanation of abbreviations used; measurements in standard length]

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN:				
22°42′33″ N., 74°23′ W	Mar. 29, 1927	BOC 1343, *Pawnee* Sta. 39	1	14.5
24°04′ N., 79°15′ W	July 24, 1957	SAFI, *Combat* 448	50	15–56.5
24°13′ N., 81°42′ W	July 21, 1957	SAFI, *Combat* 436	1	20
Nassau fish market, Bahamas	Aug. 17–20, 1956	UF 3538	2	230–246
25°10′ N., 80°02′ W	July 22, 1957	SAFI, *Combat* 438	1	19.5
26°21.2′ N., 76°46.5′ W	July 18–19, 1953	SAFI, *Gill* 3, Std	26	18.5–106
Do	July 19, 1953	do	4	44–83.5
Do	July 23, 1953	do	1	64
26°27′ N., 76°44′ W	June 12–13, 1954	SAFI, *Gill* 7, Std	16	27.5–79.5
Do	June 13–14, 1954	do	2	45.5–73
Do	June 14, 1954	do	4	25.6–27.5
26°37′ N., 79°51′ W	July 28, 1957	SAFI, *Combat* 458	1	28.5
26°47′ N., 79°53′ W	do	SAFI, *Combat* 459	1	31
26°54′ N., 79°07′ W	Aug. 29, 1954	SAFI, *Gill* 8, Settlement Point, Bahamas	25	25–49.5
26°58.5′ N., 79°40′ W	Oct. 12, 1953	SAFI, *Gill* 4, Reg. 2	1	18
27°01′ N., 80°04′ W	Apr. 23, 1953	SAFI, *Gill* 2, Reg. 3	1	22.5
27°14′ N., 79°50′ W	July 29, 1957	SAFI, *Combat* 462	3	43–54.5
27°40′ N., 79°18.5′ W	Apr. 23, 1953	SAFI, *Gill* 2, Reg. 7	2	23.2–23.2
Do	Oct. 13, 1953	SAFI, *Gill* 4, Reg. 7	2	26.7–33.5
Do	June 23, 1954	SAFI, *Gill* 7, Reg. 7	1	21
28°00′ N., 78°00′ W	July 18, 1953	SAFI, *Gill* 3, Spc. 8	1	92.5
28°17.5′ N., 79°28′ W	Sept. 12, 1954	SAFI, *Gill* 8, Reg. 8	1	19.8
28°18.5′ N., 79°26′ W	July 26, 1953	SAFI, *Gill* 3, Reg. 8	8	17.5–31.1
28°19′ N., 79°26′ W	Apr. 24, 1953	SAFI, *Gill* 2, Reg. 8	7	25–40
28°40′ N., 78°46′ W	May 3, 1886	USNM 148334, *Albatross* Sta. 2660	1	59
28°56.3′ N., 79°45.6′ W	July 27, 1953	SAFI, *Gill* 3, Reg. 15	2	25–27
28°59.5′ N., 79°26.5′ W	June 25, 1954	SAFI, *Gill* 7, Reg. 16	7	23–84.5
29°00′ N., 77°00′ W	July 17, 1953	SAFI, *Gill* 3, Spc. 6	3	23–54
29°10′ N., 80°19′ W	June 1, 1957	SAFI, *Combat* 336	3	27.5–35.5
29°10′ N., 80°19′ W to 29°19′ N., 80°15′ W	do	SAFI, *Combat* 336 to *Combat* 337	3	19.4–23.5
29°16′ N., 80°04′ W	May 30, 1957	SAFI, *Combat* 328	5	27–40.5
29°19′ N., 80°18′ W	June 1, 1957	SAFI, *Combat* 343	1	63
29°20′ N., 80°04′ W	Apr. 27, 1957	SAFI, *Combat* 316	1	25
29°26′ N., 80°08′ W	do	SAFI, *Combat* 315	10	17.5–32
Do	do	do	10	15–22
29°28′ N., 80°09′ W	May 30, 1957	SAFI, *Combat* 326	2	23.5–35
29°29′ N., 80°09′ W	Aug. 18, 1957	SAFI, *Combat* 485	3	43.5–66
29°29′ N., 80°10′ W	Aug. 19, 1957	SAFI, *Combat* 490	3	39–72
29°38′ N., 80°12′ W	Aug. 14, 1957	SAFI, *Combat* 474	1	60
29°47′ N., 80°05′45″ W	May 4, 1886	USNM 134076, *Albatross* Sta. 2665	5	28.3–36
30°00′ N., 77°00′ W	July 16, 1953	SAFI, *Gill* 3, Spc. 5	1	105
Do	June 10, 1954	SAFI, *Gill* 7, Spc. 5	5	31.5–56
30°19.5′ N., 79°50′ W	Sept. 14, 1954	SAFI, *Gill* 8, Reg. 27	3	23–29
30°19.8′ N., 79°25.5′ W	Oct. 16, 1953	SAFI, *Gill* 4, Reg. 28	1	31
30°20′ N., 79°50′ W	June 26, 1954	SAFI, *Gill* 7, Reg. 27	4	21.6–68.5
30°56.8′ N., 79°37.4′ W	July 29, 1953	SAFI, *Gill* 3, Reg. 30	2	20–23
30°57′ N., 79°14.5′ W	Nov. 19, 1954	SAFI, *Gill* 9, Reg. 29	2	41–74.5
30°58′ N., 79°37.5′ W	Oct. 16, 1953	SAFI, *Gill* 4, Reg. 30	1	37.3
Do	June 27, 1954	SAFI, *Gill* 7, Reg. 30	1	18.1
31°29.1′ N., 78°41′ W	May 5, 1953	SAFI, *Gill* 2, Reg. 40	2	20.1–23
31°57′ N., 78°09′ W	Aug. 6, 1953	SAFI, *Gill* 3, Reg. 50	44	23–49.5
32°15′ N., 78°32′ W	Sept. 25, 1954	SAFI, *Gill* 8, Reg. 48 to Reg. 49	1	13.8
32°19′ N., 77°34′ W	Aug. 7, 1953	SAFI, *Gill* 3, Reg. 51	1	73
32°39′ N., 76°46′ W	Aug. 10, 1953	SAFI, *Gill* 3, Reg. 62	1	41
32°43′ N., 76°47.5′ W	May 8, 1953	SAFI, *Gill* 2, Reg. 62	3	24–33
Off Charleston, S. C	Sept. 4, 1938	ChM 38.207.9	1	67
32°50′ N., 77°27′ W	Apr. 21, 1957	SAFI, *Combat* 295	1	23.5
33°13′ N., 76°55′W	Apr. 20, 1957	SAFI, *Combat* 290	1	29
33°14′ N., 76°25′ W	Sept. 27, 1954	SAFI, *Gill* 8, Reg. 63	1	19.9
33°14.7′ N., 76°23′ W	May 8, 1953	SAFI, *Gill* 2, Reg. 63	8	25.2–57
33°24′ N., 76°25′ W	Aug. 11, 1953	SAFI, *Gill* 3, Reg. 63	5	62–83
33°29′ N., 76°37.5′ W	Sept. 28, 1954	SAFI, *Gill* 8, Reg. 64	1	94
33°29′ N., 76°40′ W	Aug. 11, 1953	SAFI, *Gill* 3, Reg. 64	1	65
33°43.5′ N., 76°56′ W	Sept. 28, 1954	SAFI, *Gill* 8, Reg. 65	1	41.5
33°49′ N., 75°59′ W	May 10, 1953	SAFI, *Gill* 2, Reg. 72	1	65
34°00′ N., 74°14.5′ W	May 14, 1953	SAFI, *Gill* 2, Spc. 1	1	45
34°03.7′ N., 76°14.5′ W	July 10, 1954	SAFI, *Gill* 7, Reg. 71	5	12.4–15.7
34°33.5′ N., 74°55′ W	Sept. 29, 1954	SAFI, *Gill* 8, Reg. 80	3	26–30
34°37.7′ N., 74°45.5′ W	May 12, 1953	SAFI, *Gill* 2, Reg. 80	17	26–52
34°39′ N., 76°12′ W	Oct. 19, 1885	USNM 92619, *Albatross* Sta. 2607	2	26.4–34.5
34°39′30″ N., 75°35′30″ W	Oct. 18, 1885	USNM 111788, *Albatross* Sta. 2600	1	20.3
35°08′30″ N., 75°10′ W	Oct. 17, 1885	USNM 101523, *Albatross* Sta. 2596	3	16.2–22.1
Near Cape Hatteras, N. C	June 5, 1903	UNSM 53109	1	43
35°24′ N., 67°33′ W to 36°48′ N., 68°55′ W	Aug. 26–27	BOC 1358, *Atlantis* Sta. 1934	2	14–17
38°07′ N., 68°45′ W to 37°12′ N., 67°39′ W	Aug. 21–22	BOC, *Atlantis* Sta. 1954	14	14.5–49
Havanna, Cuba, to New York	May 10–15, 1932	BOC 3457, *Mable Taylor*	33	15–34
GULF OF MEXICO:				
Havana market, Batabano, Cuba	Nov. 17, 1954	UF 5349	1	169
Tortugas, Fla	Nov. 25, 1919	USNM 144018, *Albatross*	18	93.5–119
150 mi. south of Mobile Bay	Aug. 1955	GFEGR, *Oregon*	1	53.5
28°17′ N., 88°37′ W	Aug. 25, 1955	GFEGR, *Oregon* 1380	5	18.5–31.5
28°58′ N., 87°55′ W	July 20, 1956	UF 3921, *Oregon* 1582	1	24.5
29°01′ N., 83°21′ W	Aug. 21, 1957	SAFI, *Silver Bay* 152	2	129–137
CARIBBEAN SEA:				
Rocky Point, Jamaica	June 23, 1957	UF (uncataloged)	1	218

that they may have been spawned within this area (12.4 to 15.7 mm. and 14 to 17 mm. specimens off North Carolina, and 14.5 to 49 mm. specimens about 350 miles off Virginia). Spawning in this area probably occurs in association with the Gulf Stream since the small juveniles are found there. Spawning to the south of this area that contributes young *ruber* to the area probably occurs in waters contributing to the Gulf Stream.

Caranx bartholomaei Cuvier

(Figures 48–54)

Caranx bartholomaei Cuvier, *in* Cuvier and Valenciennes, 1833, p. 100 (Saint-Barthelemi, West Indies).
Caranx cibi Poey, 1860, p. 224 (Cuba).
Carangus bartholomaei, Poey, 1866, p. 14 (Cuba).
Carangoides cibi, Poey, 1866, p. 15 (Cuba).
Caranx beani Jordan, 1881, p. 486 (Beaufort, N. C.).
Carangus cibi, Jordan and Gilbert, 1882b, p. 436 (West Indies to Florida).
Carangus beani, Jordan and Gilbert, 1882b, p. 436 (Beaufort, N. C.).
Caranx ruber (*non* Bloch), Jordan and Gilbert, 1883, p. 198 (in part; West Indies to North Carolina).
Caranx pisquetus (*non* Cuvier), McCormick, *in* Smith, 1896, p. 175 (Biscayne Bay, Fla.).
Caranx latus (*non* Agassiz), Jordan and Evermann, 1900, pl. CXLII, fig. 389 (figure only). Fowler, 1950, p. 70 (northwest of Cay Sal Bank).
Elaphotoxon bartholomaei, Jordan, Evermann, and Clark, 1930, p. 272 (West Indies, north to North Carolina).
Caranx guara (*non* Bonnaterre, *fide* Jordan and Evermann), Fowler, 1945, p. 292, fig. 307 (Boca Chica, Key West, Fla.). Fowler, 1950, p. 70, fig. 3 (northwest of Cay Sal Bank).

Nomenclature

The nomenclature of *Caranx bartholomaei* Cuvier has been decisive since Jordan and Gilbert (1884: 32) amended their earlier consolidation (1883: 198) of this species with *C. ruber*. As pointed out by Bailey (1951: 251), Cuvier should be recognized as the sole author. However, Fowler (1944: 443; 1952a: 127; 1952b: 99; and elsewhere) has regarded Valenciennes as the only author.

Material

Measurements and counts were taken on a series of 78 fish from 6.0 to 243 mm. standard length, and meristic values were recorded for an additional 8 specimens within this size range. The 6.0-mm. specimen is tentatively identified as this species. A damaged specimen of 315 mm. was the largest examined. The 125 specimens identified are listed in table 14.

A 17.4-mm. specimen of *bartholomaei*, ANSP 72689, northwest of Cay Sal Bank, 23°50′N., 80°40′W., March 26, 1948, identified as a 22-mm. total length *latus* by Fowler (1950: 70) has 26 dorsal and 22 anal soft-rays, 20 lower-limb gill rakers, 4 upper-limb and 7 lower-limb preopercular spines, and traces of 4 vague bars above the lateral line. This combination of characters distinguishes *bartholomaei* of this size from the other species of Western Atlantic *Caranx*.

Two specimens of *bartholomaei*, ANSP 70973–74, 24.4 mm. and 45 mm. standard length, from Boca Chica, Key West, Fla., that were labeled *guara*,

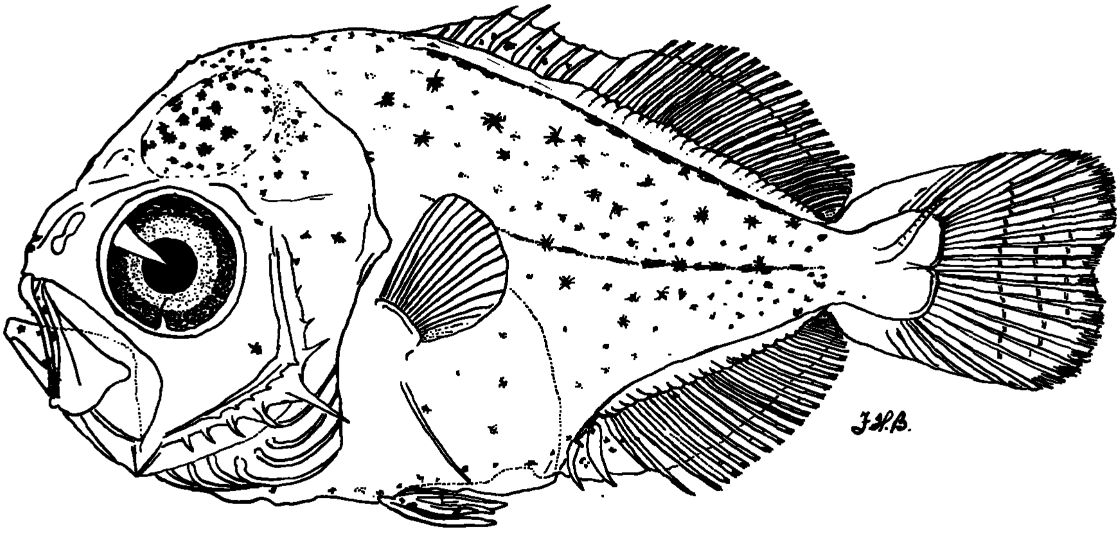

FIGURE 48.—*Caranx bartholomaei* (?) larva, 6.0 mm. standard length (*Gill* 2, Reg. 2).

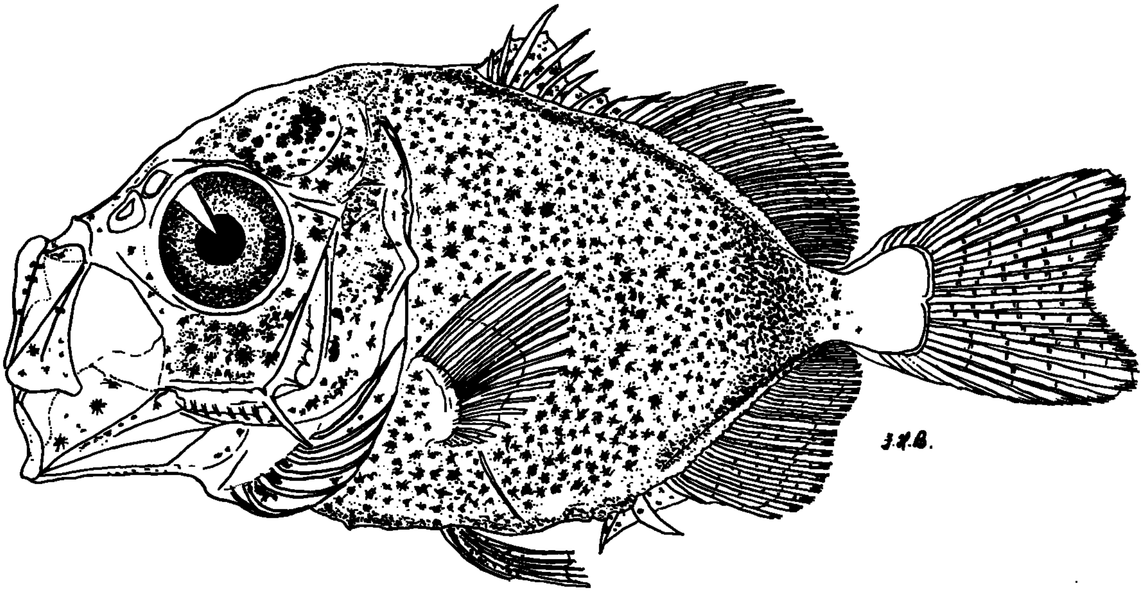

FIGURE 49.—*Caranx bartholomaei* larva, 8.1 mm. standard length (*Gill* 4, Reg. 50).

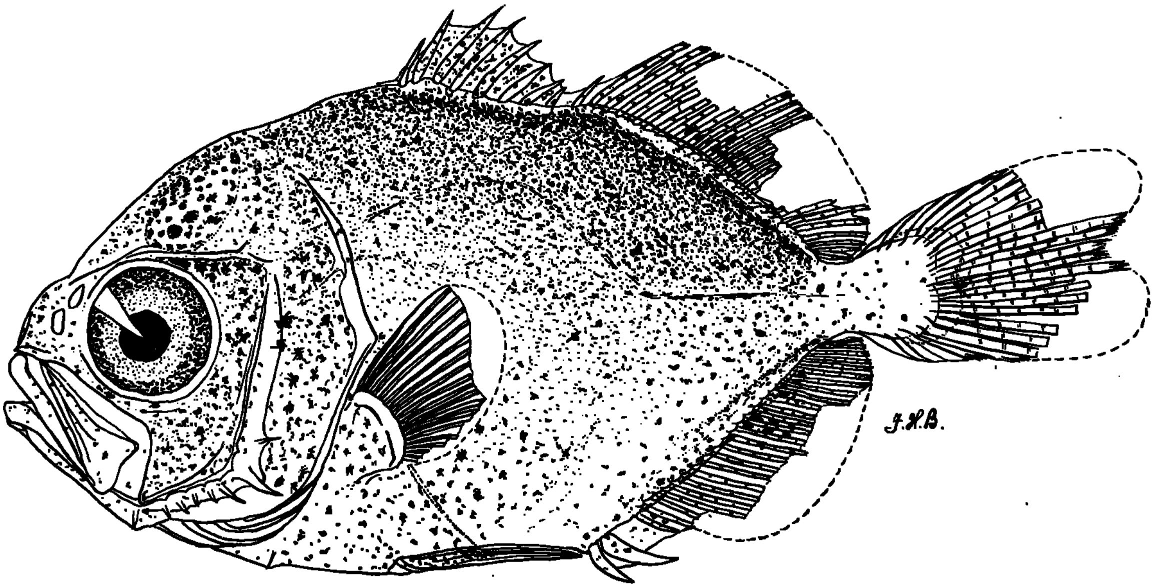

FIGURE 50.—*Caranx bartholomaei* juvenile, 10.5 mm. standard length (USNM 164537).

apparently furnished the basis for the identification of a 28-mm. total length specimen of *guara* (=*dentex*) by Fowler (1945: 292, fig. 307). Fowler's identification records the same locality, date, collector's name, and *Physalia* association contained on the label with the two specimens from Boca Chica. The 24.4-mm. specimen, presumably the one referred to as *guara* (=*dentex*) by Fowler, has D. VIII–I–26, A. II–I–23, and 4 to 5 completely developed scutes. It has a slightly greater depth than two other *bartholomaei* of about the same length, but this excess is well within the range of observed individual variation. Both of the ANSP specimens have 20 lower-limb gill rakers. The posterior body bars of the 24.4-mm. specimen are more angular than depicted in

Fowler's figure 307. Fowler (1950: 70) recognized this misidentification, but his statements concerning his recognition are not clear.

Two specimens of *bartholomaei*, ANSP 72693, 15.8 mm. and 17.2 mm. standard length taken at 23°50′ N., 80°40′ W. (northwest of Cay Sal Bank), March 26, 1948, on the Catherwood-Chaplin West Indies Expedition were labeled *guara* (=*dentex*) and referred to as such by Fowler (1950: 70, fig. 3). Both specimens have 5 slightly bent body bars and 7 upper-limb and 19 lower-limb gill rakers. The 17.2-mm. specimen has 26 dorsal and 23 anal soft-rays. The 28 dorsal and 25 anal soft-rays of the 15.8-mm. specimen are slightly wavy

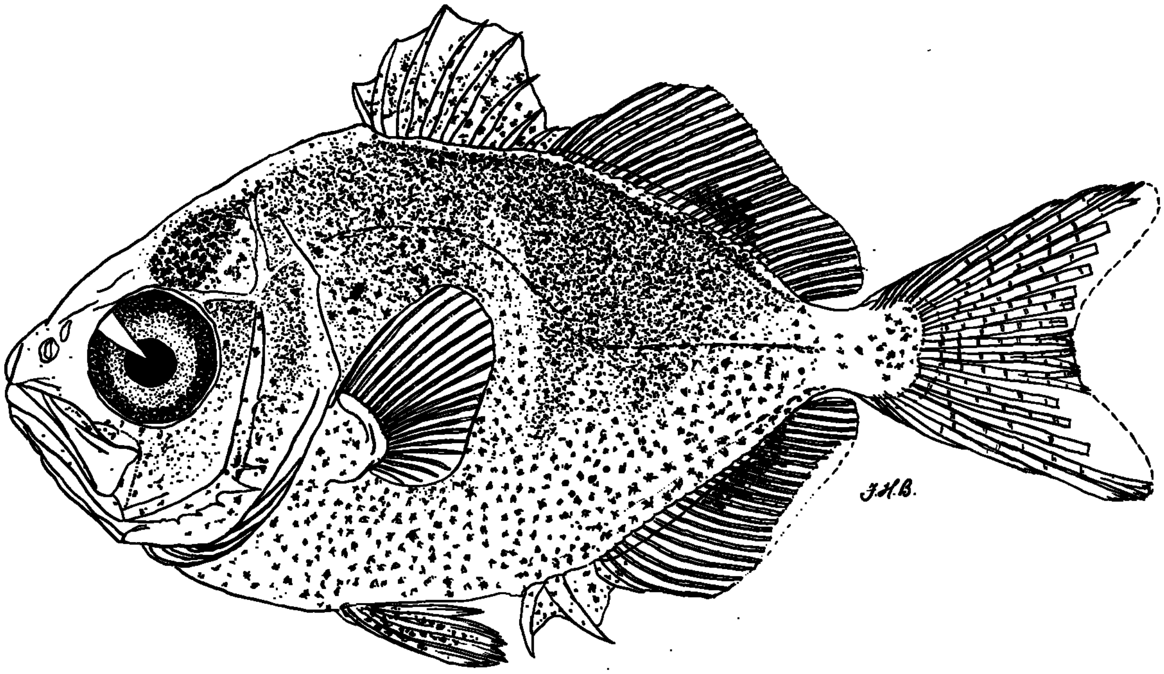

FIGURE 51.—*Caranx bartholomaei* juvenile, 14.3 mm. standard length (*Gill* 8, Reg. 6).

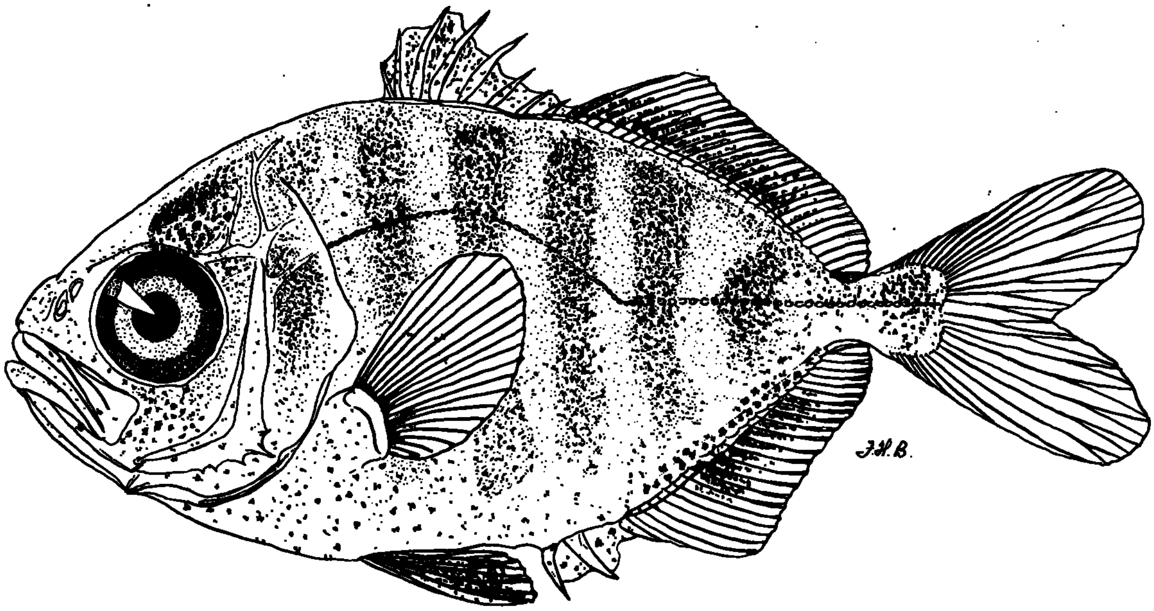

FIGURE 52.—*Caranx bartholomaei* juvenile, 17.4 mm. standard length (*Gill* 4, Reg. 16).

or distorted; and the first element of the second dorsal fin (normally the ninth dorsal spine), although having the thickened, shortened, and pointed appearance of a spine, has three segment marks.

Characters

Dorsal spines.—VIII and I. All spines are well formed at 6.0 mm. (fig. 48). The fourth spine averages the greatest length to about 33 mm. standard length; above 33 mm., the third spine is longest. An interspinous membrane connects the eighth and ninth spines to about 90 mm. On specimens 176 to 315 mm. the membrane connecting the seventh and eighth spines has disappeared.

The regression of third dorsal-spine length on standard length is shown in figure 55 and table 12. A line fitted to this regression for specimens from 10.5 to 79.5 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.12-mm. increase in spine length per 1.0-mm. increase in standard length). The coordinates of the seven specimens larger than 79.5 mm. fall below the extension of the calculated regression line, indicating a decrease in spine growth rate above this size.

Anal spines.—II and I. The spines are well formed at 6.0 mm. (fig. 48). The second spine is longer than the first at all sizes. An interspinous membrane connects the second and third spines to about 35 mm. standard length (figs. 48 and 53). The second anal spine length for the two specimens smaller than 10 mm. is illustrated in figure 4.

Dorsal soft-rays.—25 to 28 (table 12). The 6.0-mm. specimen has 25 soft-rays—one or more are probably unformed (fig. 48). The 25 soft-rays of the 8.1-mm specimen (fig. 49) may represent the full complement of this fish. Segmentation has begun at 6.0 mm. standard length (fig. 48). The terminal ray is branched to its base by 10.5 mm. (fig. 50), and the other rays become branched between about 17 mm. and 20 mm. (fig. 53). The extension of the anterior 5 or 6 rays to produce the lobe begins at about 15 mm. (fig. 52) and is pronounced by 30 mm. (fig. 53). The second ray averages the greatest length to about 23 mm.; above 23 mm., the first ray is longest. The longest soft-ray averages a greater length than the longest dorsal spine (fig. 55).

The regression of length of the first dorsal soft-ray on standard length is shown in figure 55 and table 11. A line fitted to this regression for specimens from 6.0 to 95.0 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.15-mm. increase in soft-ray length per 1.0-mm. increase in standard length). The spread of the coordinates of specimens larger than 95.0 mm. on both sides of the extension of the calculated regression line is

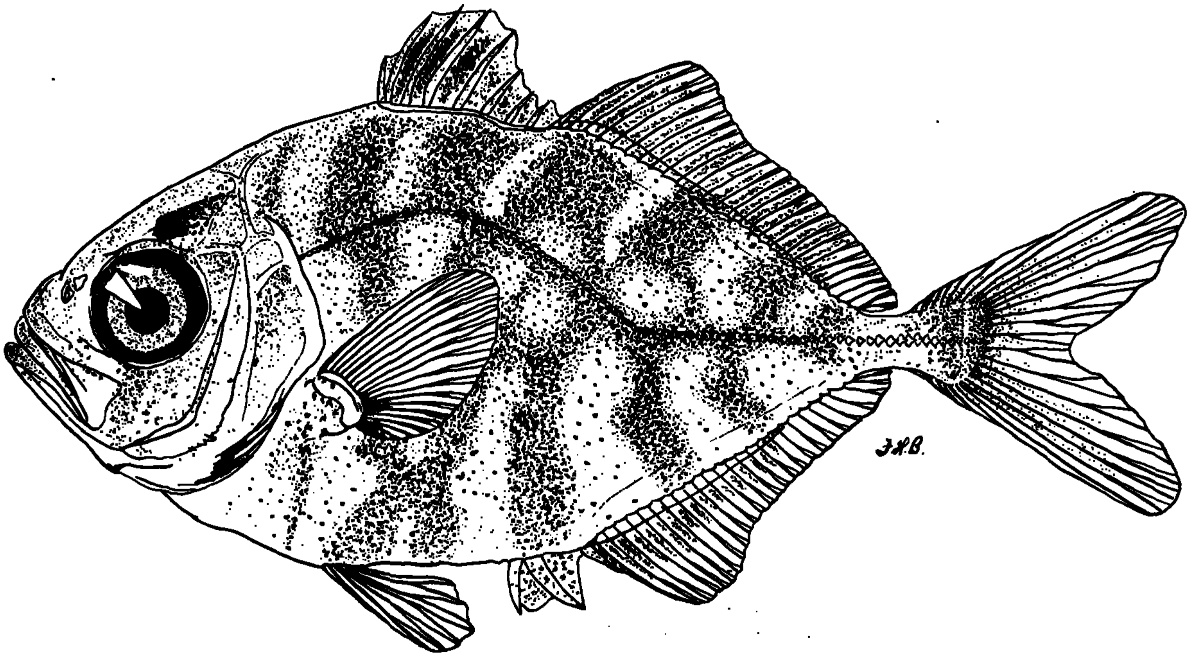

FIGURE 53.—*Caranx bartholomaei* juvenile, 30.7 mm. standard length (*Gill* 7, Reg. 27).

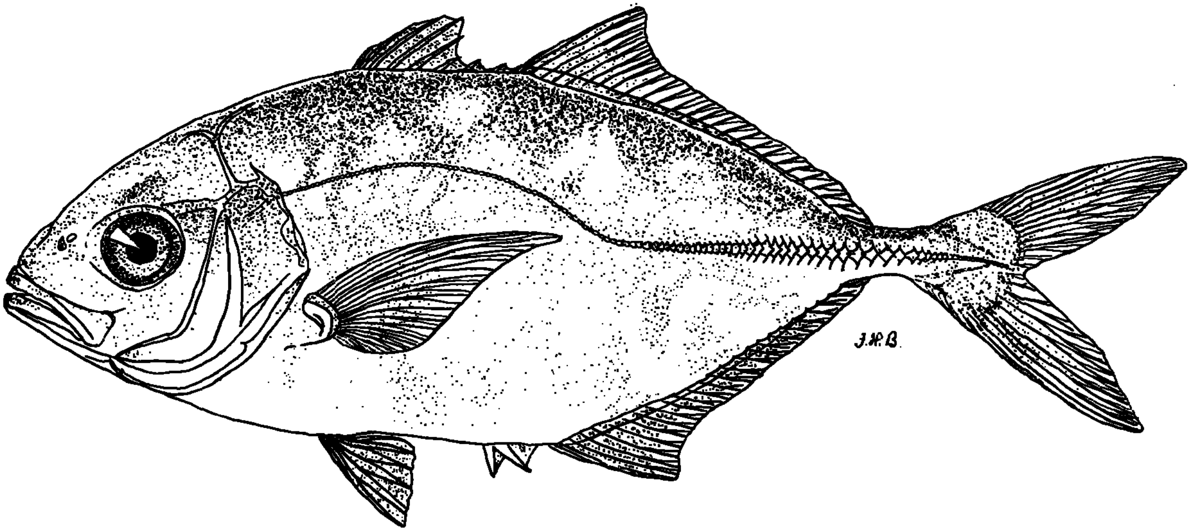

FIGURE 54.—*Caranx bartholomaei* juvenile, 95 mm. standard length (*Gill* 3, Reg. 62).

TABLE 11.—Caranx bartholomaei: *Statistics describing regressions of body parts on standard length*

$\bar{x}$ = mean of independent variable x
$\bar{y}$ = mean of dependent variable y
N = number of specimens
b = rate of increase of y
a = y-intercept of regression line
$Sy{\cdot}x$ = standard deviation from regression (standard error of estimate)

Independent variable x	Dependent variable y	Size range of specimens (mm.)	$\bar{x}$	$\bar{y}$	N	b	a	$Sy{\cdot}x$
Standard length	Dorsal-fin spine length (3d)	10.5–79.5	35.29	4.24	56	0.121	−0.017	0.378
Do	Dorsal soft-ray length (1st)	6.0–95.0	33.97	4.69	48	.146	−.279	.502
Do	Pectoral length	8.1–66.5	34.54	8.16	59	.265	−1.001	.551
Do	do	66.5–243	124.75	38.09	12	.388	−10.261	1.521
Do	Body depth	12.7–108	43.46	19.35	69	.388	2.508	.952
Do	Head length	6.0–95.0	38.51	13.27	69	.314	1.197	.647
Do	Eye diameter	6.0–83.5	37.68	4.47	68	.095	.875	.277
Do	Snout length	6.0–95.0	38.48	3.67	69	.106	−.209	.373

insufficient to suggest a possible change in growth rate, and the same rate may prevail at these larger sizes.

Anal soft-rays.—21 to 24 (table 12). Formation, segmentation, branching, and lobation occur about as with the second dorsal fin. The second ray averages the longest to about 23 mm. standard length; above 23 mm., the first ray is longest. The longest anal and dorsal rays are nearly equal to about 40 mm.; above 40 mm., the dorsal is the longer. The second anal spine is two-thirds as long as the longest anal ray at 6.0 mm. standard length, one-half as long at 60 mm., less than one-third as long at 151 mm., and almost one-fourth as long at 243 mm.

Interneural and interhemal spines.—Posterior lateral projections of these spines are not extended above the body surface (as occurs in *latus* and *hippos*).

TABLE 12.—Caranx bartholomaei: *Correlation of the numbers of dorsal and anal soft-rays of 115 specimens*

[The upper number in each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

		DORSAL SOFT-RAYS			
		25	26	27	28
ANAL SOFT-RAYS	21	3 (2.6)			
	22	5 (4.3)	27 (23.5)	1 (.9)	
	23	1 (.9)	47 (40.9)	28 (24.3)	2 (1.7)
	24			1 (.9)	

Caudal.—9+8 principal rays; about 8 or 9+7 to 9 secondary rays. The principal rays are all present and segmentation has begun at 6.0 mm. standard length (fig. 48). One or two dorsal and ventral secondary rays are probably unformed at 8.1 mm., but the full complement is present at

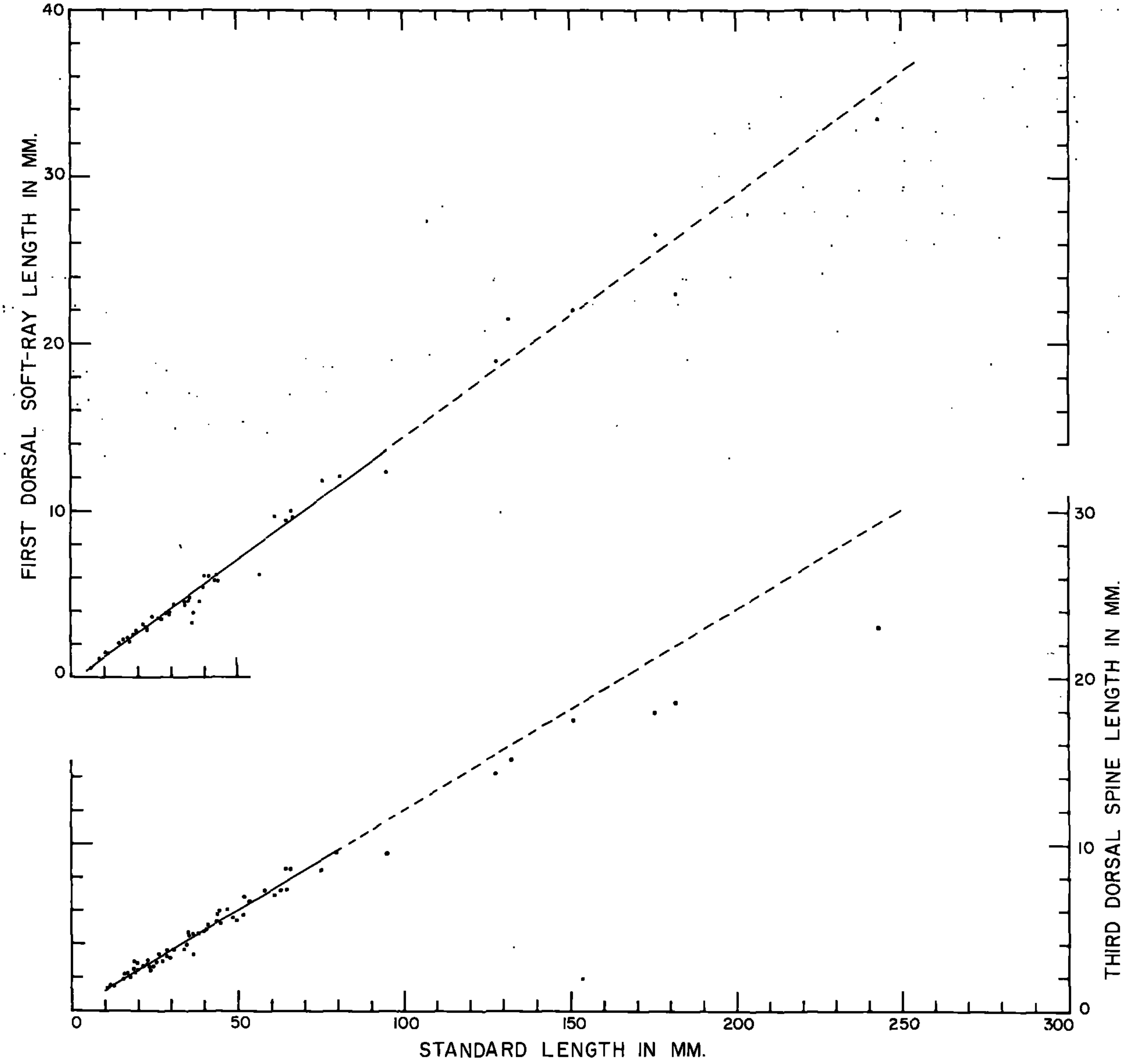

FIGURE 55.—*Caranx bartholomaei:* Relation of length of first dorsal soft-ray and of third dorsal spine to standard length.

10.5 mm. Branching begins at about 10 mm. (fig. 50) and is pronounced at about 16 mm. (fig. 52). Forking of the tail is represented by a slight indentation at 6.0 mm. (fig. 48) and is pronounced at 8.0 mm. (fig. 49). The urostyle is visible at 6.0 mm. (fig. 48) but not at 8.1 mm. (fig. 49).

Pectoral.—I–19 to 21. About 14 rays are developed at 6.0 mm. standard length (fig. 48), and the full complement apparently is formed at 8.1 mm. Branching of the rays has begun by 25 mm. The distal end of the fin is rounded from 6.0 mm. to about 35 mm., above which it becomes pointed and falcation begins (figs. 48 to 53). Falcation is pronounced by 95 mm. (fig. 54).

The regression of pectoral length on standard length is shown in figure 56 and table 11. Two lines were fitted to this regression: for specimens from 8.1 to 66.5 mm. and for specimens from 66.5 to 243 mm. standard length. An extension of the lower line intersects the upper line at approximately 75 mm., indicating that an inflection occurs at about that size and that a faster pectoral growth rate prevails above that size. The proportional rates of increase for the two variates are 0.27-mm.

(below 75 mm.) and 0.39-mm. (above 75 mm.) increase in pectoral length per 1.0-mm. increase in standard length.

Pelvic.—I–5. All the rays are discernible at 6.0 mm. (fig. 48). Branching has begun by 15 mm. standard length.

Body depth.—The depth at first anal spine averages less than depth at pelvic to about 45 mm., is nearly equal from about 45 to 55 mm., and averages greater above 55 mm. standard length. The body depth at pelvic for the two specimens smaller than 10 mm. is illustrated in figure 9.

The regression of body depth at pelvic on standard length is shown in figure 57 and table 11. A line fitted to this regression for specimens from 12.7 to 108 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.36-mm. increase in body depth per 1.0-mm. increase in standard length). The alinement of the coordinates of the four smallest specimens below the extension of the calculated regression line indicates that a faster body-depth growth rate prevails below approximately 13 mm. The alinement of the coordinates of the five largest specimens below the extension of the calculated regression line indicates that a decrease in body-depth growth rate occurs between approximately 110 mm. and 150 mm. standard length.

Head.—The nostril is undivided at 6.0 mm. (fig. 48) and divided at 8.1 mm. (fig. 49). Serrations occur on the supraoccipital crest at 6.0 mm. (fig. 48); none at 8.1 mm. (fig. 49). Two posterolaterally projecting spines are located on

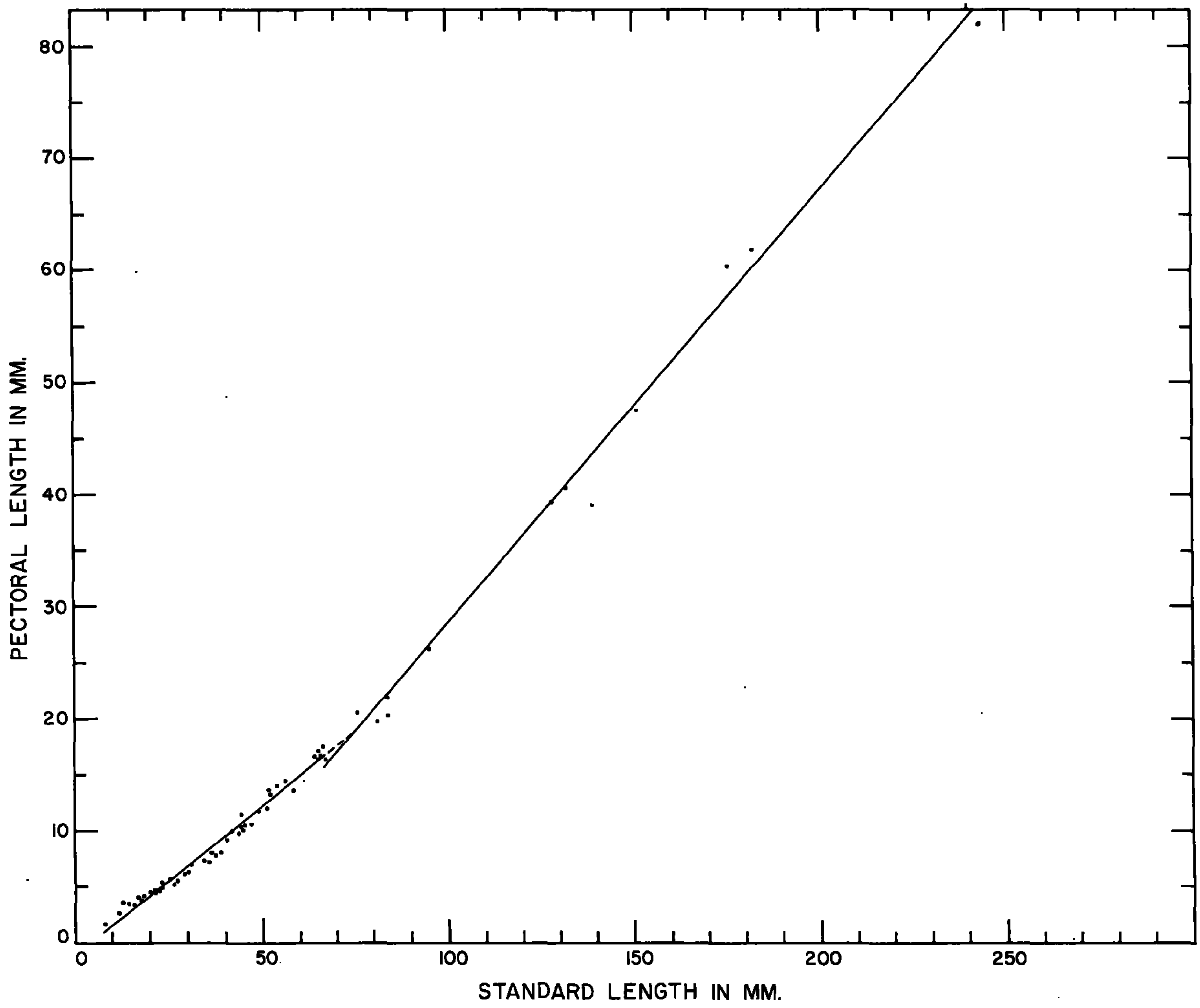

FIGURE 56.—*Caranx bartholomaei:* Relation of pectoral length to standard length.

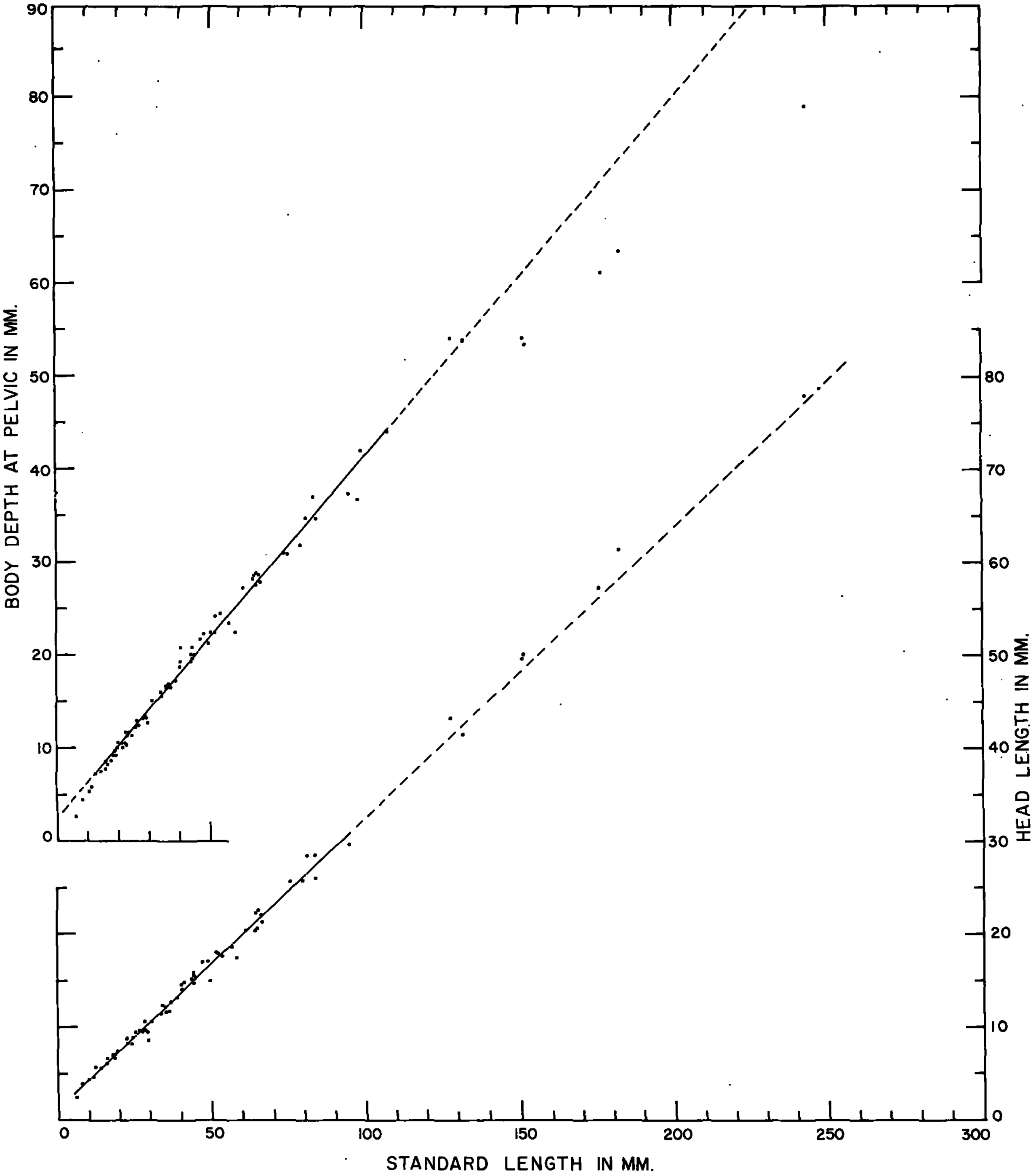

FIGURE 57.—*Caranx bartholomaei:* Relation of body depth at pelvic and of head length to standard length.

the cleithrum just below its junction with the operculum on the 6.0-mm. specimen. These spines are not present at 8.1 mm. or above.

The regression of head length on standard length is shown in figure 57 and table 11. A line fitted to this regression for specimens from 6.0 to 95.0 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.31-mm. increase in head length per 1.0-mm. increase in standard length). The coordinates of the specimens larger than 95 mm. fall along the extension of the calculated regression line, indicating that the head growth may continue at the same proportional rate.

Eye.—The regression of eye diameter on standard length is shown in figure 58 and table 11. A line fitted to this regression for specimens from 6.0 to 83.5 mm. standard length shows a proportional rate of increase for the two variates from about 12 to 83.5 mm. (0.095-mm. increase in eye diameter per 1.0-mm. increase in standard length). The alinement of the two smallest specimens suggests that a faster eye growth rate may prevail for specimens below approximately 12 mm. The coordinates of the specimens larger than 83.5 mm. fall below the extension of the calculated regression line, indicating a decrease in eye growth rate above this size.

Snout.—The regression of snout length on standard length is shown in figure 58 and table 11. A line fitted to this regression for specimens from 6.0 to 95.0 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.11-mm. increase in snout length per 1.0-mm. increase in standard length). The alinement of coordinates of specimens larger than 95 mm. above the extension of the calculated regression line suggests that an increase occurs in snout growth rate at about that size.

Gill rakers.—Lower limb, 18 to 21; upper limb, 6 to 9; total, 25 to 29 (table 13). About 80 percent of the specimens examined above 20 mm. had one or more rudimentary gill rakers at the origin of the lower limb; one was present on specimens up to 131 mm., 2 at 151 mm. and 176 mm., 4 at 182 mm., and 5 at 243 mm. and 315 mm. About 75 percent of the specimens above 20 mm. had one or more shorter or rudimentary rakers at the origin of the upper limb; one was present on specimens up to 151 mm., 2 at 176 mm. and 182 mm., 3 at 243 mm., and 6 at 315 mm. Ginsburg (1952: 96) reported 3 to 4 upper-limb and 1 to 2 lower-limb rudiments in large specimens (up to about 278 mm., converted). Apparently, there is an association between increase in body size and increase in number of gill rakers which become smaller or rudimentary.

TABLE 13.—Caranx bartholomaei: *Correlation of numbers of lower-limb to upper-limb gill rakers of 84 specimens*

[The upper number in each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

	LOWER-LIMB GILL RAKERS			
UPPER-LIMB GILL RAKERS	18	19	20	21
6		1 (1.2)		
7	2 (2.4)	14 (16.7)	13 (15.5)	
8		10 (11.9)	31 (36.9)	1 (1.2)
9		4 (4.8)	8 (9.5)	

Scutes.—Range of the mean number of scutes above 100 mm. standard length: about 22 to 28 (fig. 59). Ginsburg (1952: 96), working with specimens about 26.5 to 278 mm. (converted), gave a scute range of 20 to 31. Meek and Hildebrand (1925: 352), with specimens up to about 120 mm. (converted), gave a range of "about 22 to 35." The developing scutes appear between 12.7 mm. and 14.3 mm. (figs. 50 and 51). The first scutes to complete their development are present between 22 and 23 mm. All scutes of fish above 80 to 100 mm. have completed, or nearly completed, their individual development (fig. 59).

Lateral line.—Range of mean lateral-line ratio above 60 mm. standard length: about 1.0 to 1.4 (fig. 60). The lateral-line ratio–standard length relation is variable, but the value of the ratio tends to increase with respect to standard length up to about 50 mm., and it may decrease gradually above this size. Nichols (1939: 9), with specimens 16 to 51 mm. standard length, declared the curved lateral line to be about equal to the straight lateral line. This generalization is accommodated by the perimeter of figure 60, but the variation and change of this ratio with growth are much greater than Nichols' statement indicates.

Preopercular spines.—There were too few small specimens to evidence the early growth of the preopercular angle spine. This spine apparently begins to decrease in length at some size smaller than 12 mm., and is completely covered by the preopercular margin between about 32.5 and 39 mm. (fig. 61). The number of preopercular upper- and lower-limb spines varies considerably with size, but a trend of decrease in number of spines with increase in body size is apparent (table 1).

Pigmentation.—There are two rows of elongated

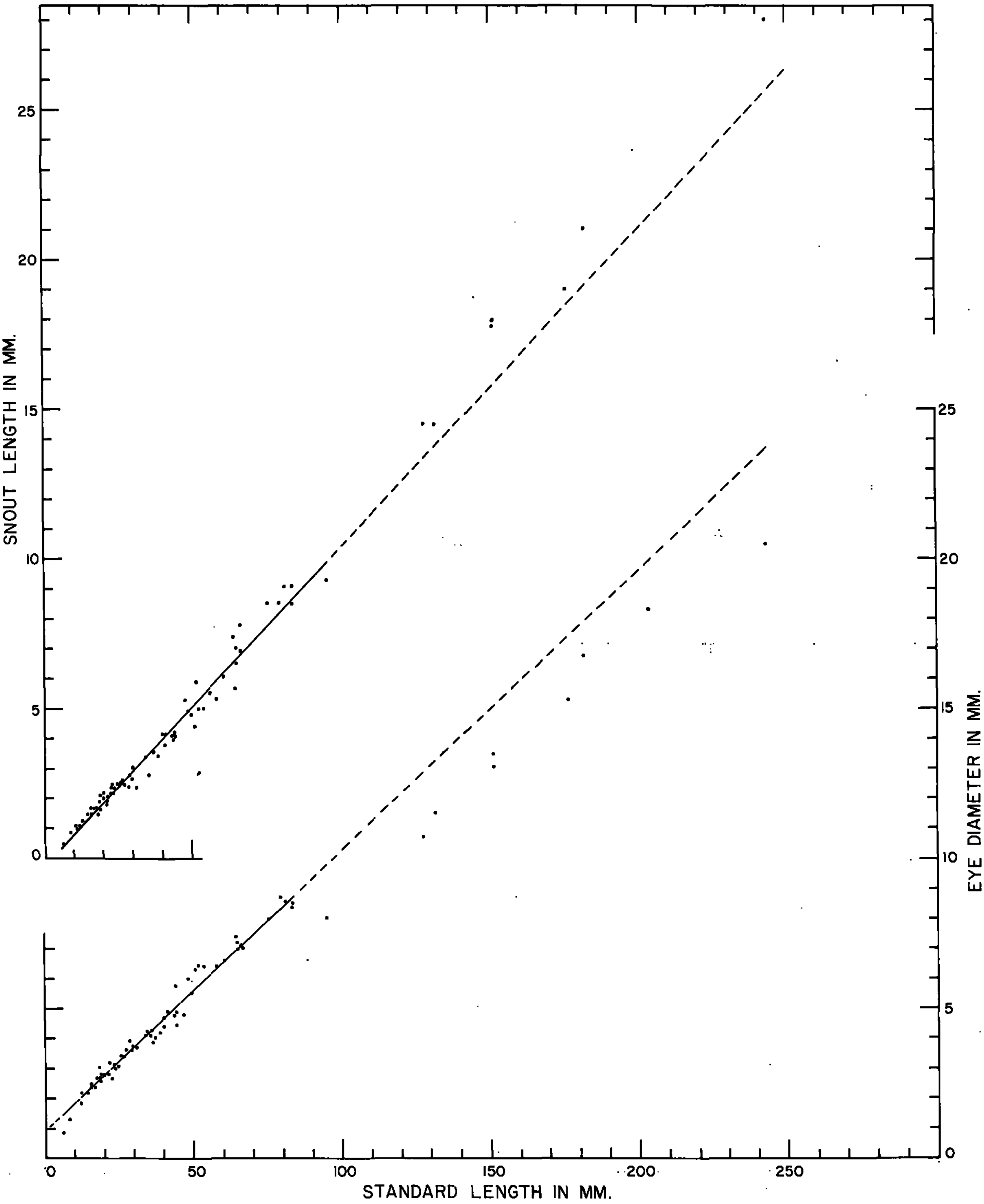

FIGURE 58.—*Caranx bartholomaei:* Relation of snout length and of eye diameter to standard length

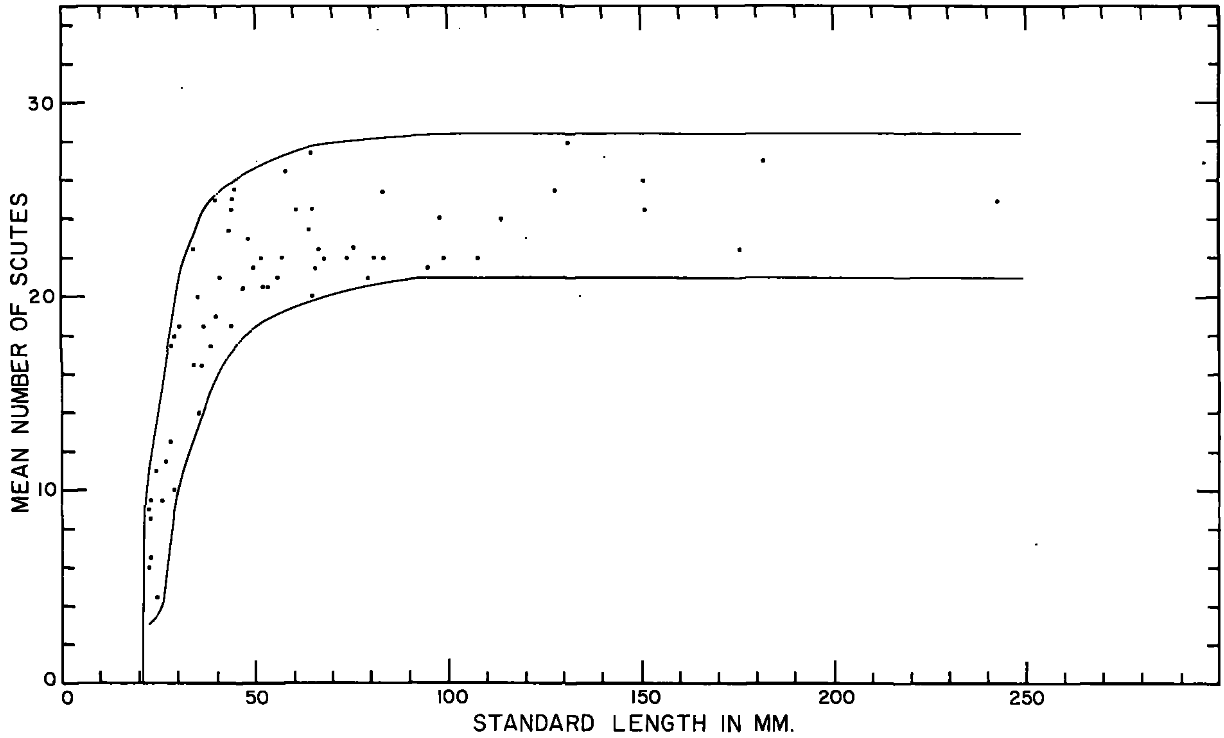

FIGURE 59.—*Caranx bartholomaei:* Relation of the mean number of scutes to standard length.

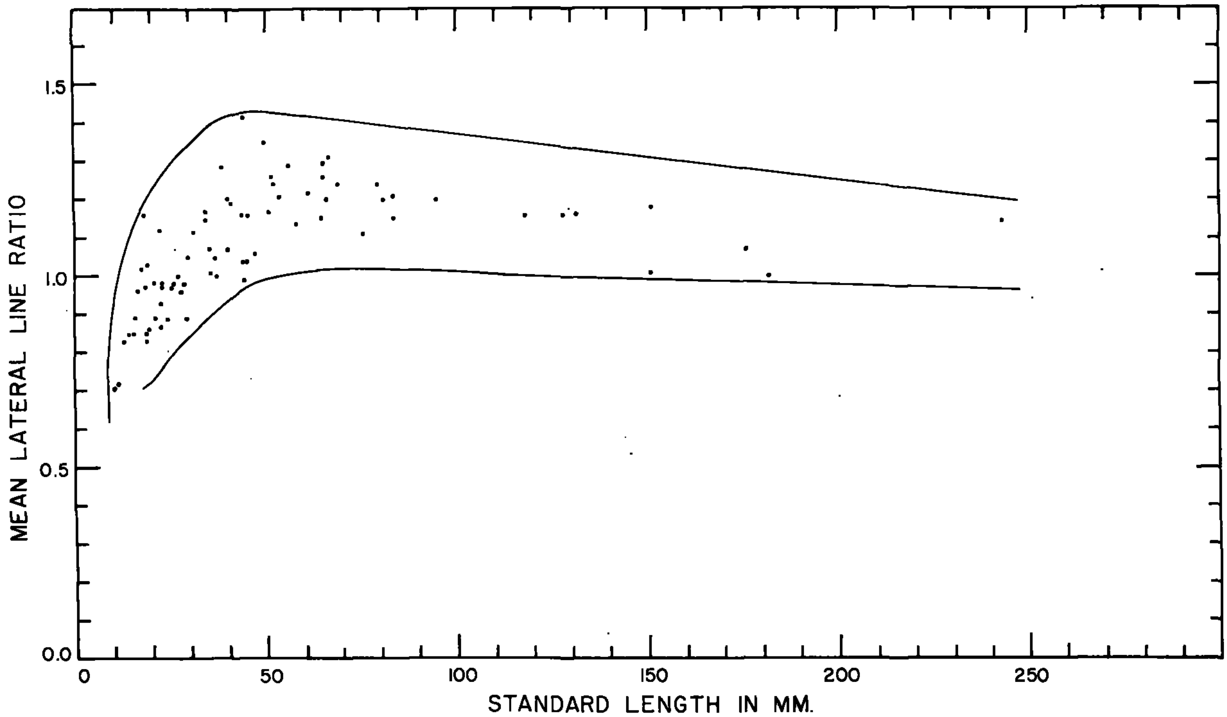

FIGURE 60.—*Caranx bartholomaei:* Relation of the mean lateral-line ratio to standard length.

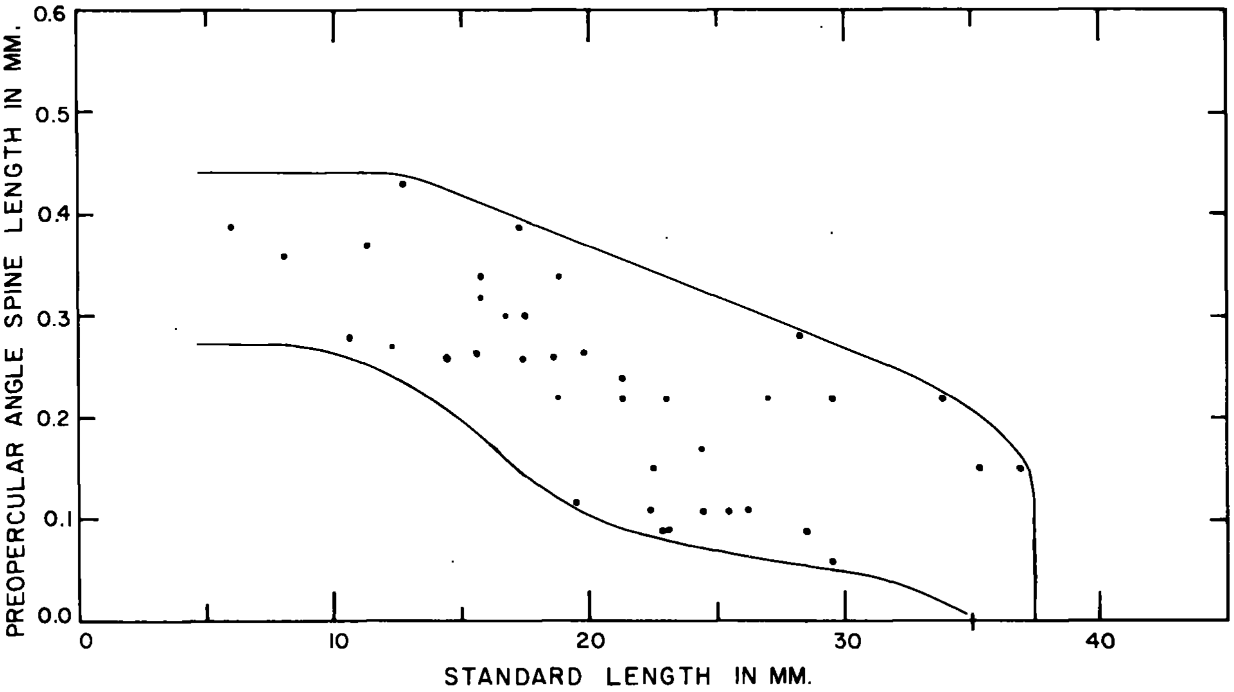

FIGURE 61.—*Caranx bartholomaei:* Relation of the length of the preopercular-angle spine to standard length.

melanophores on the body of the 6.0-mm. specimen—one below the base of the dorsal fin and one on the midline posteriorly. A few melanophores are scattered over the body, the snout, mouth parts, and operculum. A group of denser melanophores occurs over the eye on the transparent portion of the head. A few pigment spots occur on the interspinous membranes of the dorsal and anal fins, on the pelvic fins, and along the base of the anal soft-rays (fig. 48).

The 8.1-mm. specimen has an appreciable increase in the number of pigment spots on the body, head, and first dorsal and pelvic fins. Contrasting with the 6.0-mm. specimen, the two elongated rows of dorsal and lateral melanophores are not apparent, and there is only one pigment spot at the base of the anal soft-rays. A dense concentration of pigment occurs on the anterior portion of the caudal peduncle, and the fleshy portion of the caudal fin is conspicuously unpigmented (fig. 49).

Pigmentation of the body has intensified and appears dark between 10.5 and about 14 mm. standard length (fig. 50). Between 14 mm. and 17 mm., 3 to 5 vague bars have formed—the anterior ones are more distinct (fig. 51). Above 17 mm. (fig. 52) the full complement of 5 bars (rarely 4 or 6 on one or both sides of the body) is present. Above about 19 mm. the posterior 2 or 3 bars tend to become angular with their dorsal and ventral parts directed posteriorly and the lateral line extending through their apex; above about 22 mm. all of the bars become irregularly distorted or wavy. By about 28 mm., the bars begin to break into the mottled or spotted pattern that lasts to over 95 mm. (figs. 53 and 54), although this is not distinct in some specimens over 60 mm. Traces of the posterior 2 or 3 bars persist along the bases of the dorsal and anal fins of some specimens to about 48 mm.

The transparent part of the brain case has become opaque by 14 mm., and the melanophores on this area increase and are extended posterodorsally to form the nuchal band by about 17 mm. (fig. 52). A small accumulation of pigment below the eye gives the impression that the nuchal band passes vertically through the eye (figs. 52 to 54).

Pigment spots occur basally between the soft-rays of the dorsal and anal fins at 10.5 mm. (fig. 50). Pigmentation of the caudal fin is pronounced by 25 mm. (fig. 53). Pigmentation of all the fins intensifies to over 95 mm. (figs. 50 to 54).

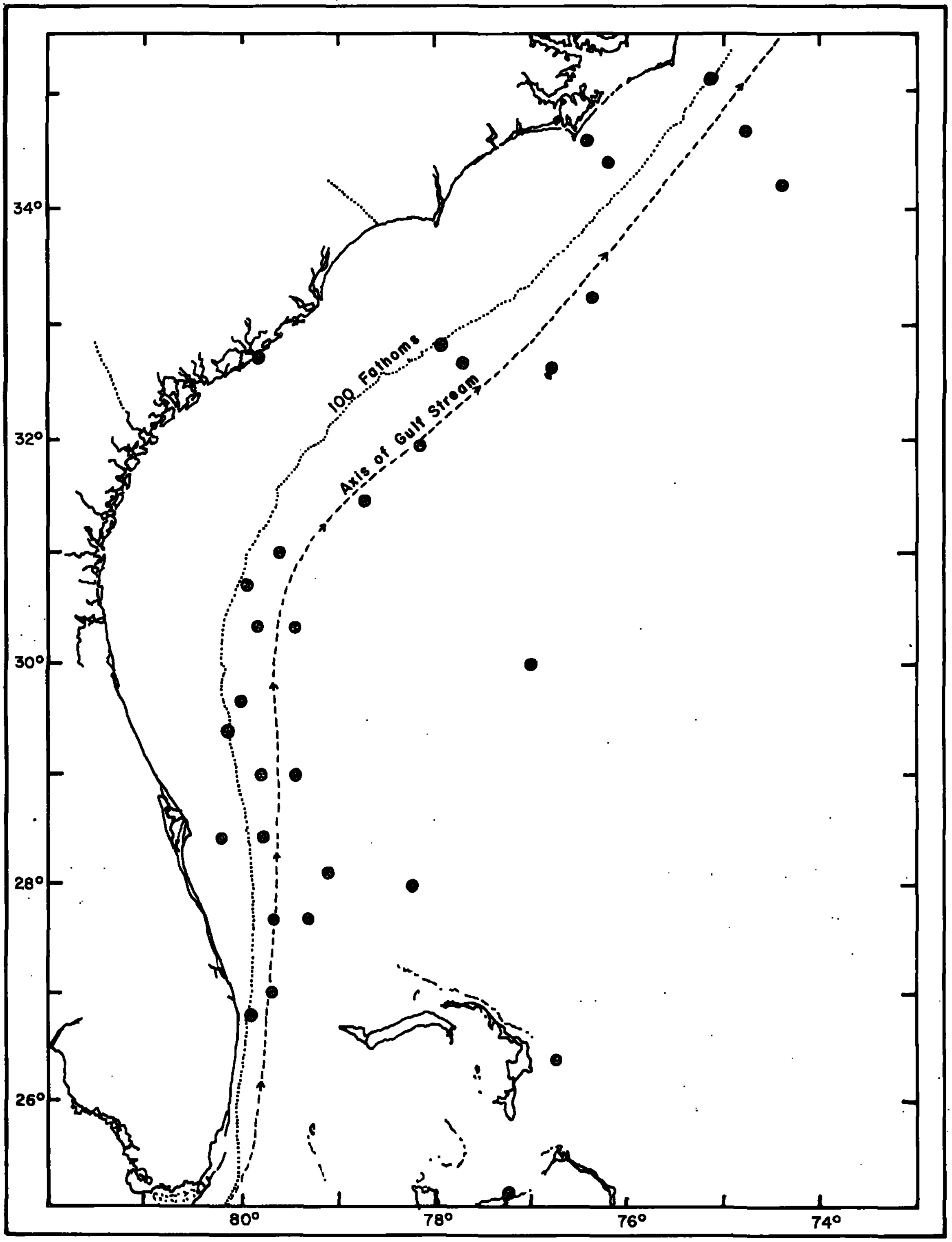

FIGURE 62.—*Caranx bartholomaei:* Locations of capture off the southeastern Atlantic coast of the United States.

Distribution off Southeastern Atlantic Coast of the United States

Specimens have previously been reported from the following specific localities within this area: Cape Lookout, N. C., by Nichols (1937c: 4); Beaufort, N. C., by Jordan (1881: 486), Smith (1907: 204), and Ginsburg (1952: 95); from North Carolina by Nichols (1912: 185; 1920a: 28); from Magnolia Beach, S. C., by Fowler (1945: 190); in the Gulf Stream off Bimini, Bahamas, by Nichols (1937b: 237); Bimini, Bahamas, by Fowler (1944: 443); Nassau, Bahamas, by Lee (1889: 670) and Bean (1905: 302); and Nassau and Green Turtle Cay, Bahamas, by Rosen (1911: 61).

Figure 62 shows the locations of specimens taken on the *Gill* cruises, by the *Combat* off Florida, Georgia, and South Carolina, USNM specimens examined (Cape Lookout and Beaufort, N. C.; 35°08′ N., 75°10′ W.; 34°39′ N., 76°12′ W.; and 27°57′ N., 78°15′ W.), CBSFP specimens examined (Nassau, Bahamas), and a ChM specimen examined (Magnolia Beach, S. C.) (tables 2 and14). Of these specimens, the two smallest, 6.0 mm. and 8.1 mm., are larvae taken off southern Florida and South Carolina on the axis of the Gulf Stream; the two largest, 176 mm. and 182 mm., from Nassau, are probably not large enough to be adult; and the others are juveniles. The locations of capture were generally beyond the 100-fathom line and indicate an association with the Gulf Stream (as depicted by the approximate axis of the Stream in figure 62). Specimens taken north of the Bahamas probably represent the effect of the northern dispersal of this species by the Antilles Current. Because of the relatively less-concentrated collecting by the *Gill* east of the axis of the Gulf Stream, it is not practical to estimate the relative abundance or distribution of young *bartholomaei* in that area. This occurrence of young in the Gulf Stream extends from about May into November (fig. 63).

The 38-mm. specimen recorded by Nichols (1937c: 4) from Cape Lookout, N. C., is the smallest *bartholomaei* that has been reported from

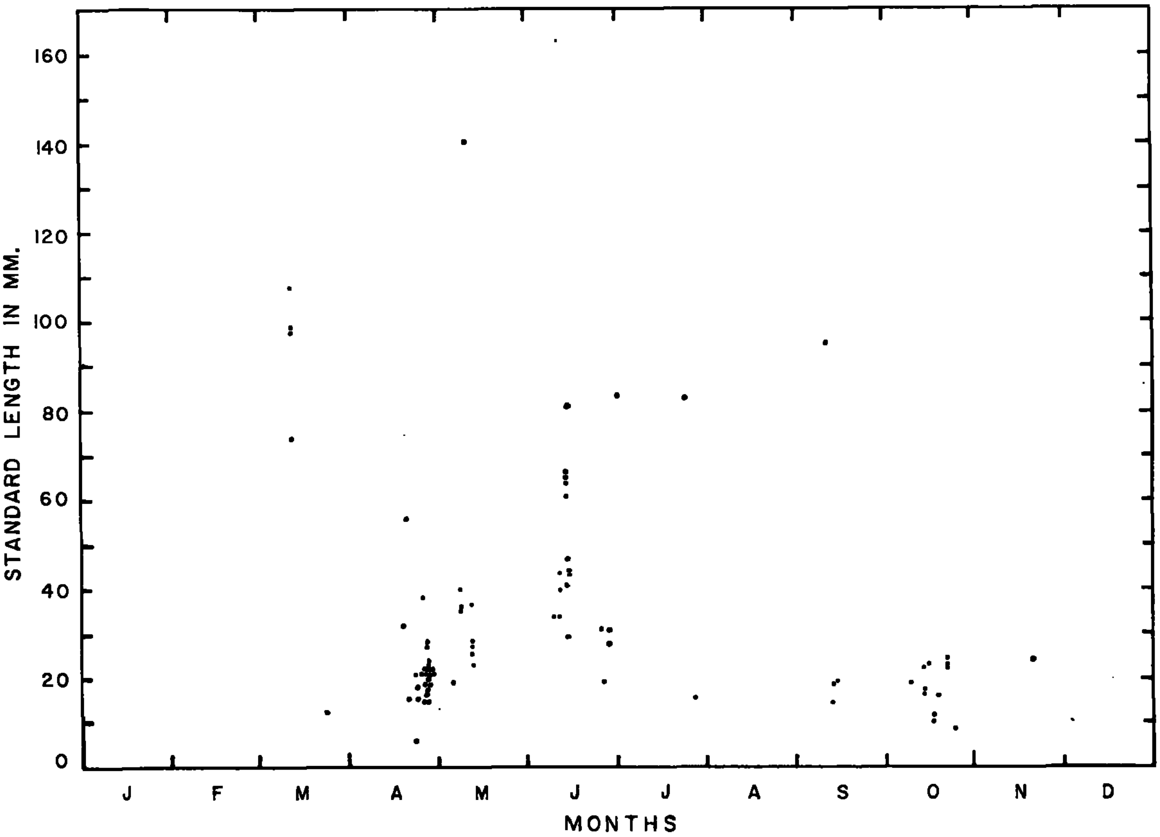

FIGURE 63.—*Caranx bartholomaei:* Size distribution, by months, of specimens taken off the southeastern Atlantic coast of the United States.

inshore waters of this Continent. A specimen of about 52 mm. (converted) reported by Smith (1898: 98) from Woods Hole, Mass., August 10, is the smallest specimen from northern inshore waters that has been recorded. A 32.5-mm. specimen, ANSP account No. 156 and 157, from Guana Island, Virgin Islands, March 22, and a 34.8-mm. specimen, CBSFP account No. 171, from Hog Island, Bahamas, March 28, are the two smallest specimens to be recorded from inshore collections. This is the approximate size by which the preopercular spines have been absorbed. The absence of inshore records of larvae and smaller juveniles indicates that these periods are spent in offshore currents.

I believe the young in this area represent a summer-to-fall population of larvae and juveniles that drifts northward in the Gulf Stream, with juveniles occasionally migrating or drifting inshore. This population appears to be largely the result of recruitment from waters to the south of this area, although some part may result from reproduction within the area. Absence of records of *bartholomaei* from inshore waters along the Atlantic coast of the United States during the colder months of the year indicates that during this period the species either returns to the south or moves to warmer offshore waters. It is doubtful that this species continues its movement with the Stream to the east since it has never been recorded east of the longitude of Bermuda along the route of the Gulf Stream or from the Eastern Atlantic.

Spawning

The spawning season that contributes larval and juvenile *bartholomaei* to this area may be estimated, from the smallest specimens taken in March (12.7 mm.) and October (8.1 mm.), to extend from mid-February to mid-September (fig. 63).

If, as suggested, there is a northward-drifting population of developing young, the majority of specimens taken by the *Gill* would probably have been spawned to the south of this area. The 8.1-mm. specimen taken in the Gulf Stream off South Carolina (table 14) may have been spawned in the southern portion of the area.

TABLE 14.—Caranx bartholomaei: *Location and date of capture, number and size range of 125 specimens examined*

[See pp. 412 and 419 for explanation of abbreviations used; measurements in standard length]

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN:				
Guana Island, Virgin Is.	Mar. 22, 1953	ANSP Acct. No. 156–157	1	32.5
Spanish Wells, Bahamas	July 4, 1903	USNM 164532	4	44–65
23°50′ N., 80°40′ W	Mar. 26, 1948	ANSP 72693	2	15.8–17.2
Do	do	ANSP 72689	1	17.4
24°12′ N., 80°01′ W	July 25, 1957	SAFI, *Combat* 451	2	26–31.5
24°28.5′ N., 77°28.5′ W	Oct. 8, 1953	SAFI, *Gill* 4, TO-2	1	18.8
Nassau fish market, Bahamas	Aug. 17–20, 1955	UF 3539	1	243
Hog Island, Bahamas	Mar. 26, 1954	CBSFP Acct. No. 209	2	176–182
Do	Mar. 28, 1954	CBSFP Acct. No. 171	1	34.8
Do	Mar. 12, 1954	CBSFP Acct. No. 186	4	74–108
Do	Aug. 19, 1955	CBSFP Acct. No. 251	1	51.5
26°27′ N., 76°44′ W	June 12–13, 1954	SAFI, *Gill* 7, Std.	3	34–44
Do	June 13–14, 1954	do	2	40.5–47
Do	June 14, 1954	do	3	29.5–44.5
26°47′ N., 79°53′ W	July 28, 1957	SAFI, *Combat* 459	2	28–31
26°56′ N., 79°41′ W	Apr. 23, 1953	SAFI, *Gill* 2, Reg. 2	1	6.0
27°40′ N., 79°18.5′ W	do	SAFI, *Gill* 2, Reg. 7	1	21.2
27°41′ N., 79°40.5′ W	Sept. 11, 1954	SAFI, *Gill* 8, Reg. 6	1	14.3
27°57′ N., 78°15′ W	Mar. 22, 1914	USNM 148910, *Grampus* 10209	1	12.7
28°19.5′ N., 80°10′ W	Apr. 27, 1954	SAFI, *Gill* 6, Reg. 10	1	38.5
28°21′ N., 79°48′ W	Apr. 26, 1954	SAFI, *Gill* 6, Reg. 9	1	21.2
28°56.3′ N., 79°45.6′ W	July 27, 1953	SAFI, *Gill* 3, Reg. 15	1	15.5
29°00′ N., 79°26′ W	Oct. 14, 1953	SAFI, *Gill* 4, Reg. 16	3	16.7–22.4
29°26′ N., 80°08′ W	Apr. 27, 1957	SAFI, *Combat* 315	19	15–28
29°40′ N., 80°00′ W	Sept. 13, 1954	SAFI, *Gill* 8, Reg. 18	1	18.5
30°00′ N., 77°00′ W	June 10, 1954	SAFI, *Gill* 7, Spc. 5	1	33.9
30°19.5′ N., 79°50′ W	Sept. 14, 1954	SAFI, *Gill* 8, Reg. 27	1	19
30°19.8′ N., 79°25.5′ W	Oct. 16, 1953	SAFI, *Gill* 4, Reg. 28	1	23
30°20′ N., 79°50′ W	June 26, 1954	SAFI, *Gill* 7, Reg. 27	1	30.7
30°40′ N., 79°57′ W	Apr. 24, 1957	SAFI, *Combat* 310	2	15.5–18.5
30°58′ N., 79°37.5′ W	June 27, 1954	SAFI, *Gill* 7, Reg. 30	1	19.8
31°28′ N., 78°42′ W	Oct. 25, 1953	SAFI, *Gill* 4, Reg. 40	3	22.5–24.4
31°29′ N., 78°41′ W	May 5, 1953	SAFI, *Gill* 2, Reg. 40	1	19.5
31°57′ N., 78°09′ W	Oct. 26, 1953	SAFI, *Gill* 4, Reg. 50	1	8.1
32°39′ N., 76°46′ W	Aug. 10, 1953	SAFI, *Gill* 3, Reg. 62	1	95
32°40′ N., 77°40′ W	Apr. 21, 1957	SAFI, *Combat* 296	2	15.5–57
Magnolia Beach, S. C	Aug. 1933	ChM 34.55.5	1	68
32°49′ N., 77°56′ W	Apr. 19, 1957	SAFI, *Combat* 284	1	32
33°14.7′ N., 76°23′ W	May 8, 1953	SAFI, *Gill* 2, Reg. 63	3	35.3–40

TABLE 14.—Caranx bartholomaei: *Location and date of capture, number and size range of 125 specimens examined—Con.*

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN—Continued				
34°37.7′ N., 74°45.5′ W	May 12, 1953	SAFI, *Gill* 2, Reg. 80	5	23.1–36.9
34°39′ N., 76°12′ W	Oct. 19, 1885	USNM 164534, *Albatross*	1	15.8
35°08′30″ N., 75°10′ W	Oct. 17, 1885	USNM 164537, *Albatross* 2596	2	10.5–11.3
Cape Lookout, N. C	July 1912	USNM 74295	2	75.5–131
Beaufort, N. C	July–Aug., 1904	USNM 51929	1	128
Do	July–Aug., 1904	USNM 164533	1	48
Do	June 14, 1932	USNM 111786	5	61–81
Pivers Island, Beaufort, N. C	July 1, 1932	USNM 111785	1	83.5
41°28′30″ N., 65°35′30″ W	Aug. 27, 1886	USNM 39448, *Albatross* 2706	1	18
Woods Hole, Mass	1876	USNM 134291	2	64–83.5
Do	Sept. 15, 1877	USNM 144008	1	53
Do	Aug. 10, 1886	USNM 73483	1	50.5
GULF OF MEXICO:				
Cuba	1885	USNM 37521	1	56
Havana fish market, Cuba	Jan. 7, 1956	SAFI	1	315
Havana market, Batabano, Cuba	Nov. 7, 1954	UF 5348	1	151
Key West, Fla	1886	USNM 38731	1	52
Do	May 10, 1929	USNM 89787	1	35.3
Boca Chica, Key West, Fla	Feb. 18, 1942	ANSP 70873–74	2	24.4–45
Tortugas, Fla	No date.	USNM 116860	3	25.4–79.5
Do	June–Aug. 1926	USNM 88091	2	28.2–29.3
Tortugas, Fla	June 17, 1956	GFEGR, *Bowers*	5	54–80
Pensacola, Fla	No date.	USNM 30167	1	66.5
CARIBBEAN SEA:				
Galeta Point, Fort Randolph, Panama	Oct. 31, 1948	USNM 148667	1	44
20°50′ N., 86°10′ W	Apr. 28, 1955	GFI, *Oregon* 1297	1	22
Palisadoes, Kingston, Jamaica	June 15, 1957	UF (uncataloged)	1	114
Kingston Harbor, Jamaica	June 25, 1957	UF (uncataloged)	1	151

Caranx sp. ("*latus* and/or *hippos*")

(Figures 65–68)

Material

Nine specimens measuring from 5.4 to 8.3 mm. standard length (table 15) are included in this series (abbreviated in the text and figures to "*latus* and/or *hippos*") because no specimens of *latus* smaller than 16.1 mm. or of *hippos* smaller than 15.3 mm. standard length that were suitable for comparison were available. However, morphometric trends, meristic values, and pigmentation delimit the series to these two species. The term "*latus* and/or *hippos*" is utilized for convenience in briefly denoting relationship without implying a specific nomenclatorial identity. This series is not homogenous in all of the characters examined, but it is impossible to determine if one or both species are represented. I believe that the largest specimen (fig. 68) is *latus*, because of the nature of the pigmentation of the first dorsal fin (compare with figs. 69 and 81), and because the number of its anal rays (18) was found in 8 out of 82 specimens of *latus* that were counted while the maximum number counted in 132 specimens of *hippos* was 17. The 4.9-mm. specimen illustrated in figure 64 and identified as *Caranx* sp. may belong to this series. Several characters of the specimen suggest this: body depth (2.6 mm.), second anal spine length (0.23 mm.), and preopercular angle spine length (0.53 mm.). This specimen was taken at *Gill* 3, Reg. 60, 33°07′ N., 77°20′ W., August 10, 1953.

Morphometric values of the "*latus* and/or *hippos*" series have been plotted on the graphs of *latus* and *hippos*. Their description is treated separately here and not under the accounts of *latus* or *hippos*.

Characters

Dorsal spines.—VIII and I. The spines are well-formed at 5.4 mm. standard length (fig. 65). The third and fourth spines are the longest and are nearly equal in length at 5.4 mm. and 6.1

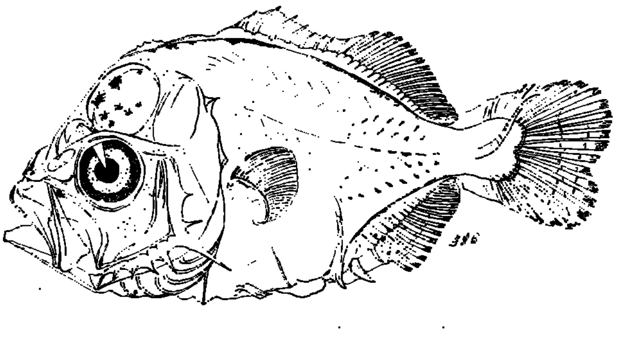

FIGURE 64.—*Caranx* sp. (*latus* or *hippos*?) larva, 4.9 mm. standard length (*Gill* 3, Reg. 60).

mm.; from 6.2 to 8.3 mm., the third spine is the longest. The coordinates of third dorsal spine length on standard length are plotted on figures 73 and 86.

Anal spines.—II and I. The spines are well formed at 5.4 mm. standard length (fig. 65). There is some variation in comparative lengths, but the second spine appears to be the longest from 5.4 to 6.3 mm., and the first is longest at 6.9 mm. and 8.3 mm. The length of the second anal spine of these specimens is illustrated in figure 4.

Dorsal soft-rays.—21 at 8.3 mm. standard length, 20 at 6.9 mm. On the specimens of 6.3 mm. and smaller the posterior soft-rays have not formed. The second ray is longer than the first on all specimens with unbroken dorsal fins. The third spine of the dorsal averages a greater length than the first soft-ray from 5.4 to 6.2 mm. standard length; at 8.3 mm. the first soft-ray is longer. The coordinates of first dorsal soft-ray length on standard length are plotted in figures 73 and 86.

Anal soft-rays.—18 at 8.3 mm. standard length, 16 at 6.9 mm. On the specimens of 6.3 mm. and smaller the posterior soft-rays have not formed. The second soft-ray is longer than the first on all specimens and has a slightly greater length than the longest dorsal ray on most specimens.

Interneural and interhemal spines.—The posterior lateral projections that extend above the body surface along both sides of the dorsal and anal soft-ray bases on larger *latus* and *hippos* have not protruded above the body surface by 8.3 mm.

Caudal.—9+8 principal rays; 8+8 secondary rays (at 8.3 mm. standard length). Only 6 dorsal and 6 ventral secondary rays are present at 6.9 mm.—less than the adult complement of *latus* or *hippos*. The number of secondary caudal rays of the 8.3-mm. specimen is within the range of the adult complement of *latus* and *hippos*. Segmentation has begun by 5.4 mm. (fig. 65), but branching has not begun by 8.3 mm. (fig. 68). Forking of the tail is represented by a slight indentation at 5.4 mm. and is pronounced at 8.3 mm. The urostyle remains visible at 8.3 mm.

Pectoral.—The full complement of rays is present at 8.3 mm. but not at 6.9 mm. The distal end of the fin is rounded at all sizes (figs. 65 to 68). The coordinate of pectoral length on standard length of the 8.3-mm. specimen is plotted in figures 74 and 87.

Pelvic.—The fin is very small and incompletely formed at 5.4 mm. standard length (fig. 65). The full count of rays is present at 6.9 mm. (fig. 67), and segmentation is present on the unbranched rays at 8.3 mm. (fig. 68).

Body depth.—At corresponding body lengths, the depth at first anal spine is less than the depth at pelvic. The coordinates of body depth at pelvic on standard length are plotted in figures 9, 75, and 88.

Head.—The nostril is not completely divided

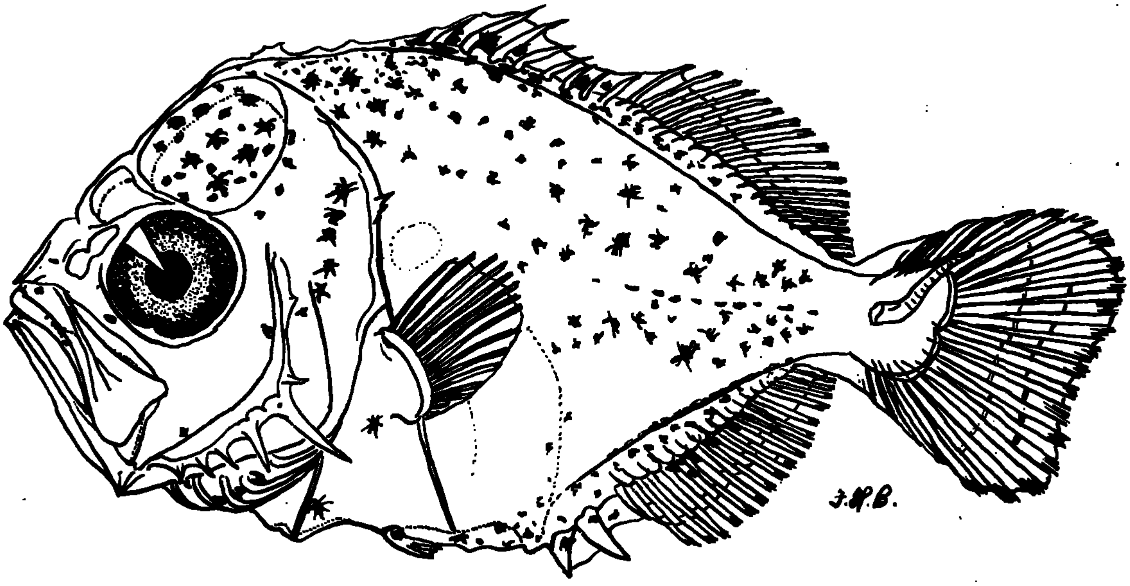

FIGURE 65.—*Caranx* sp. (*latus* or *hippos*) larva, 5.4 mm. standard length (*Gill* 7, Reg. 79).

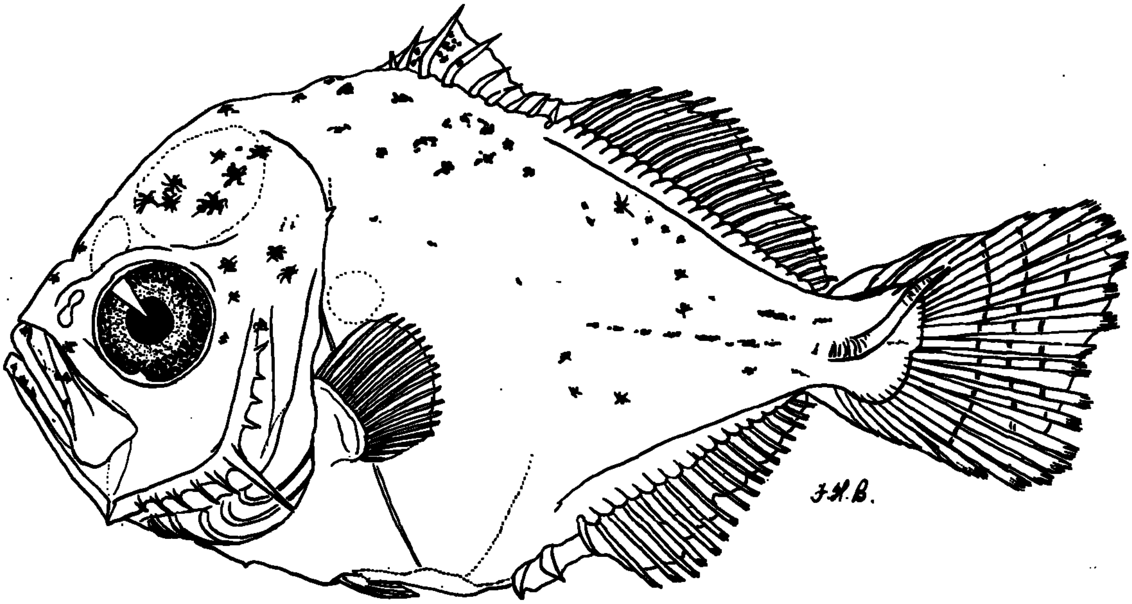

FIGURE 66.—*Caranx* sp. (*latus* or *hippos*) larva, 6.2 mm. standard length (*Gill* 2, Reg. 6).

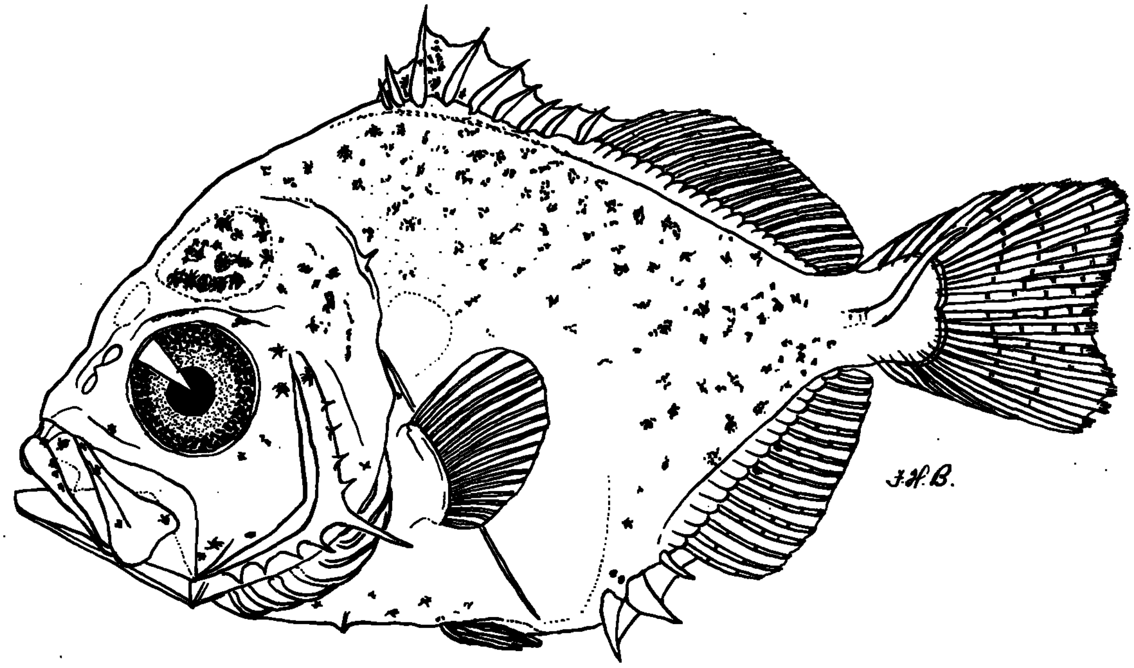

FIGURE 67.—*Caranx* sp. (*latus* or *hippos*) larva, 6.9 mm. standard length (*Gill* 2, Reg. 6).

at 6.9 mm. or below (figs. 65 to 67), but is divided at 8.3 mm. (fig. 68). The supraorbital crest has a serrated edge at 5.4 and 5.7 mm. (fig. 65), but not at 6.2 mm. or above (figs. 66 to 68). A single posterolaterally projecting spine is located on the cleithrum just below its junction with the operculum on all except the 8.3-mm. specimen (figs. 65 to 67). The coordinates of head length on standard length are plotted in figures 75 and 88.

Eye.—The coordinates of eye diameter on standard length are plotted in figures 76 and 89.

Snout.—The coordinates of snout length on standard length are plotted in figures 76 and 89.

Scutes.—Not developed by 8.3 mm. standard length.

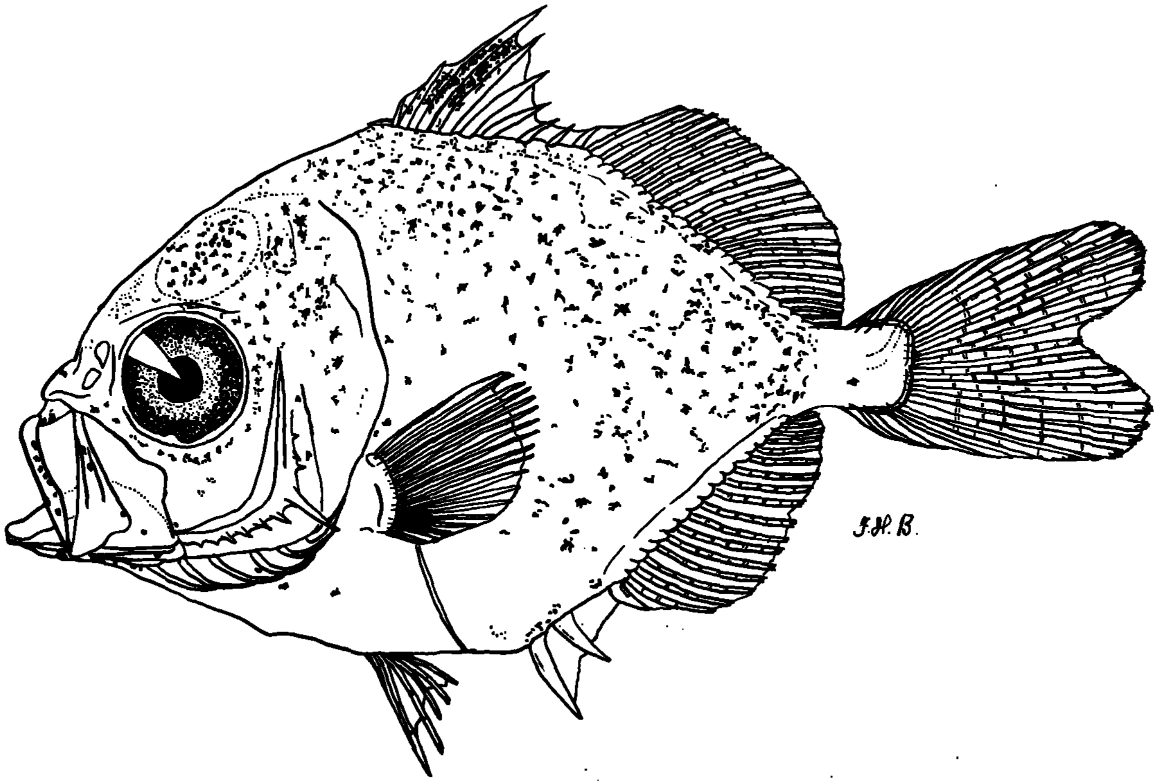

FIGURE 68.—*Caranx* sp. (*latus* or *hippos*) juvenile, 8.3 mm. standard length (*Gill* 3, Spc. 8).

Lateral line.—Not developed by 8.3 mm. standard length.

Preopercular spines.—Apparently the preopercular-angle spine begins to decrease in length at some size between 5.4 to 8.3 mm. (figs. 79 and 94). The preopercular upper-limb spines number 3 or 4, and the lower-limb spines range from 4 to 6 (table 1).

Pigmentation.—A row of elongated melanophores is present on the midline posteriorly of specimens 5.4 to 6.3 mm. (figs. 65 and 66), but this is absent at 6.9 and 8.3 mm. (figs. 67 and 68). The scattered body-pigment spots and larger melanophores on the transparent part of the brain case increase in number from 5.4 to 8.3 mm. (figs. 65 to 68).

A few pigment spots occur on the anal fin at its base on some specimens (figs. 65 and 67), not on others (figs. 66 and 68). Three pigment spots occur on the membranes of the anal spines at 5.4 mm. (fig. 65), but not at other lengths. The interspinous membrane of the first dorsal fin has a few melanophores at 5.4 mm. (fig. 65); these increase in number to 8.3 mm., and tend to become associated with the first 4 spines by 8.3 mm. (figs. 66 to 68).

Distribution off Southeastern Atlantic Coast of the United States

All specimens (table 15) were taken to the east of the 100-fathom line. One location of capture was directly north of the Bahamas; the other six were in association with the Gulf Stream (as depicted by the approximate axis of the Stream in figure 95).

Spawning

The spawning season, estimated from the size ranges of the few larvae taken within this area, extends at least from early February to early July (figs. 80 and 96). By comparison, the spawning of *latus* may terminate in July (fig. 80), but that of *hippos* apparently extends into September (fig. 96). Specimens of the two most northern locations of capture, 5.7 mm. and 6.3 mm., from off South Carolina, may have been spawned within this area (table 15).

TABLE 15.—*Caranx sp.* ("latus *and/or* hippos"): *Location and date of capture, number and size range of 9 specimens examined*

[See pp. 417 and 419 for explanation of abbreviations used; measurements in standard length]

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN:				
34°53′ N., 75°04′ W	July 11, 1954	SAFI, *Gill* 7, Reg. 79	1	5.4
27°40′ N., 79°41′ W	Apr. 23, 1953	SAFI, *Gill* 2, Reg. 6	2	6.2–6.9
28°00′ N., 78°00′ W	July 18, 1953	SAFI, *Gill* 3, Spc. 8	2	5.7–8.3
28°20′ N., 79°48′ W	Apr. 24, 1953	SAFI, *Gill* 2, Reg. 9	1	6.2
31°00.2′ N., 79°38.3′ W	Apr. 27, 1953	SAFI, *Gill* 2, Reg. 30	1	6.1
32°35′ N., 77°46′ W	Aug. 7, 1953	SAFI, *Gill* 3, Reg. 52	1	6.3
33°08′ N., 77°20′ W	Mar. 3, 1953	SAFI, *Gill* 1, Reg. 60	1	5.7

Caranx latus Agassiz

(Figures 69–72)

Caranx latus Agassiz, *in* Spix and Agassiz, 1831, p. 105, pl. LVI b, fig. 1 (Brazil).

Caranx lepturus Agassiz, *in* Spix and Agassiz, 1831, p. 106, pl. LVI b, fig. 2 (Brazil).

Caranx fallax Cuvier, *in* Cuvier and Valenciennes, 1833, p. 95 (West Indies and Brazil).

Caranx richardi Holbrook, 1860, p. 96, pl. XIII, fig. 1 (near Charleston, S. C.).

Caranx hippos (*non* Linnaeus), Günther, 1860, p. 449 (in part; St. Vincent; Jamaica; Puerto Cabello; South America; West Indies; excluding records other than Atlantic).

Carangus fallax, Gill, 1863, p. 433 (Charleston, S. C.).

Carangus aureus Poey, 1875, p. 76 (Cuba).

Caranx sexfasciatus (*non* Quoy and Gaimard), Jordan, 1886b, p. 36 (Havana, Cuba).

Xurel lata, Jordan, Evermann, and Clark, 1930, p. 272 (tropical Atlantic to Virginia).

Caranx sexfasciatus latus Agassiz (*non* Quoy and Gaimard), Nichols, 1936, p. 119 ("more or less replaces *C. hippos* on off-shore islands of the Atlantic").

Caranx sexfasciatus fallax Cuvier (*non* Quoy and Gaimard), Nichols, 1938a, p. 2 (Bermuda; West Indies; Florida and northward;? Atlantic coast of Panama).

Nomenclature

A geographic distinction based on usage should be applied to *Caranx latus* of the Western Atlantic and the closely related, if not identical, *C. sexfasciatus* Quoy and Gaimard of the Indo-Pacific until significant comparisons of the two populations have been made.

Earlier authors (Jordan and Gilbert, 1883: 200; Jordan 1887: 531; Jordan and Evermann, 1896: 923; and others) considered the name *C. sexfasciatus* to be unidentifiable and referred to both populations as *C. latus.* Jordan and Evermann (1903: 337) and Jordan and Seale (1906: 231) later used *C. sexfasciatus* to refer to the Pacific forms. The practice then evolved to use the geographic distinction stated here. Nichols (1938a) incorporated these two forms into a circumtropical species divisible into five subspecies of *C. sexfasciatus*; but, because he used a relatively small number of specimens and his criteria of separation were not too convincing, his treatment has not been generally accepted.

Material

Measurements and counts were taken on a series of 57 specimens from 16.1 to 172 mm. standard length, and meristic values were recorded for an additional 31 specimens within this size range. The 106 specimens identified are shown in table 19.

Nichols (1939: 6) described two specimens of *latus* (under the name *C. sexfasciatus fallax* Cuvier) of 12 and 15 mm., from *Atlantis* station 1934, 36°48′ N., 68°55′ W. to 38°59′ N., 69°46′ W., August 27 to 28. I examined two specimens from the Bingham Collection which are similarly cataloged and may be the ones examined by Nichols, but they are so badly damaged that identification of them as *latus* is tentative. The smaller specimen measures between 12.7 and 13.0 mm., the larger about 16.4 mm. Measurements of body parts of these specimens that were not too distorted are included on the graphs.

Three specimens of *latus* from Bermuda were apparently misidentified as *hippos* by Barbour (1905: 119). This negates one of the two records of *hippos* from Bermuda that I have found. Barbour described as *hippos* a specimen taken on hook-and-line and two specimens of MCZ 28989. The collection number given for the last two seems to be incorrect—the jar of specimens, 37 mm. and 57.5 mm. in length, is numbered MCZ 28979. A third fish, MCZ 32076, 77 mm. long, is labeled *hippos* from Bermuda of the Barbour Collection, and may be the specimen described as taken on hook-and-line. These three specimens are *latus.* They have completely scaled chests. The mean numbers of scutes for the fish measuring 37 mm., 57.5 mm., and 77 mm. respectively are 32.5, 35.5, 32.5; the mean lateral-

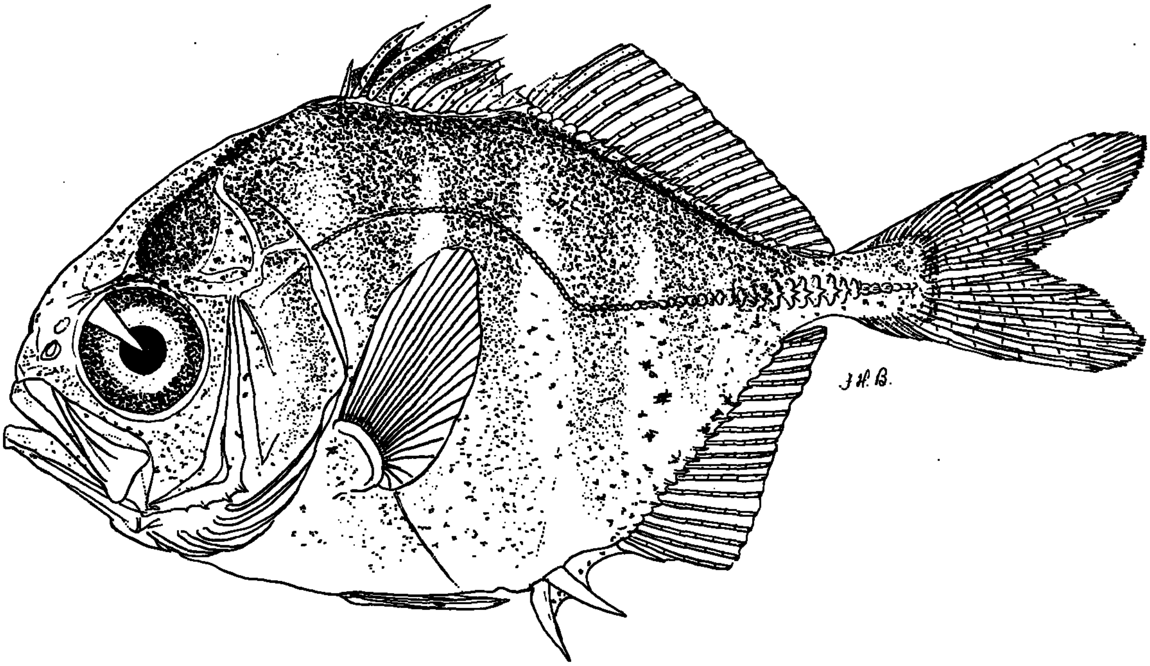

FIGURE 69.—*Caranx latus* juvenile, 16.1 mm. standard length (UF 4291).

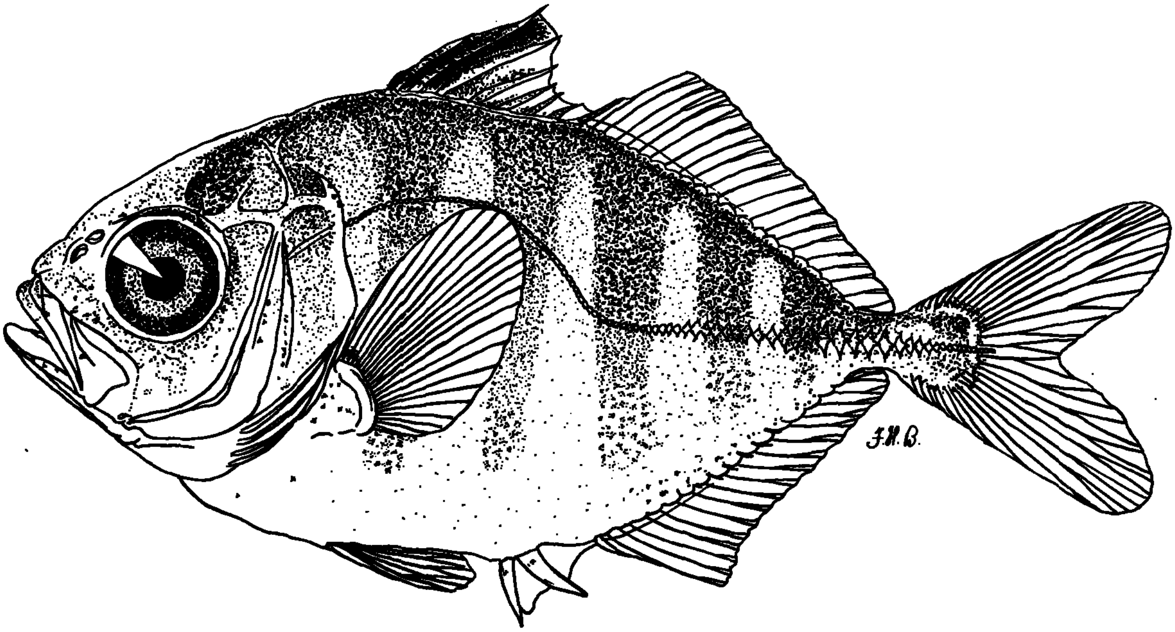

FIGURE 70.—*Caranx latus* juvenile, 21.8 mm. standard length (*Gill* 8, Reg. 29 to 30).

line ratios are 1.75, 1.80, 1.68. Of these two characters, the only value that overlaps the predicted range of *hippos* is the mean number of scutes on the 77-mm. specimen.

A 17.4-mm. specimen of *bartholomaei*, ANSP 72689, from northwest of Cay Sal Bank, which Fowler (1950: 90) identified as *latus*, is discussed under *bartholomaei*, page 472.

Characters

Dorsal spines.—VIII and I. The third spine is the longest at all sizes. An interspinous membrane connects the first and second dorsal fins

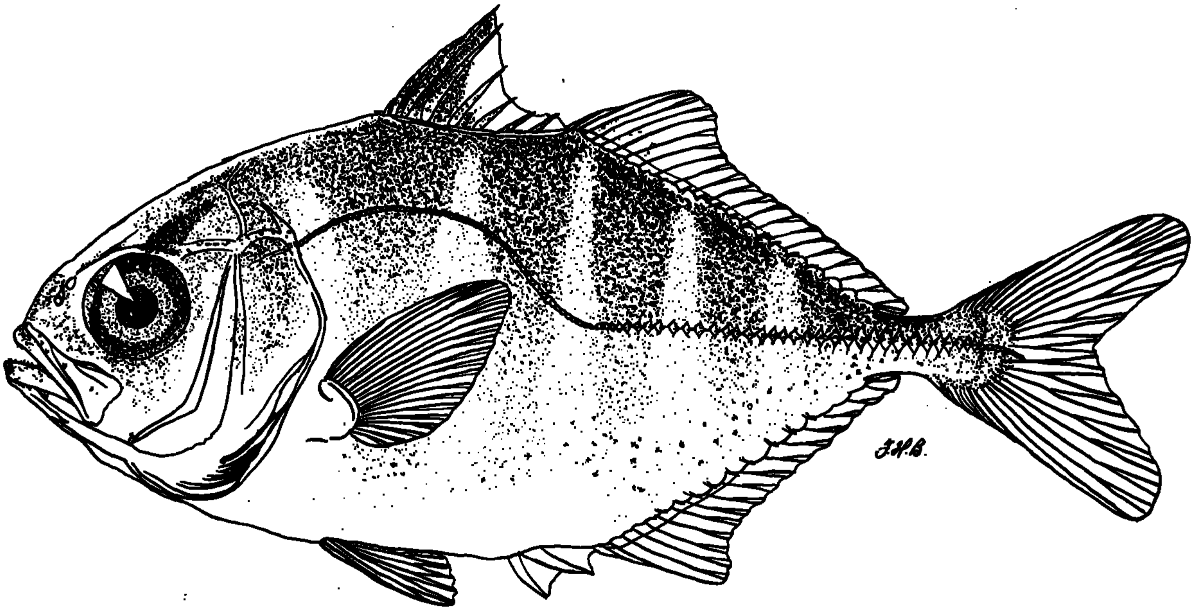

FIGURE 71.—*Caranx latus* juvenile, 31.9 mm. standard length (*Gill* 8, Settlement Point, Bahamas).

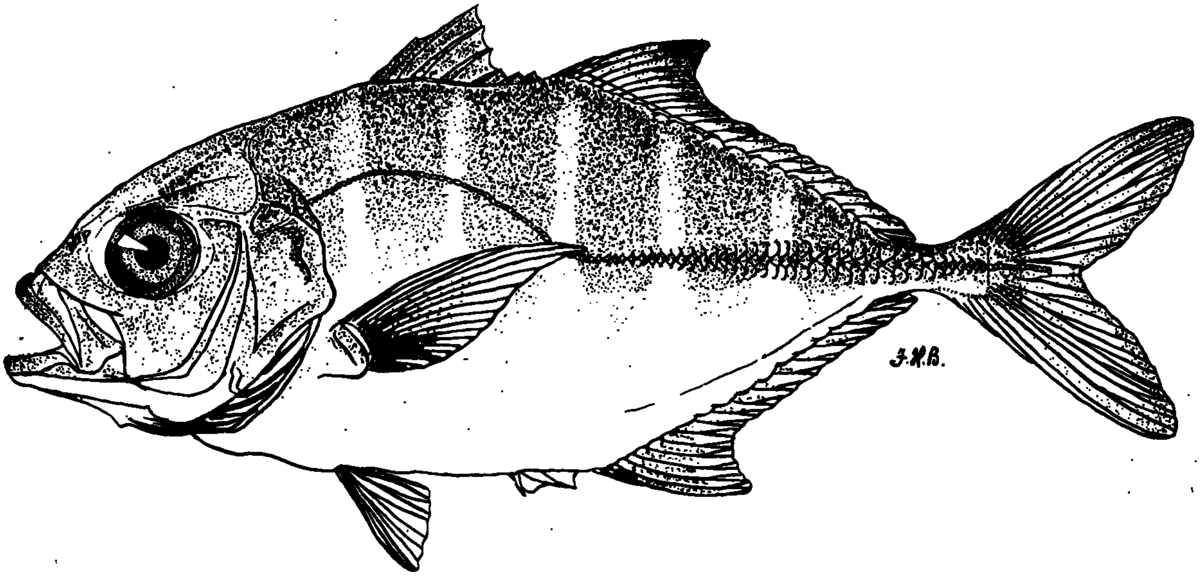

FIGURE 72.—*Caranx latus* juvenile, 83.5 mm. standard length (UF 3021).

(eighth and ninth spines) to about 75 mm. standard length.

The regression of length of the third dorsal spine on standard length is shown in figure 73 and table 16. A line fitted to this regression for specimens from 16.1 to 113 mm. standard length indicates that a proportional rate of increase of the two variates is maintained from about 22 to 113 mm. (0.105-mm. increase in spine length per 1.0-mm. increase in standard length). The alinement of the coordinates for the four specimens of *latus* smaller than 20 mm. and for specimens in the "*latus* and/or *hippos*" series suggests that a faster spine growth rate prevails below approximately 20 mm. The coordinates of the two specimens larger than 113 mm. fall above the extension of the calculated regression line, indicating an increase in spine growth rate at some size around 113 mm. standard length.

Anal spines.—II and I. The second spine is

TABLE 16.—Caranx latus: *Statistics describing regressions of body parts on standard length*

$\bar{x}$=mean of independent variable x
$\bar{y}$=mean of dependent variable y
N=number of specimens
b=rate of increase of y
a=y-intercept of regression line
$Sy{\cdot}x$=standard deviation from regression (standard error of estimate)

Independent variable x	Dependent variable y	Size range of specimens (mm.)	$\bar{x}$	$\bar{y}$	N	b	a	$Sy{\cdot}x$
Standard length	Dorsal-fin spine length (3d)	16.1–113	54.13	7.42	39	0.105	1.718	0.595
Do	Dorsal soft-ray length (1st)	31.9–119	63.76	10.02	35	.207	−3.172	1.210
Do	Pectoral length	16.1–42.5	33.34	7.40	17	.235	−.429	.475
Do	do	42.5–172	90.75	27.46	28	.377	−6.792	1.060
Do	Body depth	16.1–119	55.10	22.82	42	.364	2.793	.891
Do	Head length	16.1–94	50.53	17.04	39	.319	.937	.571
Do	Eye diameter	16.1–172	69.14	7.27	52	.091	1.012	.491
Do	Snout length	16.1–172	70.47	6.38	50	.092	−.106	.531

longer than the first at all sizes. An interspinous membrane connects the second and third spines to about 35 mm.

Dorsal soft-rays.—19 to 22 (table 17). At 16.1 mm. the posterior rays are beginning to branch (fig. 69). Extension of the anterior 5 or 6 soft-rays to produce the lobe has occurred by 31.9 mm. (fig. 71). The second ray averages the greatest length to about 34 mm. standard length; above 34 mm., the first ray is longest. The third dorsal spine averages longer than the first soft-ray to about 50 mm.; above 50 mm., the soft-ray is longer (fig. 73).

The regression of length of the first dorsal soft-ray on standard length is shown in figure 73 and table 16. A line fitted to this regression for specimens from 31.9 to 119 mm. standard length illustrates appreciable variation of coordinate values around the line, but indicates a proportional rate of increase for the two variates within this size range (0.21-mm. increase in soft-ray length per 1.0-mm. increase in standard length). Alinement of the coordinates of the three smallest specimens of *latus* and of the "*latus* and/or *hippos*" specimens suggests that a slower soft-ray growth rate prevails below approximately 30 mm. The coordinates of the specimens larger than 119 mm. fall above the extension of the calculated regression line, indicating an increase in soft-ray growth rate above that size.

TABLE 17.—Caranx latus: *Correlation of the numbers of dorsal and anal soft-rays of 88 specimens*

[The upper number in each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

ANAL SOFT-RAYS	DORSAL SOFT-RAYS			
	19	20	21	22
16		7 (8.0)		
17	1 (1.1)	12 (13.6)	58 (65.9)	1 (1.1)
18			5 (5.7)	4 (4.6)

Anal soft-rays.—16 to 18 (table 17). Only the terminal ray is branched at 16.1 mm. standard length (fig. 69). Lobation occurs as with the dorsal fin. The second soft-ray is longest to 21.8 mm. standard length; the first and second rays are equal and the longest at 34.4 mm.; and the first ray is longest at 36.5 mm. and above. The longest anal ray is shorter than the longest dorsal ray at 16.1 mm. and above 34 mm.; and they are nearly equal in length from 21.8 to 34.1 mm. The second anal spine is about two-thirds as long as the longest anal soft-ray at 16.1 mm., only about one-half as long at 40 mm., and about one-fourth as long at 141 mm.

Interneural and interhemal spines.—The posterior lateral projections of these spines are well developed and extend above the body surface along the bases of the second dorsal and the anal fins at 16.1 mm. standard length (fig. 69). They remain externally discernible to 156 mm., but are much less prominent than at smaller sizes. At 172 mm., these projections along the dorsal fin base are covered by the fleshy sheath that covers the bases of the soft-rays, but approximately 6 of the projections of the interhemal spines along the anal fin base remain externally exposed.

Caudal.—9 + 8 principal rays; about 8 or 9 + 8 secondary rays. Branching has occurred at 16.1 mm. (fig. 69).

Pectoral.—I–18 to 20. The full complement of rays is formed by 16.1 mm. standard length (fig. 69). The distal end of the fin is rounded to about 32 mm. standard length, after which it becomes pointed and falcation begins (figs. 69 to 71). Fal-

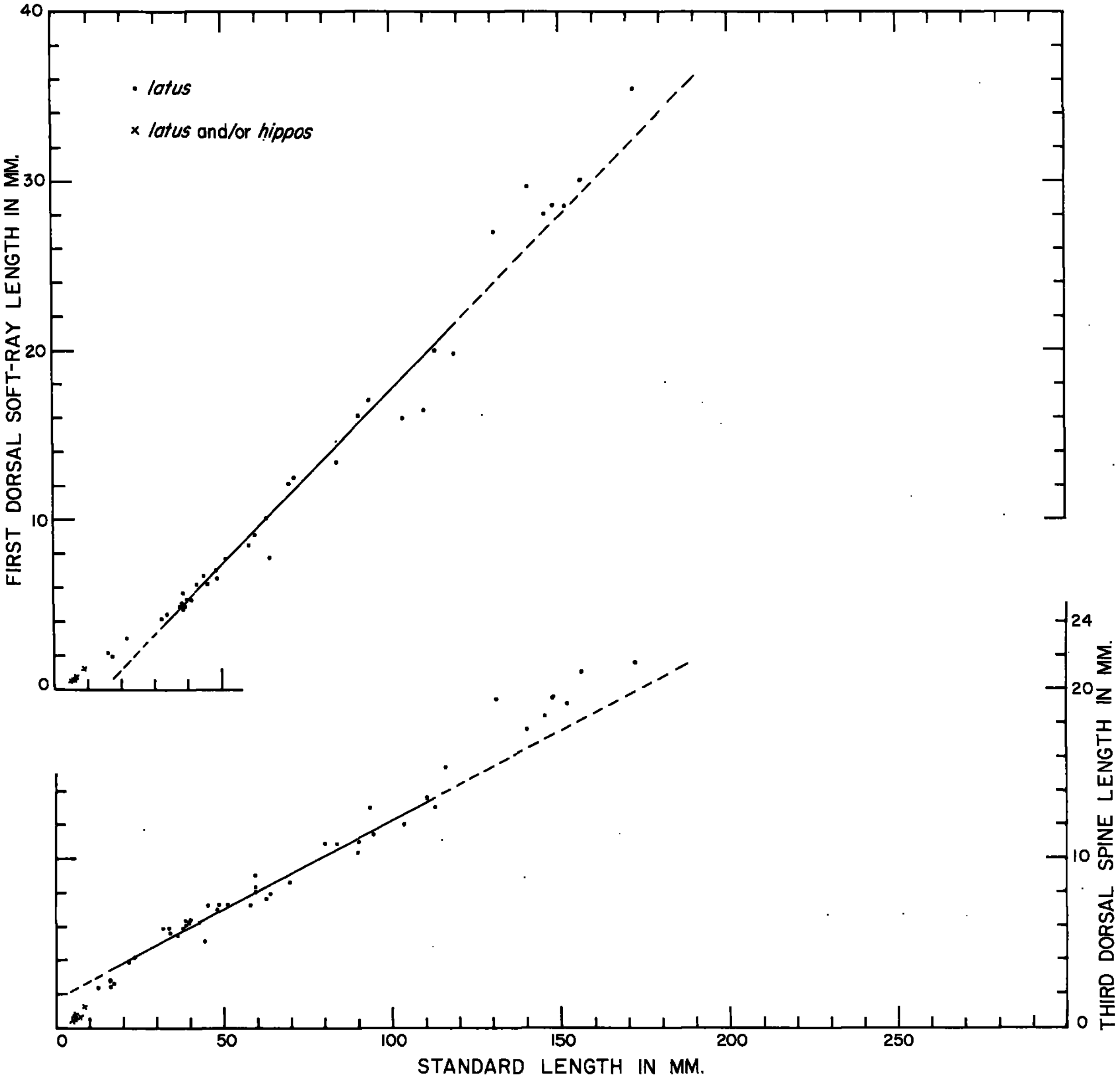

FIGURE 73.—*Caranx latus* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of length of first dorsal soft-ray and of third dorsal spine to standard length.

cation is pronounced at about 65 mm. and larger (fig. 72).

The regression of pectoral length on standard length is shown in figure 74 and table 16. Two lines were fitted to this regression: for specimens from 16.1 to 42.5 mm. and from 42.5 to 172 mm. standard length. The lines intersect at approximately 43 mm., indicating that an inflection occurs at about that size and that a faster pectoral growth rate prevails above that size. The proportional rates of increase for the two variates are 0.24-mm. (less than 43 mm.) and 0.38-mm. (more than 43 mm.) increase in pectoral length per 1.0-mm. increase in standard length.

Pelvic.—I–5. The rays are branched and segmented at 16.1 mm. standard length.

Body depth.—The depth at first anal spine averages less than the depth at pelvic from 16.1 to about 30 mm., is nearly equal from about 30 to 50 mm., and averages greater above 50 mm. The coordinates for depth at pelvic on standard length of specimens 30 mm. and smaller are plotted in figure 8.

The regression of body depth at pelvic on

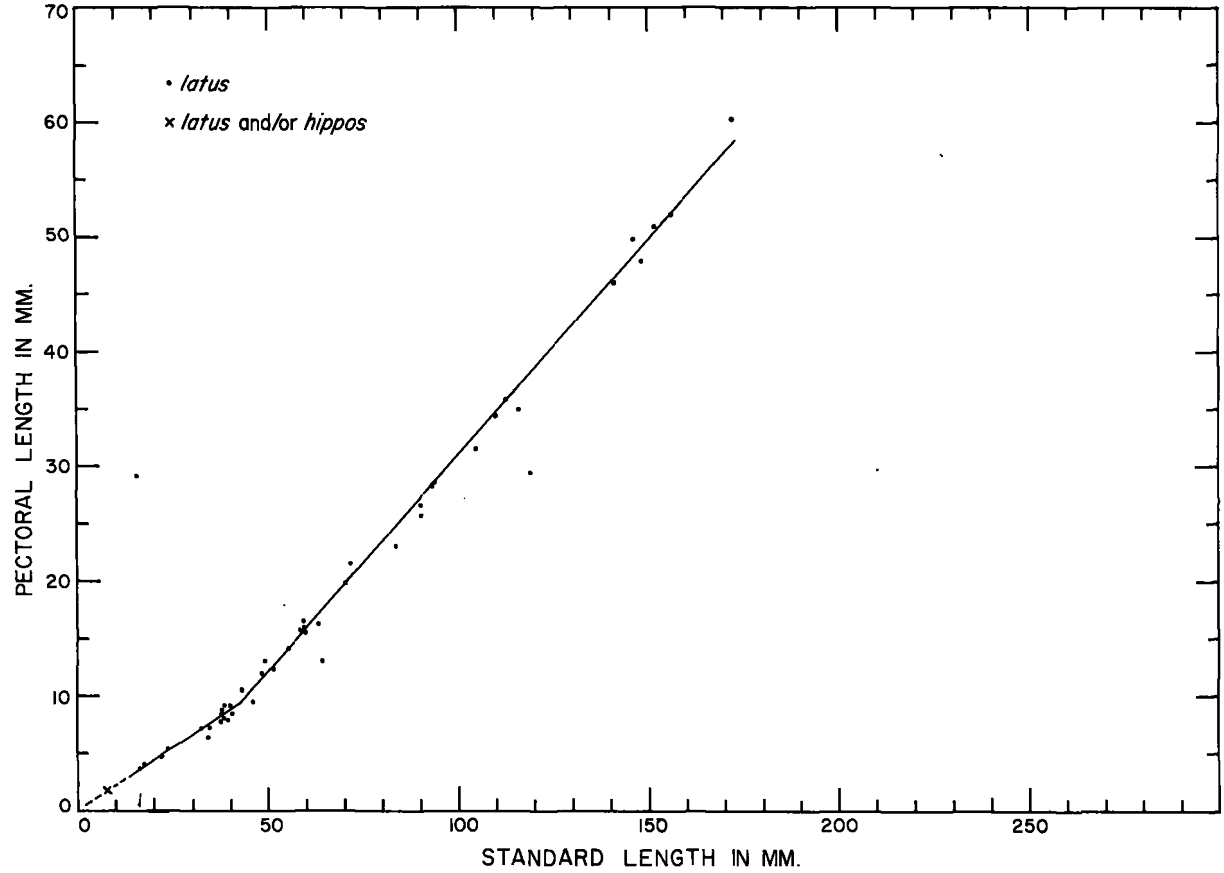

FIGURE 74.—*Caranx latus* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of pectoral length to standard length.

standard length is shown in figure 75 and table 16. A line fitted to this regression for specimens from 16.1 to 119 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.36-mm. increase in body depth per 1.0-mm. increase in standard length). The alinement of the coordinate at about 12.7 mm. with the coordinates of the "*latus* and/or *hippos*" specimens indicates that a faster body-depth growth rate occurs below approximately 16 mm. The position of the coordinates of the specimens larger than 119 mm. with respect to the extension of the calculated regression line, suggests that the body-depth growth may continue at the same proportional rate.

Head.—The regression of head length on standard length is shown in figure 75 and table 16. A line fitted to this regression for specimens from 16.1 to 94.0 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.32-mm. increase in head length per 1.0-mm. increase in standard length). The coordinates of specimens larger than 94 mm. fall along the extension of the calculated regression line, indicating that head growth may continue at the same proportional rate.

Eye.—The regression of eye diameter on standard length is shown in figure 76 and table 16. A line fitted to this regression for specimens from 16.1 to 172 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.09-mm. increase in eye diameter per 1.0-mm. increase in standard length). The position of the coordinates of the "*latus* and/or *hippos*" specimens suggests that a faster eye growth prevails below 15 or 20 mm.

Snout.—The regression of snout length on standard length is shown in figure 76 and table 16. A line fitted to this regression for specimens from 16.1 to 172 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.09-mm. increase in snout length per 1.0-mm. increase in standard length).

Gill rakers.—Lower limb, 16 to 18; upper limb, 6 or 7; total, 22 to 25 (table 18). Of the specimens examined above 20 mm., about 90 percent had from 1 to 3 rudimentary gill rakers at the origin of the lower limb (modally, 1 below 80 mm. and 2 above 80 mm.). All specimens of more than 60 mm. had these lower-limb rudiments. About 80 percent had from 2 to 5 rudimentary gill rakers at the origin of the upper limb (modally, 3 below 80 mm. and 3 to 5 above 80 mm.). All specimens above 45 mm. had these rudiments. Ginsburg (1952: 92) reported the upper 3 or 4 gill rakers on the upper limb to be short or tuberclelike in larger specimens (to about 366 mm., converted), and 1 or 2 tubercles in front on the lower limb. This indicates that gill rakers at the origins of both limbs become shorter or rudimentary with growth of the fish.

Scutes.—Range of the mean number of scutes above 100 mm. standard length: about 32 to 39 (fig. 77). Ginsburg (1952: 92), working with specimens from about 53 to 366 mm. (converted), found a scute range of 30 to 42. Nichols (1939: 4) gave an average number of scutes for his

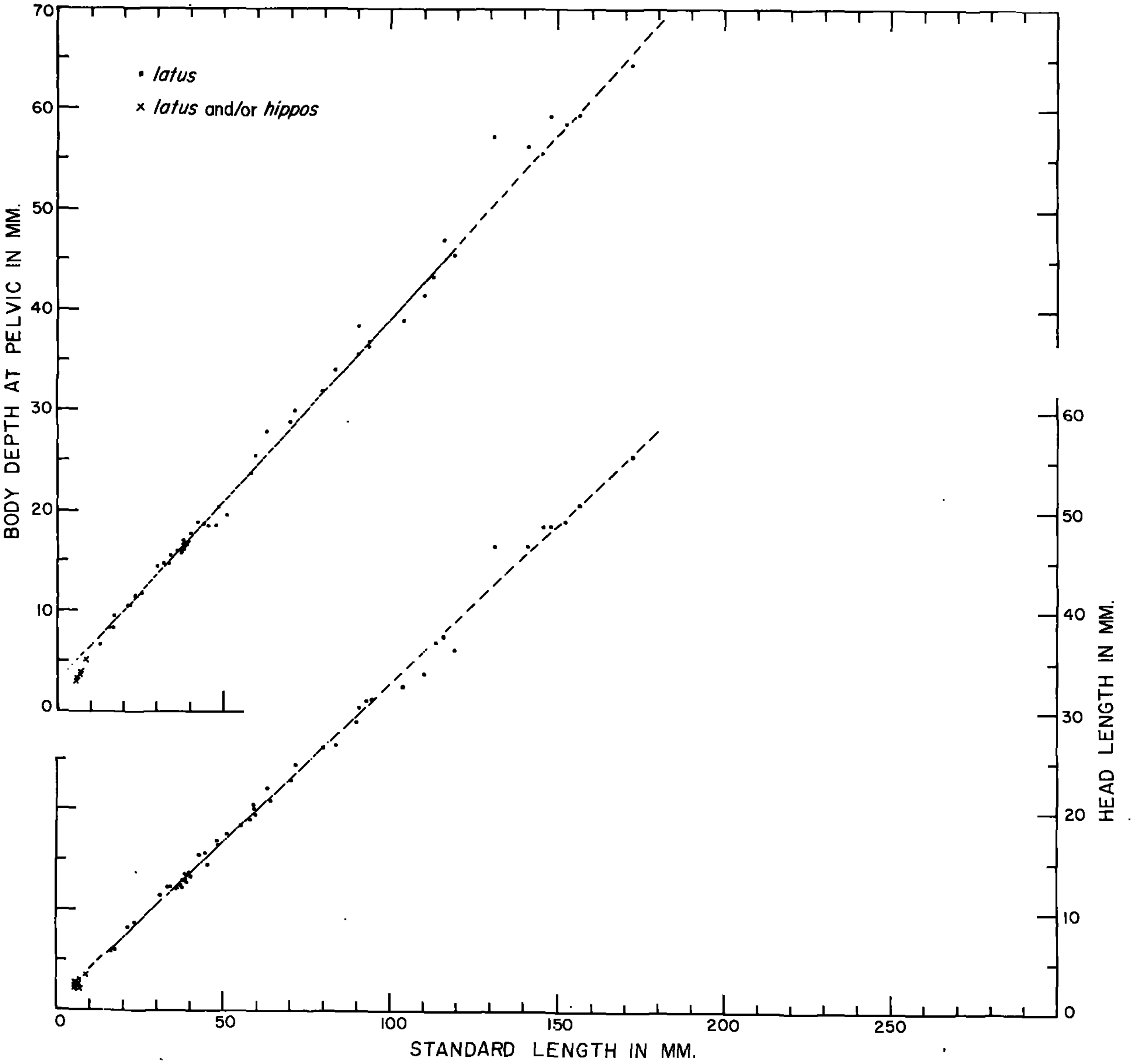

FIGURE 75.—*Caranx latus* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of body depth at pelvic and of head length to standard length.

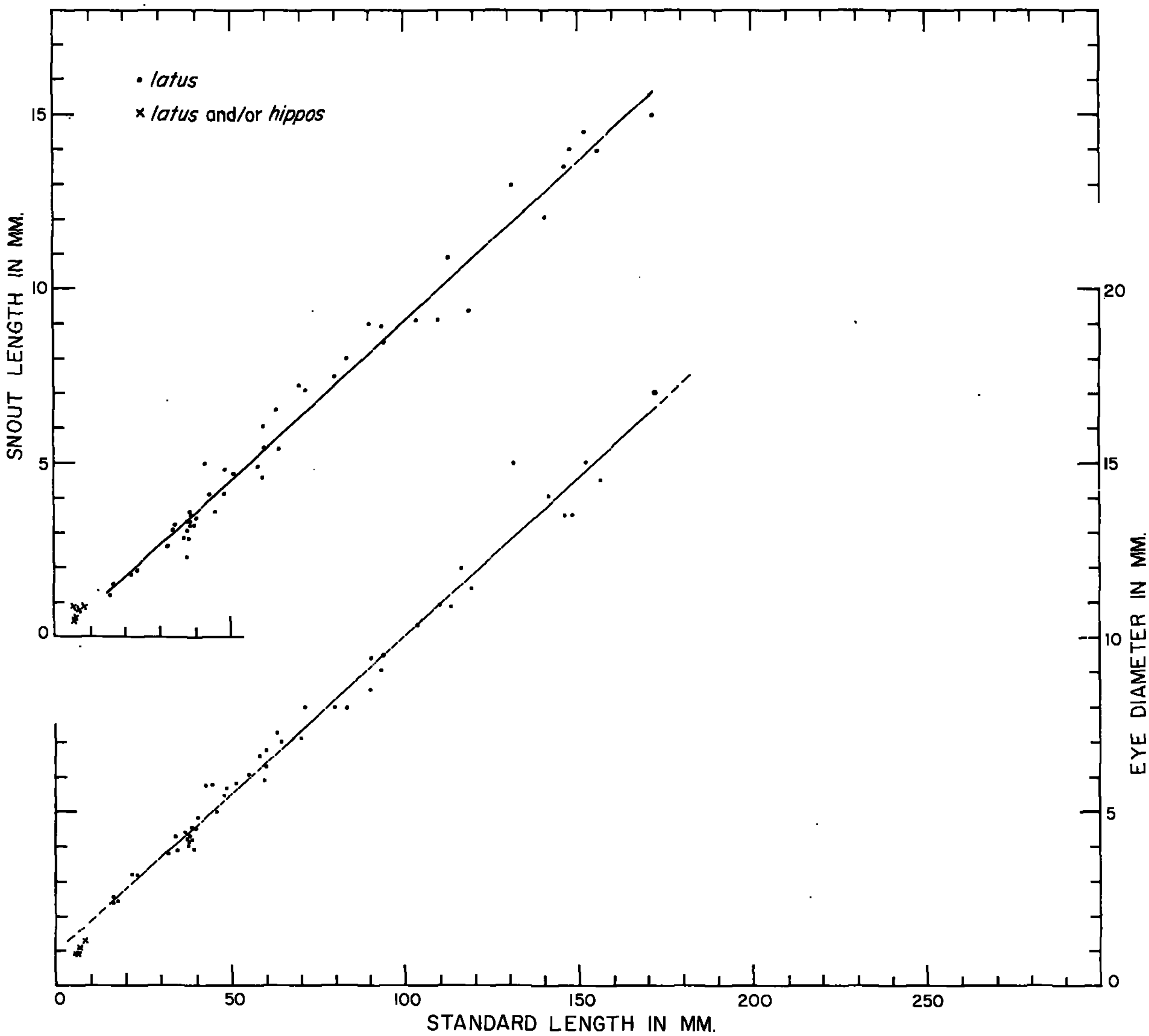

FIGURE 76.—*Caranx latus* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of snout length and of eye diameter to standard length.

TABLE 18.—Caranx latus: *Correlation of the numbers of lower-limb to upper-limb gill rakers of 78 specimens*

[The upper number of each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

UPPER-LIMB GILL RAKERS	LOWER-LIMB GILL RAKERS 16	17	18
6	3 (3.8)	17 (21.8)	6 (7.7)
7	5 (6.4)	39 (50.0)	8 (10.3)

synonymous *C. s. fallax* as 32.6, which is within my established perimeter, but is much lower than would be expected for an average. Some of the scutes along the central part of the straight lateral line have completed their development by 16.1 mm.

Lateral line.—Range of mean lateral-line ratio above 60 mm. standard length: about 1.45 to 2.0 (fig. 78). Nichols (1939: 7) gave ratios of 1.35 and 1.4 for his specimens of 12 mm. and 15 mm., which conform to my estimated perimeter.

Preopercular spines.—Preopercular spines were present on the specimen of about 13 mm. standard length, and at 16.1 mm. and 17.1 mm. They were absent on the specimen of about 16.4 mm. and at 20 mm. and above. Apparently, these spines are absorbed by the preopercular expansion between about 16 mm. and 20 mm. The lengths of the angle spine associate with the probable trend of decrease in spine length of the "*latus* and/or *hippos*" group (fig. 79). One preopercular upper-limb spine was present on the specimen of about 13 mm.; none at 16.1 or 17.1. Five lower-limb spines were present at 13 mm. and 17.1 mm. and 4 at 16.1 mm. (table 1).

Pigmentation.—The juvenile complement of five body bars is present at 16.1 mm. The pigmentation of the posterior three bars extends to the base of the anal fin. There is a heavily pigmented area on the brain case above the eye, and less-deeply pigmented areas on the upper portion of the operculum and the fleshy part of the tail. The first dorsal fin, the pelvic fins, and the interspinous membranes of the anal fin have pigment spots. The other fins are unpigmented (fig. 69).

The two damaged BOC specimens have vague and physically distorted bars. Other specimens from 16.1 to 90.5 mm. standard length have five bars, with the exception of a few whose pigment had faded out. Pigment of four specimens of 104 to 118 mm. had obviously faded after preservation. Specimens of 116 mm. and 131 mm. and larger appear to lack bars from growth changes rather than from fading. Apparently, the bars disappear between 90 and 116 mm. The pigmentation of the posterior three bars is not pronounced below the lateral line on the 16.1-mm. specimen, and on most specimens 20 mm. and larger the pigmentation of the last three bars terminates a short distance below the lateral line. At 26 mm. and above the body bars are wider than the interspaces (figs. 71 and 72). On a 34.1-mm. specimen, apparently normal in other

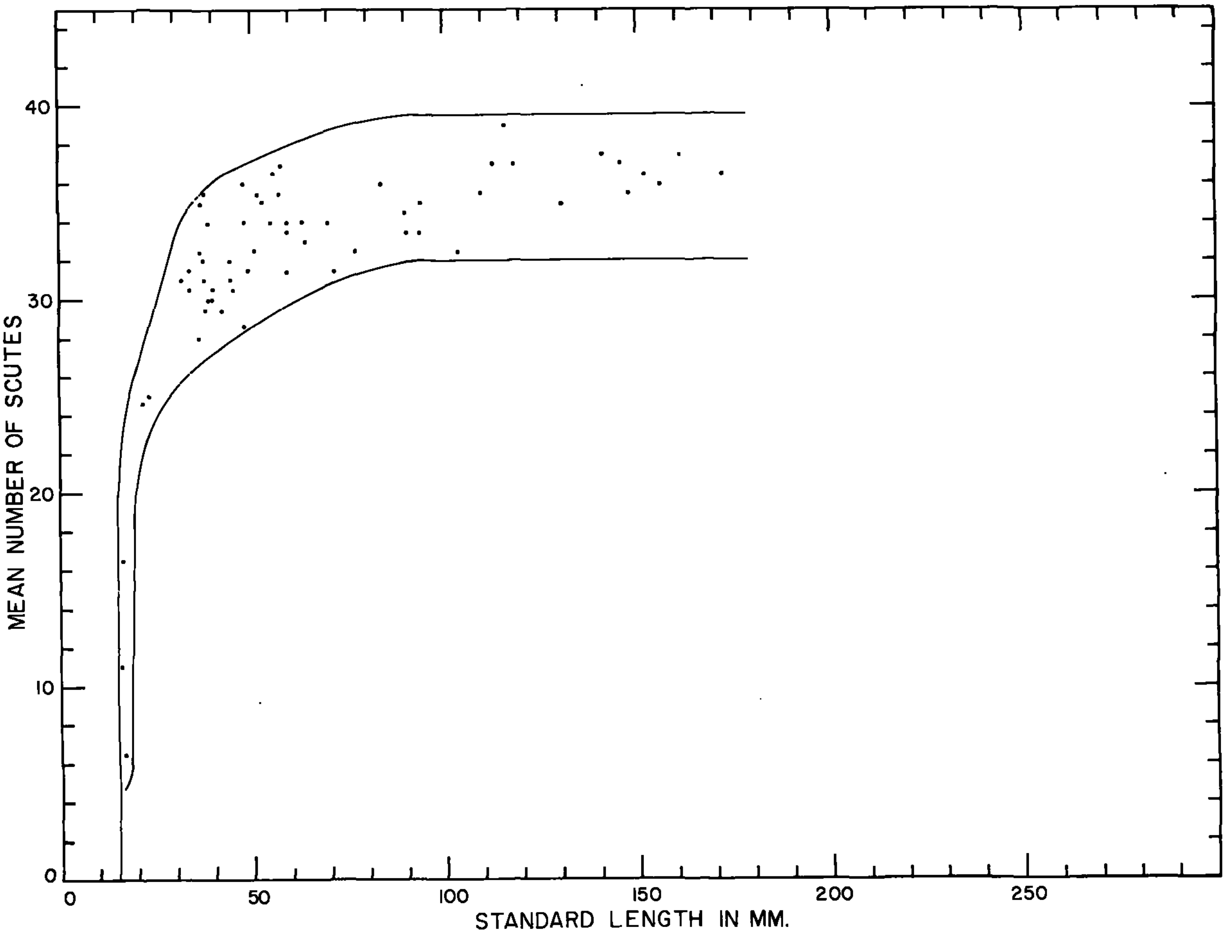

FIGURE 77.—*Caranx latus:* Relation of the mean number of scutes to standard length.

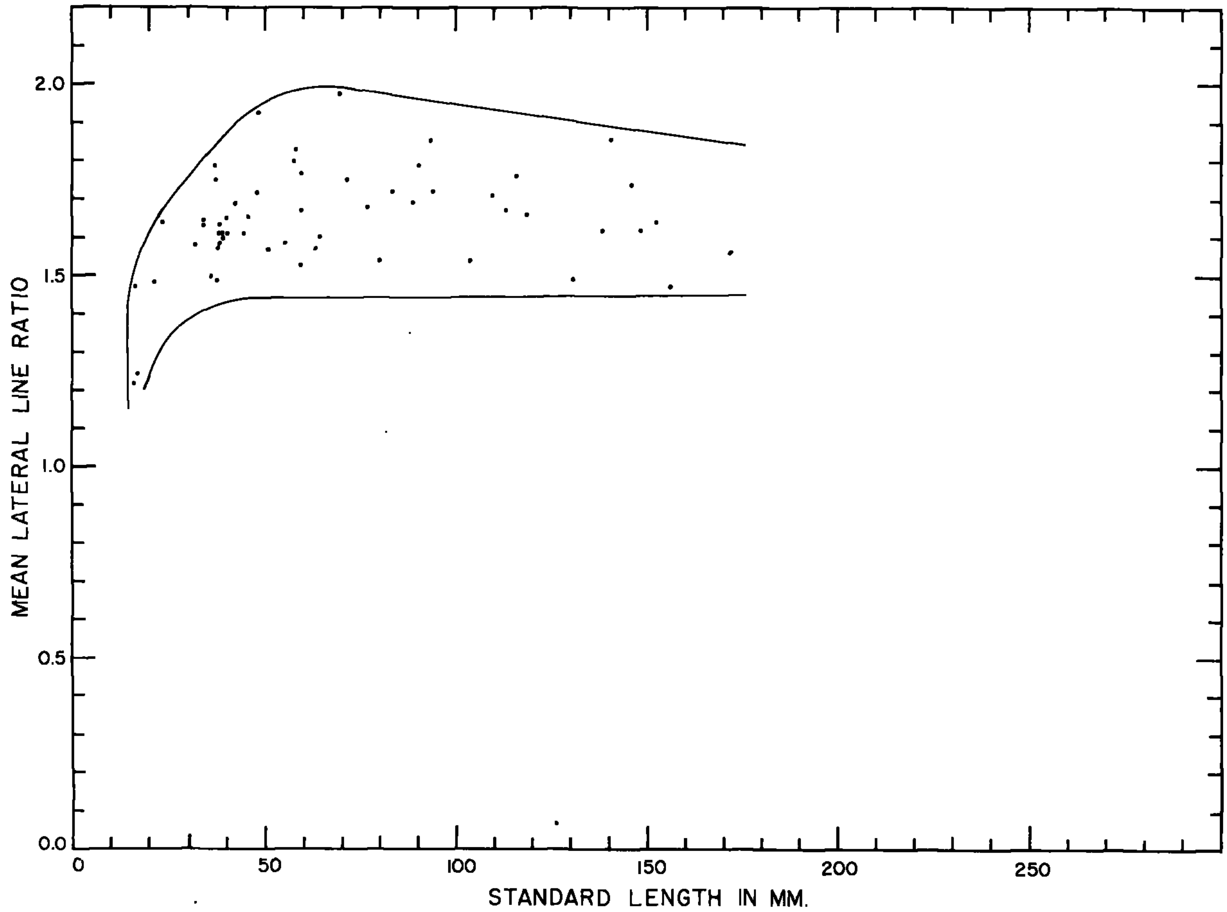

FIGURE 78.—*Caranx latus:* Relation of the mean lateral-line ratio to standard length.

respects, the fourth and fifth bars on the left side converged ventrally to unite at the lateral line and continue as a single bar for a short distance below the lateral line.

At 21.8 mm., pigmentation on the first dorsal fin is more intense than at 16.1 mm. and is largely restricted to the membranes connecting the second, third, and fourth spines (fig. 70). By 80 mm. it has spread over the fin (fig. 72). The anal spines and their membranes and the pelvic fins are unpigmented at 31.9 mm. and above. The second dorsal and the caudal fins have pigmentation at their bases at 31.9 mm. and the anal at a slightly larger size, although it is not as prominent on the anal or caudal fins as on the dorsal. Pigmentation intensifies and migrates to the edge of the dorsal fin by 40 to 60 mm. (fig. 72), and becomes concentrated on the distal half of the dorsal lobe.

Distribution off Southeastern Atlantic Coast of the United States

Specimens have been reported from the following specific localities within this area: The northern Bahamas by Lee (1889: 670), Bean (1905: 302), Breder (1934: 70; 1951: 170), Nichols (1937c: 3; 1938a: 2), Fowler (1944: 443), and Ginsburg (1952: 92); Palm Beach, Fla., by Fowler (1915: 248); Charleston, S. C., by Gill (1863: 433); Folly Island, S. C., by Nichols (1937c: 3) and Fowler (1945: 191); Perry Island, Bird Shoal, and Beaufort, N. C., by Smith (1907: 206); Beaufort, N. C., by Ginsburg (1952: 92); and near Cape Hatteras by Bean (1905: 302).

Figure 95 shows the locations for specimens taken on the *Gill* cruises, a USNM specimen examined (Cape Lookout, N. C.), the ChM specimen examined (Folly Island, S. C.), a specimen examined from Bears Bluff Laboratory

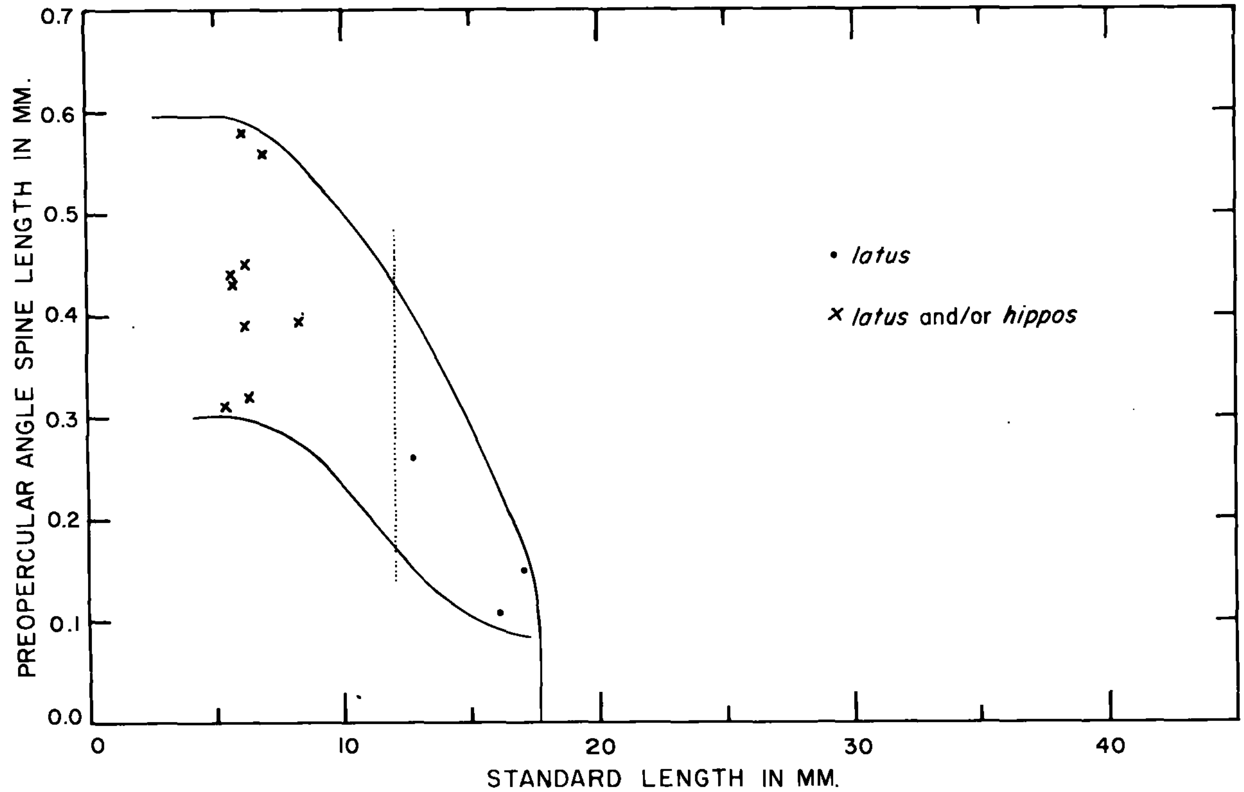

FIGURE 79.—*Caranx latus* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of length of preopercular-angle spine to standard length. Dotted line separates the two forms.

(North Edisto River, S. C.), specimens taken by SAFI (St. Simons Island and Turtle River, Ga.), UF specimens examined (St. Augustine Inlet, Vilano Beach, and St. Lucie Inlet, Fla.), and a CBSFP specimen examined (Hog Island, Bahamas) (tables 2 and 19). The specimens recorded on this chart are all juveniles. If any of the "*latus* and/or *hippos*" larval specimens recorded on figure 95 are this species, then the period of larval development of *latus* probably takes place offshore and, in this area, in association with the Gulf Stream. The 17.1-mm. juvenile *latus* taken at the 100-fathom line off Cape Lookout, N. C., contributes to this theory. The 16.1-mm. specimen from St. Lucie Inlet, Fla., distracts from it; but in that area the Gulf Stream is moving close to the coast, and this specimen could have been carried inshore by the current. The small juveniles reported by Nichols (1939: 6) from about 37°N., 69°W., were more than 300 miles offshore in the Gulf Stream. The several records of juvenile *latus* above 20 mm. standard length for the northern Bahamas and Atlantic coast of the United States, and the scarcity of records of capture of juveniles above this size in offshore waters, indicates that the species in this area adopts an inshore habitat at about 20 mm. or slightly larger. I have examined 11 juveniles 20 to 38 mm. taken by the *Oregon* in the Gulf of Mexico from 7 localities ranging from about 47 to 65 miles offshore, and there are several published records of larger juveniles and adults being taken inshore from the Gulf. Unless the habits and habitats differ greatly in the Gulf and in the Atlantic Ocean, the evidence indicates that the larvae and small juveniles are probably associated with offshore currents, and when about 16 to 20 mm. some, at least, migrate inshore.

The species occurs seasonally but not abundantly on the Atlantic coast of the United States. Presumably there is a migration southward or to warmer offshore waters during the colder months. Fowler (1905b: 258) listed the most northern inshore record for *latus* at Squan River, N. J. Dr. J. E. Böhlke stated in a personal communication that Dr. Fowler had said this specimen came from the mouth of the Manasquan River.

A possible brackish or even fresh-water affinity of this species may account for a juvenile inshore movement. Meek (1914: 121) recorded a specimen of about 139 mm. (converted) from "swift clear water at the foot of rapids." Breder (1934: 70) reported specimens 92 to 180 mm. from a fresh-water lake on Andros Island, Bahamas. Referring to the related if not identical Pacific form, *C. sexfasciatus*, Herre (1956: 1035) stated that it not only entered fresh water but remained there until it was a year or a year-and-a-half old.

Spawning

The spawning season that contributes young *latus* to this area may be estimated, from the smallest specimens taken in May (17.1 mm.) and September (21.8 mm.) to extend from about mid-March to mid-July (fig. 80). Erdman (1956: 320) noted *latus* in spawning condition during June in Puerto Rico.

If the "*latus* and/or *hippos*" specimens represent this species, in part or entirely, a limited spawning may occur in the Atlantic off the southeastern United States; but the major spawning areas for *latus* would be to the south of this area. If the larval existence is in offshore currents, as suggested previously, then spawning probably occurs in this type of environment. Breder (1951: 170) described a peculiar pattern of activity attributed to spawning behavior of five *latus* (under the name of *C. sexfasciatus*) in captivity at Bimini, Bahamas, on June 8.

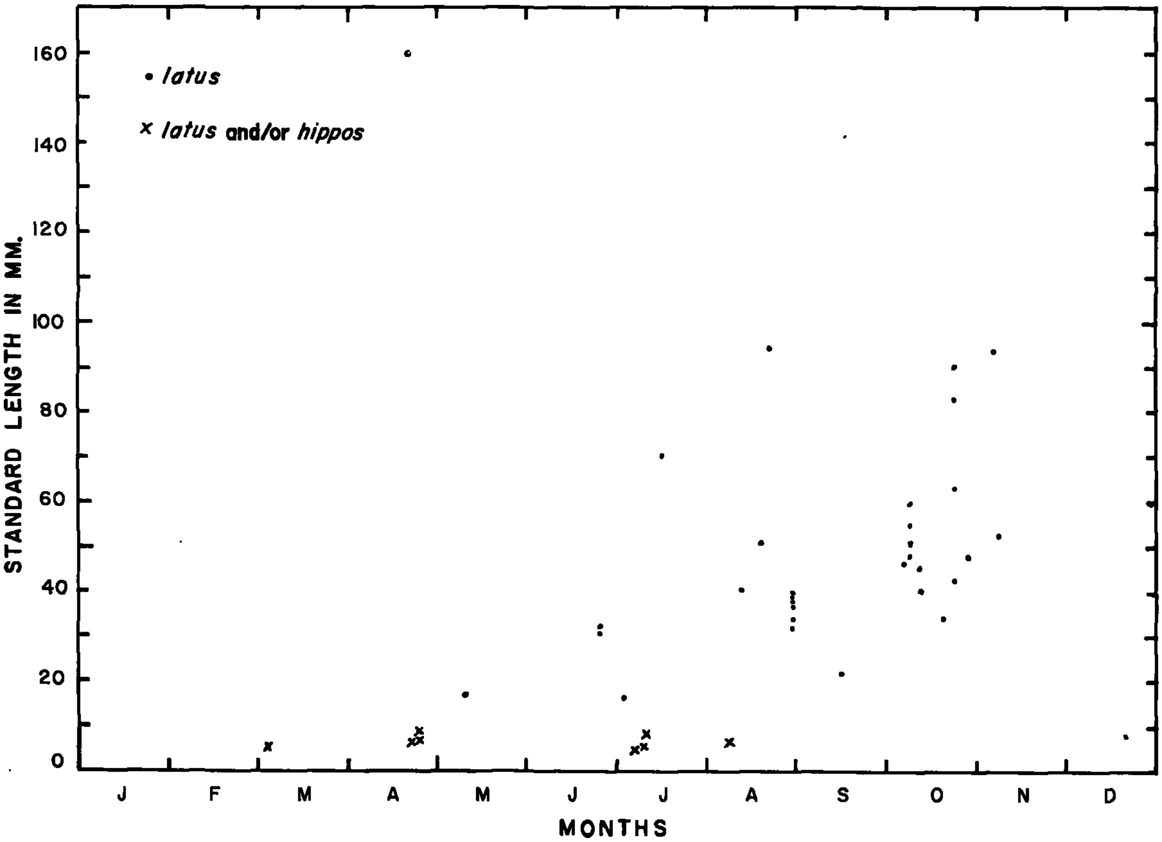

FIGURE 80.—*Caranx latus* and *Caranx* sp. ("*latus* and/or *hippos*"): Size distribution, by months, of specimens taken off the southeastern Atlantic coast of the United States.

TABLE 19.—Caranx latus: *Location and date of capture, number and size range of 106 specimens examined*

[See pp. 417 and 419, for explanation of abbreviations used; measurements in standard length]

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN:				
Playa Baracoa, Cuba	Nov. 16, 1954	UF 5355	1	140
Spanish Wells, Bahamas	July 4, 1903	USNM 53108	1	38.1
Clarence Harbor, Bahamas	July 14, 1903	USNM 53107	1	64
24°04′ N., 79°15′ W	July 24, 1957	SAFI, *Combat* 448	2	25–30
Hog Island, Bahamas	Aug. 19, 1955	CBSFP Acct. No. 251	10	42.5–94
Do	Aug. 15, 1955	CBSFP Acct. No. 248	6	41.5–59
Rose Island, Bahamas	July 31, 1955	CBSFP Acct. No. 235	15	35–55
26°27′ N., 76°44′ W	June 13, 1954	SAFI, *Gill* 7, Std	1	40
26°54′ N., 79°07′ W	Aug. 29, 1954	SAFI, *Gill* 8, Settlement Point, Bahamas	5	31.9–39.6
St. Lucie Inlet, Martin County, Fla	July 2, 1954	UF 4291	1	16.1
Sebastian Inlet, Indian River, Fla	Nov. 7, 1956	MI	1	52
Vilano Beach, Fla	July 15, 1950	UF 3324	1	70
St. Augustine Inlet, Fla	Oct. 19, 1930	UF 2964	1	33.8
St. Augustine, Fla	Oct. 23, 1953	UF 3021	4	42.5–90.5
30°59′N., 79°14′W. to 30°59′N., 79°36.5′W	Sept. 15, 1954	SAFI, *Gill* 8, Reg. 29 to Reg. 30	1	21.8
Turtle River, Glynn County, Ga	Oct. 7, 1955	SAFI	4	48–59.5
St. Simons Island, Ga	Oct. 5, 1955	do	1	45.5
Do	May 2, 1957	do	1	41
Do	Oct. 11, 1957	do	1	45
Jekyll Island Causeway, Ga	do	do	1	40
North Edisto River, S. C	Nov. 4, 1954	BBL	1	93.5
Folly Island, S. C	Oct. 28, 1929	ChM 29.234.2	1	48.5
34°03.5′ N., 76°15′ W	May 9, 1953	SAFI, *Gill* 2, Reg. 71	1	17.1
Cape Lookout, N. C	Aug. 9, 1913	USNM 111779	1	38.3
Beaufort, N. C	July-Aug. 1904	USNM 51937	1	44.5
Do	Aug. 17, 1905	USNM 111777	1	58
36°48′ N., 68°55′ W	Aug. 27–28.	BOC (no number)	2	13–16.4
Woods Hole, Mass	1876	USNM 164529	1	36.5
Bermuda		USNM 164922	2	104–110
Do	Sept. 1862	MCZ 28979	2	37–57.5
Do	1904	MCZ 32076	1	77
GULF OF MEXICO:				
Havana fish market, Cuba	Jan. 7, 1956	SAFI	1	146
Tortugas, Fla		USNM 154694	1	118
Do		USNM 116859	5	38.8–113
One mi. off Garden Key, Tortugas, Fla	Aug. 1954	ANSP Acct. No. 215	1	55.5
Ponce Park, Fla	Nov. 24, 1908	USNM 62650, *Orian*	1	71.5
28°17′ N., 88°37′ W	Aug. 25, 1955	GFEGR, *Oregon* 1380	1	23.5
28°20′ N., 87°37′ W	July 21, 1956	UF 3925, *Oregon* 1585	1	31.5
28°45′ N., 88°03′ W	July 24, 1956	UF 3922, *Oregon* 1590	1	37
28°50′N., 87°58′ W	do	UF 3926, *Oregon* 1589	3	20–26
Do	do	UF 3923, *Oregon* 1591	1	22.5
Do	July 26, 1956	UF 3924, *Oregon* 1593	1	32.5
29°01′ N., 87°48′ W	Aug. 22, 1955	GFEGR, *Oregon* 1374	3	37.5–38.5
CARIBBEAN SEA:				
Tortuguero Lagoon and River, Costa Rica	Dec. 1, 1956	UF (uncataloged)	5	44.5–56
Bequia Is., Grenadines, B.W.I	Apr. 6–10, 1952	ANSP Acct. No. 165	1	49
Jamaica	Mar. 1–11, 1884	USNM 132225, *Albatross*	1	59.5
Palisadoes, Kingston, Jamaica	June 15, 1957	UF (uncataloged)	1	116
Kingston Harbor, Jamaica	June 25, 1957	do	2	148–156
Great Salt Pond, Jamaica	do	do	3	131–172

Caranx hippos (Linnaeus)

(Figures 81–85)

Scomber hippos Linnaeus, 1766, p. 494 (Charleston, S. C., vicinity).

Scomber carangus Bloch, 1787, pl. CCCXL (East and West Indies).

Caranx erythrurus Lacépède, 1802, p. 58 (key).

Caranx erithrurus Lacépède, 1802, p. 68 (South Carolina).

Caranx daubentonii Lacépède, 1802, p. 58 and 71 (Martinique).

Caranx carangua Lacépède, 1802, p. 59 and 74 (Martinique).

Tricopterus carangus, Rafinesque, 1810, p. 41.

Caranx carangus, Cuvier, *in* Cuvier and Valenciennes, 1833, p. 91 (Brasil; Cayenne; Porto-Rico; Havana; Martinique; Goree).

Caranx xanthopygus Cuvier, *in* Cuvier and Valenciennes, 1833, p. 109 (Isle de France).

Caranx ekala Cuvier, *in* Cuvier and Valenciennes, 1833, p. 117 (Malabar and Bombay).

Caranx antillarum Bennett, 1840, p. 282 (West Indies).

Caranx defensor DeKay, 1842, p. 120, pl. XXIV, fig. 72 (New York).

Caranx chrysos (*non* Mitchill), Baird, 1855, p. 336 (*fide* Bean, 1888, p. 139; Great Egg Harbor Bay, N. J., and Greenport, Long Island, N. Y.).

Carangus esculentus Girard, 1859, p. 23, pl. XI, figs. 1 to 3 (Brazos Santiago and mouth of Rio Grande, Texas).

Carangus hippos, Gill, 1862, p. 36.

Carangus chrysos (*non* Mitchill), Gill, 1863, p. 434 (eastern coast of United States).

Carangus carangus, Poey, 1866, p. 14 (Cuba) [Fowler (1936: 692) cites an earlier use of this name by "Griffith, 1834, The Class Pisces, *in* Cuvier Animal Kingdom, X p. 325."].

Carangus hyppos, Poey, 1868, p. 365 (Cuba).

Paratractus hippos, Abbott, 1868, p. 813.

Caranx caninus Günther, 1869, p. 432 (Pacific coast of Panama).

Carangus hippus, Jordan and Gilbert, 1879, p. 376 (Beaufort, N. C.).

Caranx hippus, Jordan and Gilbert, 1882a, p. 269 (Lake Borgne, La.).

Caranx hippos, Jordan and Gilbert, 1882b, p. 970 (key).

Caranx hippos hippos, Nichols, 1920c, p. 45 (Atlantic coast of United States; Gulf of California).

Caranx hippos tropicus Nichols, 1920c, p. 45 (Para, Brazil; ? Congo River, Africa).

Caranx hippos caninus, Nichols, 1937a, p. 58 (Gulf of California; Galapagos).

Nomenclature

Caranx hippos (Linnaeus) may be regarded as a circumtropical species until comparative studies of adequate samples of forms variously attributed to and inadequately separated from this species have been made with respect to worldwide distribution. Subspecific designations are as yet incomplete and uncertain and may be disregarded.

Many incomplete comparisons and opinions have been published in reference to this species. It is apparently a composite of the following nominal populations: *C. hippos hippos* of the Western Atlantic (excluding Brazil); *C. h. tropicus* Nichols of Brazil, the Eastern Atlantic, and the Mediterranean; *C. h. caninus* Günther of the Eastern Pacific; and *C. carangus* (Bloch) of the Western Pacific and the Indian Ocean. Varying expressions on these relationships are given by Gilbert and Starks (1904: 77), Fowler (1919a: 254), Nichols (1920c: 45; 1936: 119; 1937a: 58; and 1939: 7), Meek and Hildebrand (1925: 351), Weber and de Beaufort (1931: 246 and 258), Walford (1937: 72), Hildebrand (1939: 38), and Tortonese (1955: 194).

The relation of *Caranx hippos* to *C. ignobilis* (Forskål) and *C. sansun* (Forskål) of the Indo-Pacific is poorly known.

Material

Measurements and counts were taken on a series of 94 specimens from 15.3 to 830 mm. standard length, and meristic values were recorded for an additional 39 specimens within this size range. The 178 specimens identified are listed in table 23.

The smallest specimen of *hippos* previously reported (Nichols 1939: 7) from the Western Atlantic—13 mm. standard length, from *Atlantis* station 1952, Feb. 15, 1934, BOC 3418—is no longer available. An 18.7-mm. specimen, which evidently was not examined by Nichols, seems

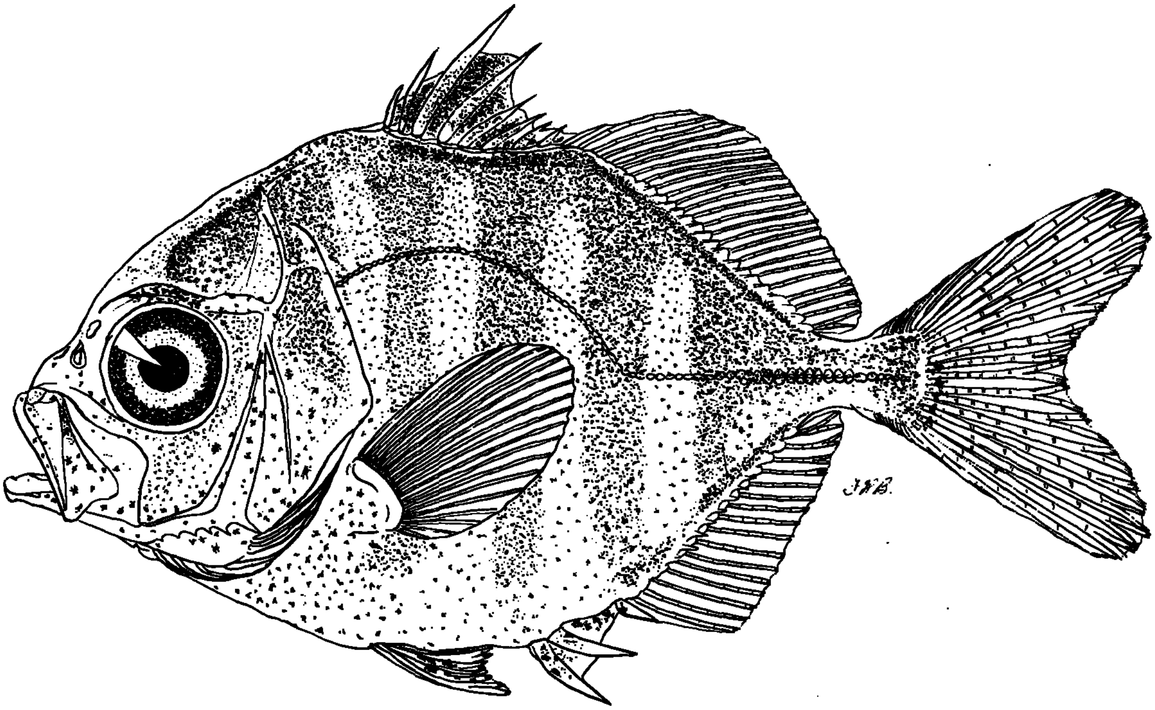

FIGURE 81.—*Caranx hippos* juvenile, 15.3 mm. standard length (UF 3815).

to be the only one in the Bingham Oceanographic Collection bearing the above BOC number, *Atlantis* station number, and date.

A 12.7-mm. specimen from the stomach of a *Sphyraena barracuda* (Walbaum) taken in the Berry Islands, Bahamas, by the *Gill*, is tentatively identified as *hippos*. The specimen was only slightly digested, but some of the characters that would associate it with the 15.3-mm. *hippos* had been destroyed. It is included only on the graphs of figures 8, 88, and 94.

Three specimens of *latus* from Bermuda, MCZ 28979 and 32076, apparently reported by Barbour (1905: 119) as *hippos*, are discussed under *C. latus* in Material, page 491. This disposed of one of the two records I have found of *hippos* from

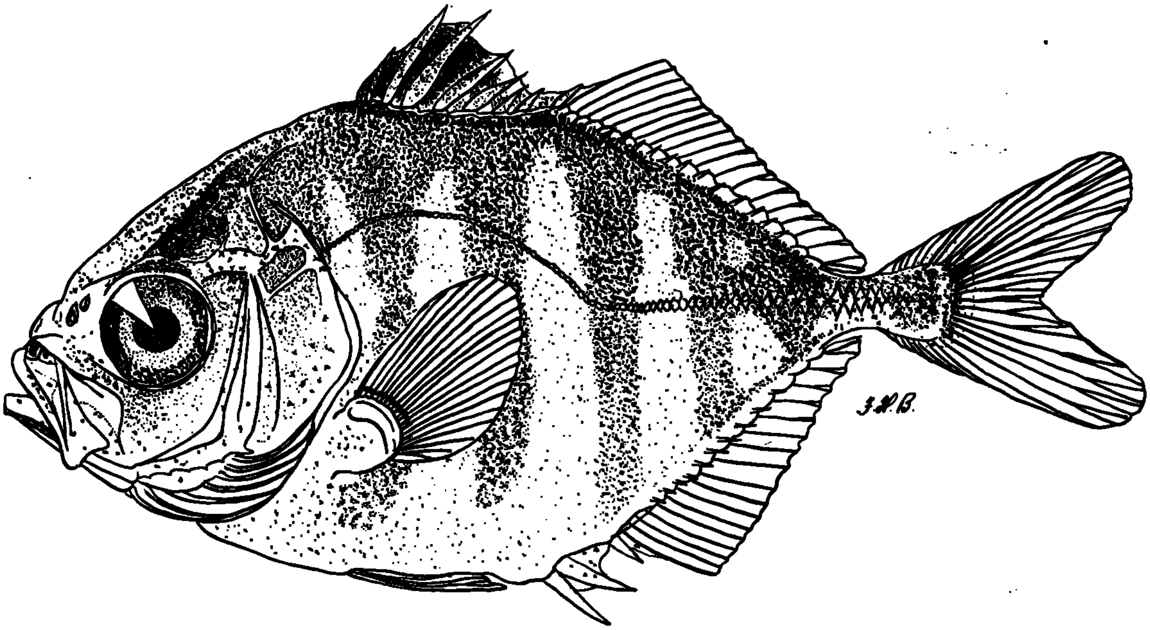

FIGURE 82.—*Caranx hippos* juvenile, 20.4 mm. standard length (UF 3803).

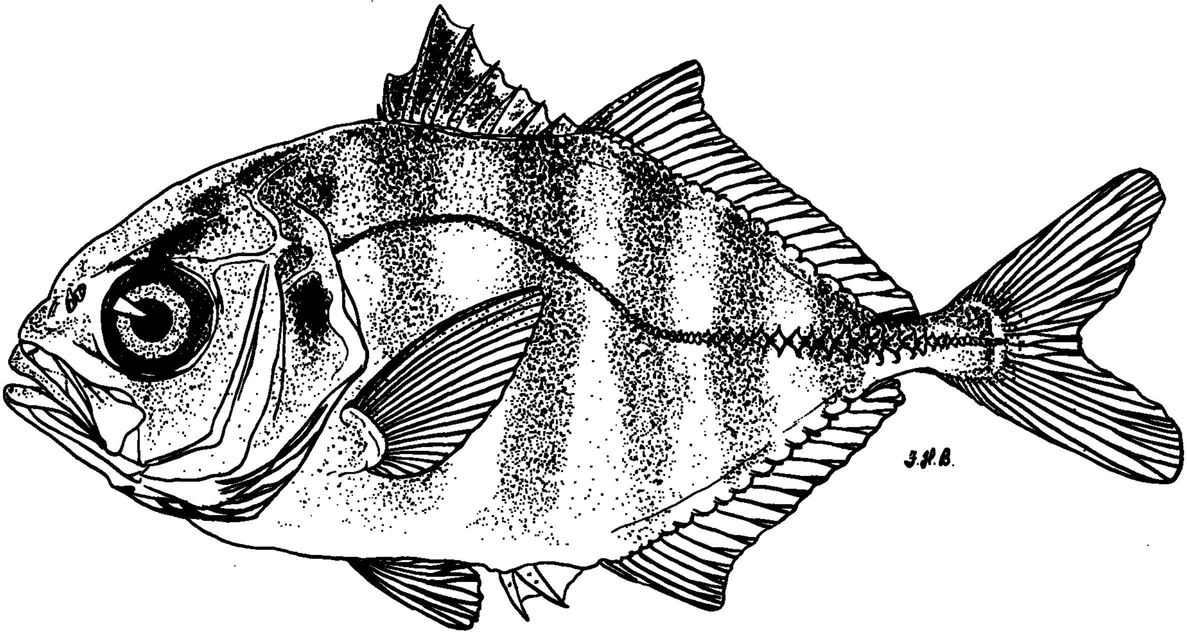

FIGURE 83.—*Caranx hippos* juvenile, 32.6 mm. standard length (SAFI, Sapelo Marsh, Ga.).

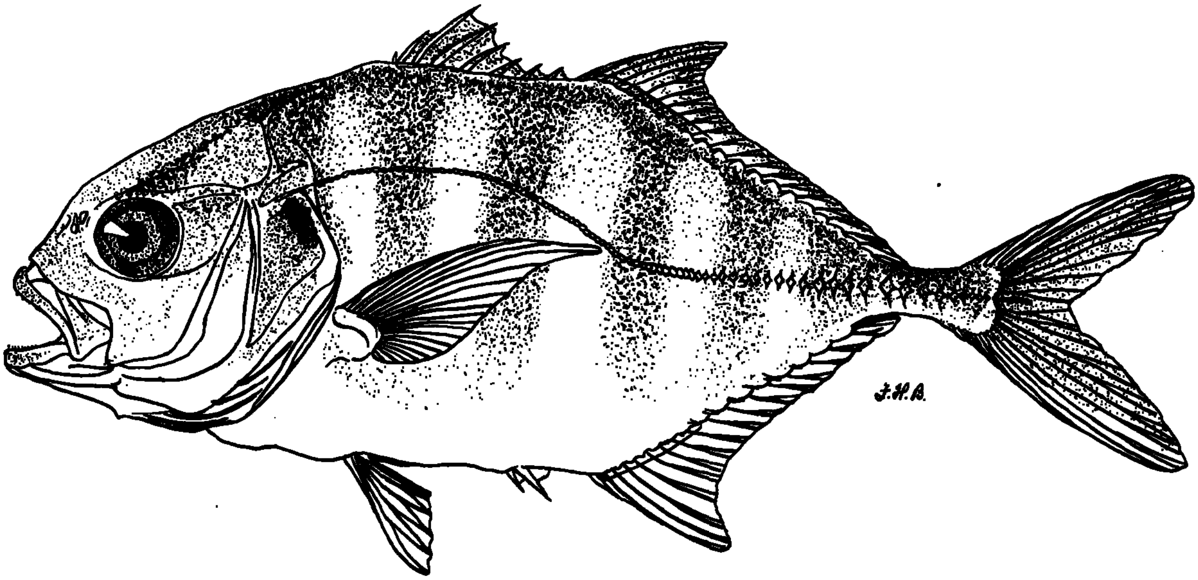

FIGURE 84.—*Caranx hippos* juvenile, 80.5 mm. standard length (SAFI, Sapelo Marsh, Ga.).

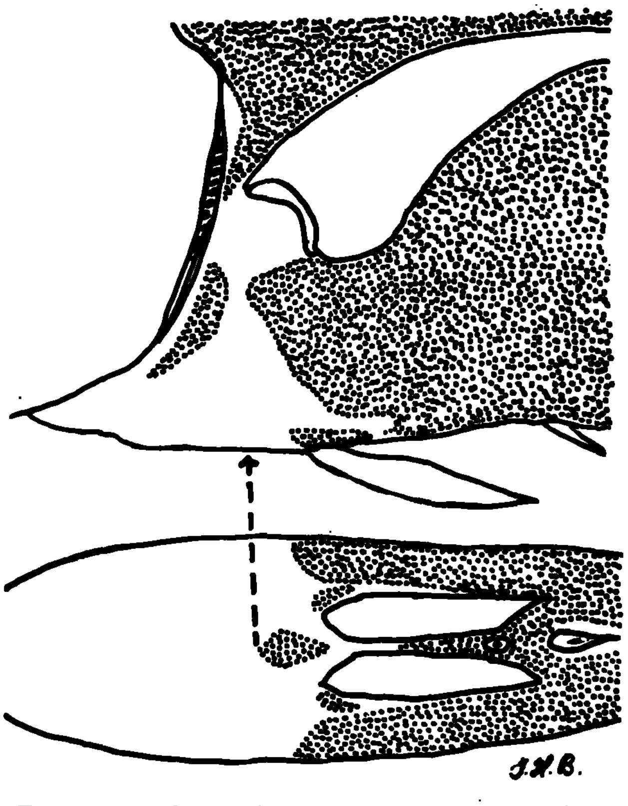

FIGURE 85.—*Caranx hippos:* Lateral view (above) and ventral view (below) of chest region of the 80.5-mm. standard length specimen of figure 84, showing scaled areas (stippled).

Bermuda. The other record, by Günther (1880: 9) of the synonymous *C. carangus* (Bloch), is doubtful, since only the name is listed, and during that era Günther's references to *carangus* and *hippos* were usually meant by him to apply to a *Caranx* with a fully scaled chest, as *latus* or *sexfasciatus*.

Morphological values of the one specimen of *lugubris* available for study are included and distinguished on the graphs with *hippos*.

Characters

Scales on chest.—The chest is unscaled at all sizes except for a small patch of scales which forms at about 25 mm. standard length and is centered in front of the pelvic fins (fig. 85). Four other patches of scales are present in the general area of the chest (at 80.5 mm.; larger sizes not examined): along each cleithrum and laterally along the insertion of each pelvic fin (fig. 85). All other Western Atlantic species of *Caranx* have completely scaled chests.

Dorsal spines.—VIII and I. The third spine is the longest at all sizes. An interspinous membrane connects the first and second dorsal fins (eighth and ninth spines) to about 80 mm. standard length (figs. 81 to 83). The membrane connecting the seventh and eighth spines disappears at about 120 mm. On 770-mm., 795-mm., and 830-mm. specimens, only the first six spines are connected, and the seventh and eighth spines are completely covered by an overgrowth of skin. Ginsburg (1952: 94) described a similar spine condition for a specimen of about 585 mm. (converted).

The regression of length of the third dorsal spine on standard length is shown in figure 86 and table 20. A line fitted to this regression for specimens from 15.3 to 110 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.11-mm. increase in spine length per 1.0-mm. increase in standard length). The position of the coordinates of the "*latus* and/or *hippos*" specimens may indicate that a faster spine growth rate prevails for specimens below approximately 15 mm. The position of the coordinates of the four largest specimens of *hippos* in figure 86 below the extension of the calculated regression line and of the coordinates of specimens up to 795 mm. (fig. 90) suggests that a decrease in spine growth rate occurs between approximately 250 mm. and 300 mm

TABLE 20.—Caranx hippos: *Statistics describing regressions of body parts on standard length*

$\bar{x}$=mean of independent variable x
$\bar{y}$=mean of dependent variable y
N=number of specimens
b=rate of increase of y
a=y-intercept of regression line
$Sy \cdot x$=standard deviation from regression (standard error of estimate)

Independent variable x	Dependent variable y	Size range of specimens (mm.)	$\bar{x}$	$\bar{y}$	N	b	a	$Sy \cdot x$
Standard length	Dorsal-fin spine length (3d)	15.3–110	41.62	5.54	60	0.108	1.052	0.601
Do	Dorsal soft-ray length (1st)	15.3–164	58.77	9.41	67	.189	2.098	2.159
Do	Pectoral length	15.3–43.7	28.92	6.61	43	.265	−1.045	.441
Do	do	43.7–283	125.78	40.85	33	.386	−7.647	2.131
Do	Body depth	15.3–164	56.79	23.99	77	.370	2.996	.934
Do	Head length	15.3–164	57.26	18.60	76	.302	1.305	.811
Do	Eye diameter	15.3–51.0	30.23	3.72	51	.093	.917	.224
Do	do	51.0–162	108.65	9.46	24	.063	2.603	.500
Do	Snout length	15.3–164	57.26	4.70	76	.084	−.091	.445

Anal spines.—II and I. The first spine averages longer than the second from 15.3 to 20.4 mm. standard length; above 23 mm. the second spine is the longer. An interspinous membrane connects the second and third spines to about 25 mm. (figs. 81 and 82).

Dorsal soft-rays.—19 to 21 (table 21). Nichols and Roemhild (1946, fig. 1) indicated 2 specimens out of 42 with only 18 dorsal soft-rays; the other 40 were within my range. The posterior rays are branched at 15.3 mm. standard length (fig. 81). The extension of the anterior 5 rays to produce the fin lobe has begun by 25 mm. and is advanced by 80.5 mm. (figs. 83 and 84). The second ray averages the greatest length to about 27 mm.; above 27 mm., the first ray is longest. The third spine averages a greater length than the longest soft-ray to about 34 mm.; above 34 mm., the ray is longer (fig. 86).

The regression of length of the first dorsal soft-ray on standard length is shown in figure 86 and table 20. A line fitted to this regression for specimens from 15.3 to 164 mm. standard length indicates that a proportional rate of increase is maintained for the two variates from about 25 to 164 mm. (0.19-mm. increase in soft-ray length per 1.0-mm. increase in standard length). The alinement of the coordinates of specimens of *hippos* smaller than 20 mm. and of the "*latus* and/or *hippos*" specimens suggests that a slower soft-ray growth rate prevails below approximately 25 mm. The position of the coordinates of larger specimens (fig. 90) suggests that soft-ray growth may continue at the same proportional rate up to 830 mm.

TABLE 21.—Caranx hippos: *Correlation of the numbers of dorsal and anal soft-rays of 132 specimens*

[The upper number in each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

DORSAL SOFT-RAYS

ANAL SOFT-RAYS	19	20	21
16	19 (14.4)	62 (47.0)	2 (1.5)
17	3 (2.3)	39 (29.5)	7 (5.3)

Anal soft-rays.—16 or 17 (table 21). Ginsburg (1952: 93) and Nichols and Roemhild (1946, fig. 1) gave a range of 15 to 17. The figure of

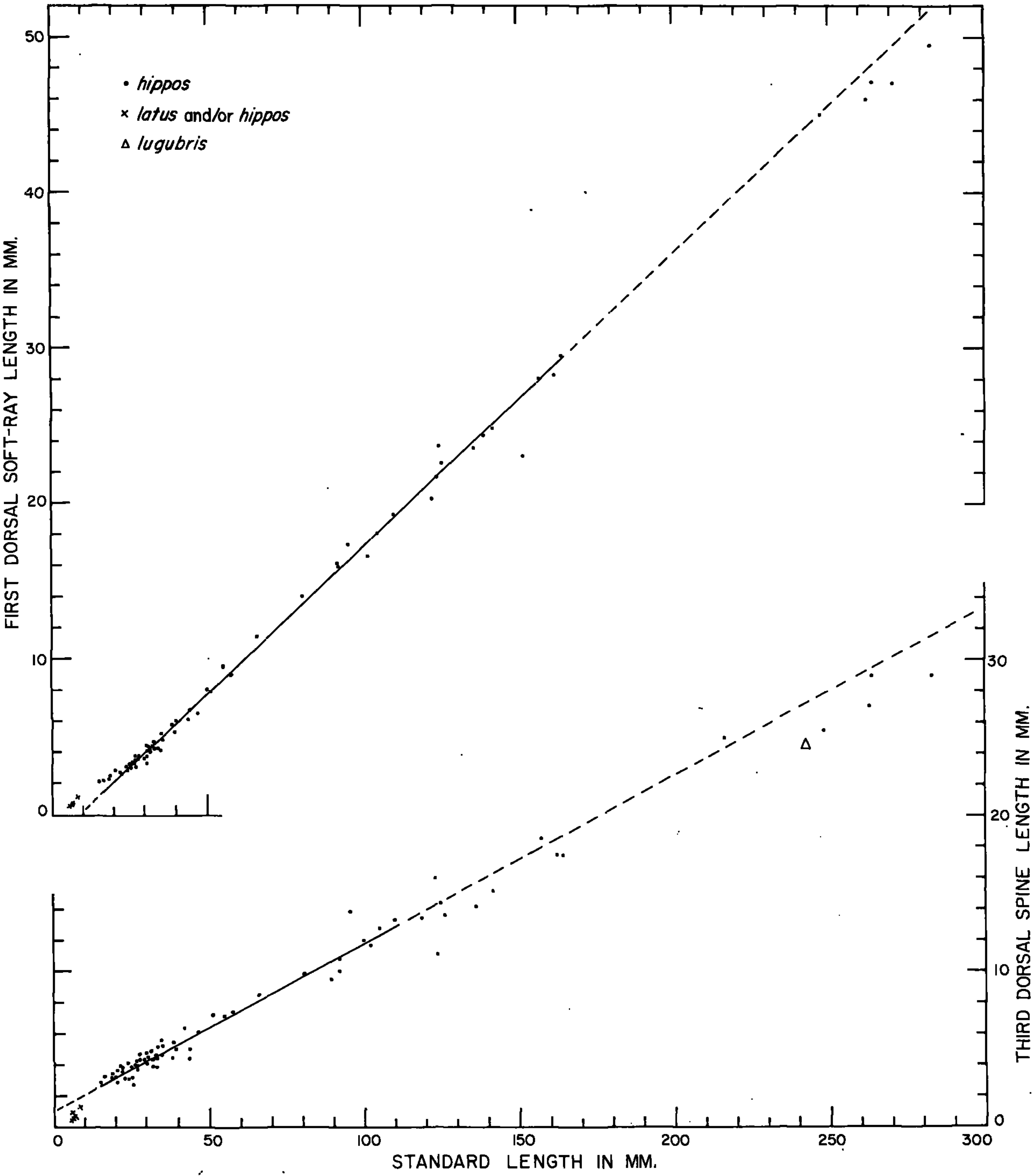

FIGURE 86.—*Caranx hippos, C. lugubris,* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of length of first dorsal soft-ray and of third dorsal spine to standard length.

dorsal and anal soft-ray relationships given by Nichols and Roemhild sustains the same modal value that my specimens exhibited (table 22). Branching and lobation occur as in the second dorsal fin. The first and second rays are longest and nearly equal to about 32 mm. standard length; above 32 mm., the first ray is longest. The longest dorsal ray averages longer than the first anal ray. The second anal spine is two-thirds as long as the longest anal soft-ray at 15.3 mm., one-half as long at 60 mm., about one-fourth as long at 164 mm., less than one-fifth as long at 432 mm., and about one-ninth as long at 830 mm.

Interneural and interhemal spines.—The posterior lateral projections of these spines are well developed and extend above the body surface along the bases of the dorsal and anal soft-rays at 15.3 mm. (fig. 81). They are also developed on the damaged 12.7-mm. specimen. At 164 mm. they are still externally visible, principally along the posterior bases of the fins, but are not projecting in a 248-mm. specimen.

Caudal.—9+8 principal rays; about 9 or 8+8 secondary rays. Branching of the principal rays has occurred by 15.3 mm. (fig. 81).

Pectoral.—I–19 or 20. The full complement of rays has formed by 20.4 mm. standard length. The distal end of the fin is rounded from 15.3 mm. to about 27 mm., after which it becomes pointed and falcation begins (figs. 81 to 83). Falcation is pronounced by 80.5 mm. (fig. 84).

The regression of pectoral length on standard length is shown in figure 87 and table 20. Two lines were fitted to this regression: for specimens from 15.3 to 43.7 mm. and from 43.7 to 283 mm. standard length. An extension of the lower line intersects the upper line at approximately 54 mm. indicating an inflection occurs at about 54 mm. and that a faster pectoral growth rate prevails above that size. The proportional rates of increase for the two variates are 0.27-mm. (below 54 mm.) and 0.39-mm. (above 54 mm.) increase in pectoral length per 1.0-mm. increase in standard length. Comparison of the upper regression line with specimens of *hippos* up to 830 mm. (fig. 91) suggests that a decrease in the pectoral growth rate occurs at some size around 300 mm.

Pelvic.—I–5. The soft-rays are branched and segmented at 15.3 mm. standard length.

Body depth.—Depth at first anal spine averages less than depth at pelvic from 15.3 mm. to about 30 mm. standard length, is about equal from 30 to 90 mm., and is greater above 90 mm. The coordinates for body depth at pelvic on standard length for specimens smaller than 30 mm. are plotted in figure 8.

The regression of body depth at pelvic on standard length is shown in figure 88 and table 20. A line fitted to this regression for specimens from 15.3 to 164 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.37-mm. increase in body depth per 1.0-mm. increase in standard length). The alinement of the coordinates of the specimens in the "*latus* and/or *hippos*" series suggests that a faster body-depth growth rate occurs below about 10 or 12 mm. The position of the coordinates of the six largest specimens in figure 88 below the extension of the calculated regression line and of the coordinates of specimens up to 830 mm. (fig. 90) suggests that a decrease in body-depth growth rate occurs at some size around 164 mm.

Head.—The regression of head length on standard length is shown in figure 88 and table 20. A line fitted to this regression for specimens from 15.3 to 164 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.30-mm. increase in head length per 1.0-mm. increase in standard length). Comparison of the extension of the calculated regression line with coordinates of larger specimens (fig. 91) suggests that head growth may continue at the same proportional rate up to 830 mm.

Eye.—The regression of eye diameter on standard length is shown in figure 89 and table 20. Two lines were fitted to this regression: for specimens from 15.3 to 51.0 mm. standard length and from 51.0 to 162 mm. The lines intersect at approximately 55 mm., indicating that an inflection occurs at about that size and that a slower eye growth rate prevails above that size. The proportional rates of increase for the two variates are 0.09-mm. (below 55 mm.) and 0.06-mm. (above 55 mm.) increase in eye diameter per 1.0-mm. increase in standard length. The position of the coordinates of the "*latus* and/or *hippos*" specimens suggests that a faster eye growth rate may prevail below approximately 15 mm. The position of the coordinates of the four largest specimens in figure 89 below the extension of the calculated regression line and of the coordinates of specimens up to 830 mm. (fig. 90) suggests that a decrease in eye growth rate occurs between approximately 200 mm. and 250 mm.

Snout.—The regression of snout length on standard length is shown in figure 89 and table 20. A line fitted to this regression for specimens from 15.3 to 164 mm. standard length shows a proportional rate of increase for the two variates within this size range (0.08-mm. increase in snout length per 1.0-mm. increase in standard length). Comparison of the extension of this calculated regression line with larger specimens (fig. 91) suggests that the snout growth may continue at the same proportional rate up to 830 mm.

Gill rakers.—Lower limb, 16 to 19; upper limb, 6 to 9; total, 22 to 27 (table 22). Of the 105 specimens examined that were more than 20 mm. standard length, all but 2 (25 mm. and 33.5 mm.) had one or more shorter or rudimentary gill

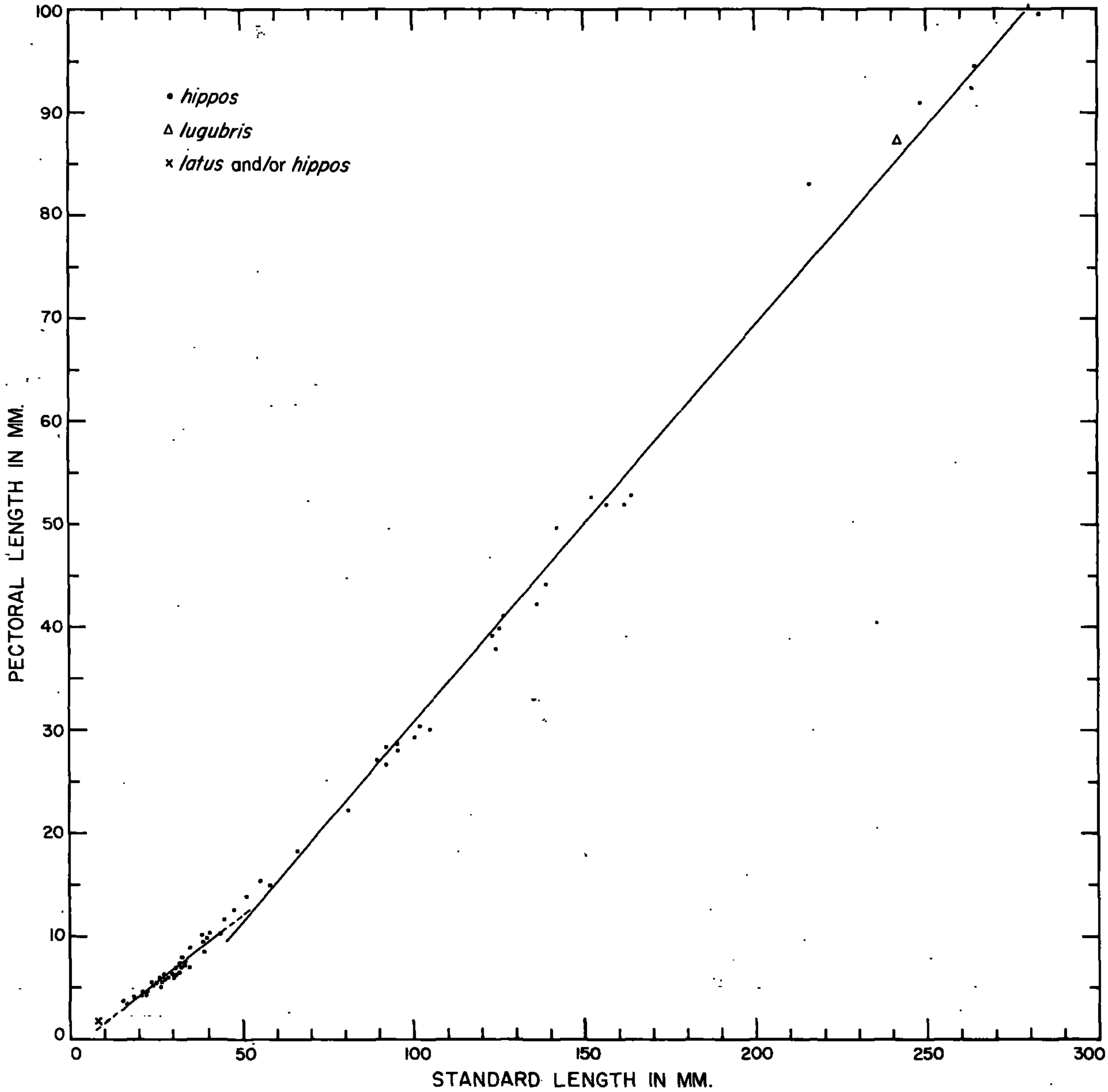

FIGURE 87.—*Caranx hippos, C. lugubris,* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of pectoral length to standard length.

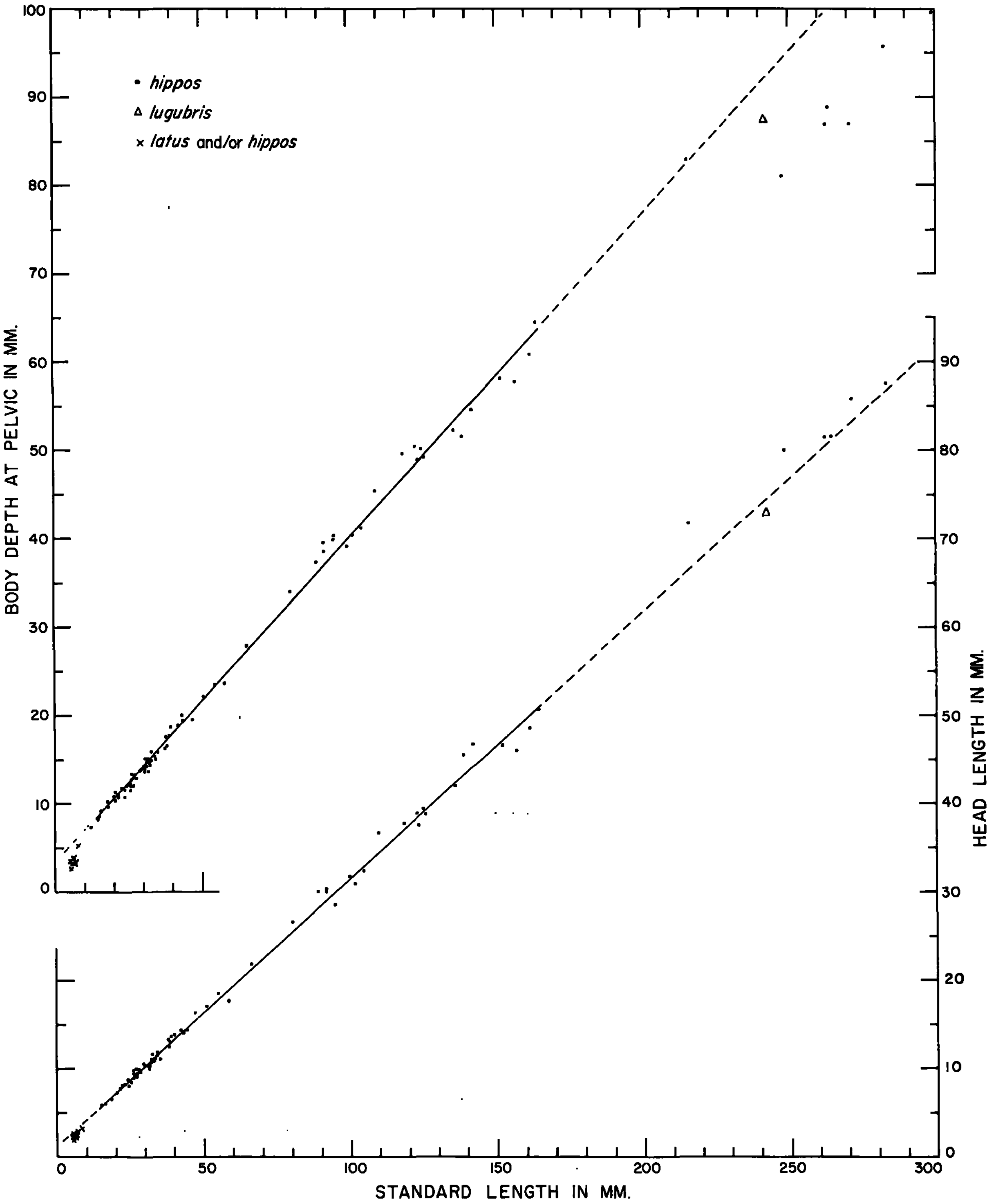

FIGURE 88.—*Caranx hippos*, *C. lugubris*, and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of body depth at pelvic and of head length to standard length.

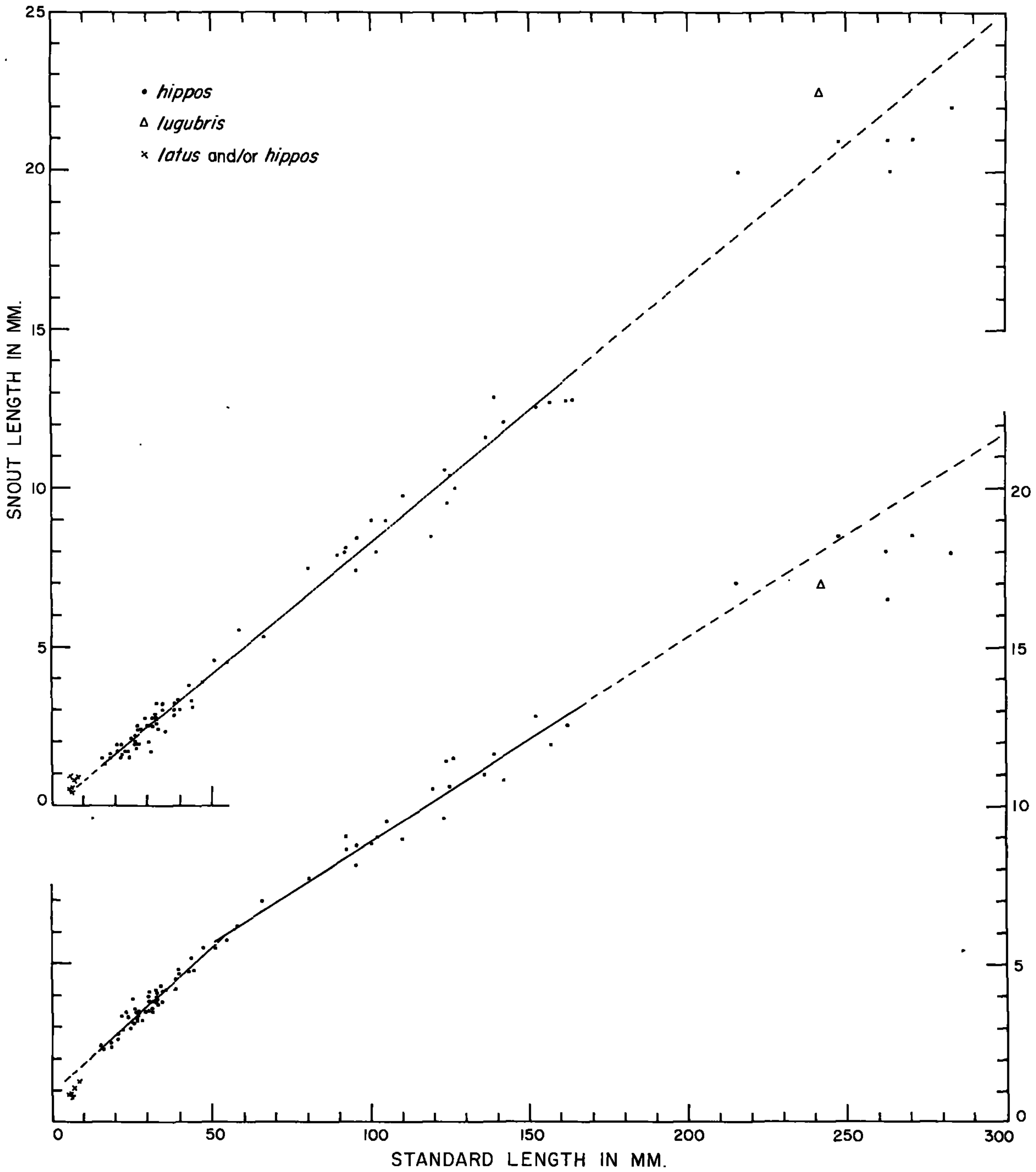

Figure 89.—*Caranx hippos, C. lugubris,* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of snout length and of eye diameter to standard length.

rakers at the origin of both limbs. A 152-mm. specimen had 6 rudimentary gill rakers (total of 9) on the upper limb. All others had from 1 to 4 rudiments on the lower limb and from 1 to 5 on the upper limb. Within the size ranges specified, the following modal numbers of rudimentary gill rakers were obtained: 20–50 mm., 1 lower, 2 upper; 50–164 mm., 2 lower, 3 to 4 upper; 248–432 mm., 3 lower, 4 upper; 795 mm., 4 lower, 4 upper; and 830 mm., 4 lower, 5 upper. Ginsburg (1952: 93) reported the inner 3 to 5 gill rakers on the upper limb to be rather abruptly shorter or tuberclelike, and 2 or 3 tubercles present on the lower limb. This illustrates that the number of rudimentary gill rakers at the origins of both limbs increases with an increase in body length.

Nichols (1937a: 59) used the number of lower-limb gill rakers exclusive of rudiments to separate a small number of specimens of *C. h. hippos* of the Atlantic and *C. h. caninus* of the Pacific for sizes over 100 mm. In view of the association of the number of rudimentary gill rakers and body size, this separation may be incomplete. Meek and Hildebrand (1925: 351) found Pacific specimens of the species to average a slightly larger number of gill rakers than Atlantic specimens, but they also omitted rudimentary gill rakers from the counts.

TABLE 22.—Caranx hippos: *Correlation of the numbers of lower-limb to upper-limb gill rakers of 105 specimens*

[The upper number in each block is the count obtained for that combination, and the number in parentheses below is the approximate percentage of that count in the total sample]

	LOWER-LIMB GILL RAKERS			
UPPER-LIMB GILL RAKERS	16	17	18	19
6	13 (12.4)	19 (18.1)	1 (1.0)	
7	13 (12.4)	45 (42.9)	9 (8.5)	1 (1.0)
8	1 (1.0)	1 (1.0)	1 (1.0)	
9			1 (1.0)	

Scutes.—Range of the mean number of scutes in fish measuring approximately 100 to 430 mm. standard length: about 26 to 35 (fig. 92). Ginsburg (1952: 93) gave a range of 24 to 39 scutes

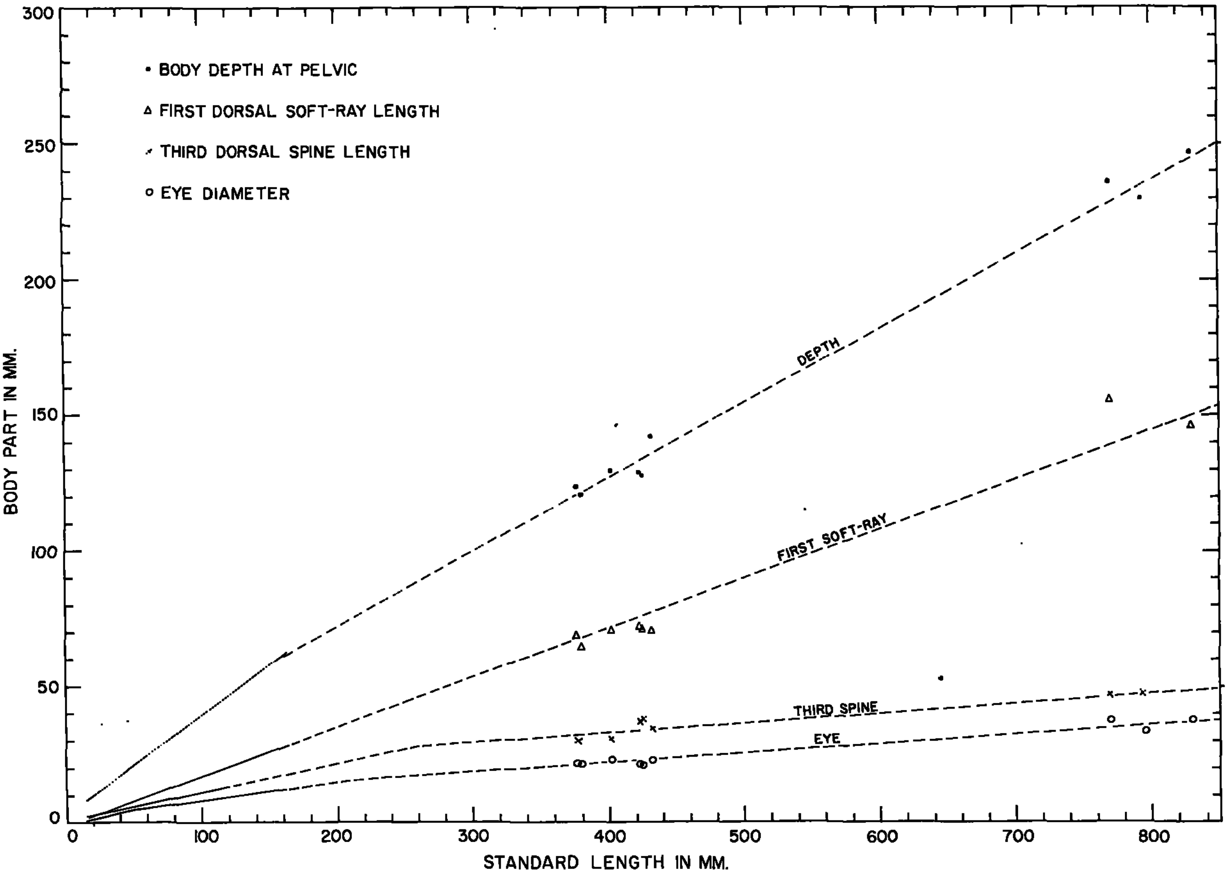

FIGURE 90.—*Caranx hippos:* Relation of body depth at pelvic, of length of first dorsal soft-ray, of length of third dorsal spine, and of eye diameter to standard length, showing calculated regression lines (solid lines) for specimens smaller than 300 mm. standard length and coordinates of and estimated regression lines (dashed lines) fitted to specimens from 377 to 830 mm. standard length.

for specimens of about 57 to 600 mm. (converted) from the Atlantic, Gulf, and Caribbean. Schultz (1949: 124), listing *hippos* from Venezuela, gave an upper limit of 40 scutes. These values obviate the character used to separate proposed Atlantic and Pacific subspecies given by Nichols (1937a: 59), who gave a range for specimens over 100 mm. standard length of 27 to 33 scutes for *C. h. hippos* and 33 to 40 for *C. h. caninus*. Some of the scutes have completed their individual development at 16.1 mm. and nearly all by 100 mm. The mean numbers of scutes of the three largest specimens examined, 770 mm., 795 mm., and 830 mm., were 30, 23.5, and 24.5, respectively. The two lowest scute counts were obtained on the two largest specimens—this is probably caused by the terminal scutes losing their posterior spines with growth and consequently being omitted from the count.

Lateral line.—Range of mean lateral-line ratio from approximately 55 to 430 mm. standard length: about 1.15 to 1.55 (fig. 93). The mean lateral-line ratio–standard length relation has appreciable variation, but the ratio tends to increase up to about 60 mm. and to become constant or to decrease slightly above this size. Nichols (1937a: 58) gave ratios of 1.1 to 1.2 for specimens 109 to 145 mm., and he (1937c: 1) gave ratios of 1.1 to 1.3 for specimens 23 to 65 mm. His values are accommodated by the perimeters of figure 93 but average lower than those I obtained. The mean lateral-line ratios of the three largest specimens examined, 770 mm., 795 mm., and 830 mm., were 0.97, 1.47, and 1.15, respectively. The value for the 770-mm. specimen was the lowest that was obtained.

Preopercular spines.—Preopercular spines were present on specimens from 12.7 to 22.1 mm. standard length, but absent on specimens of 21.0

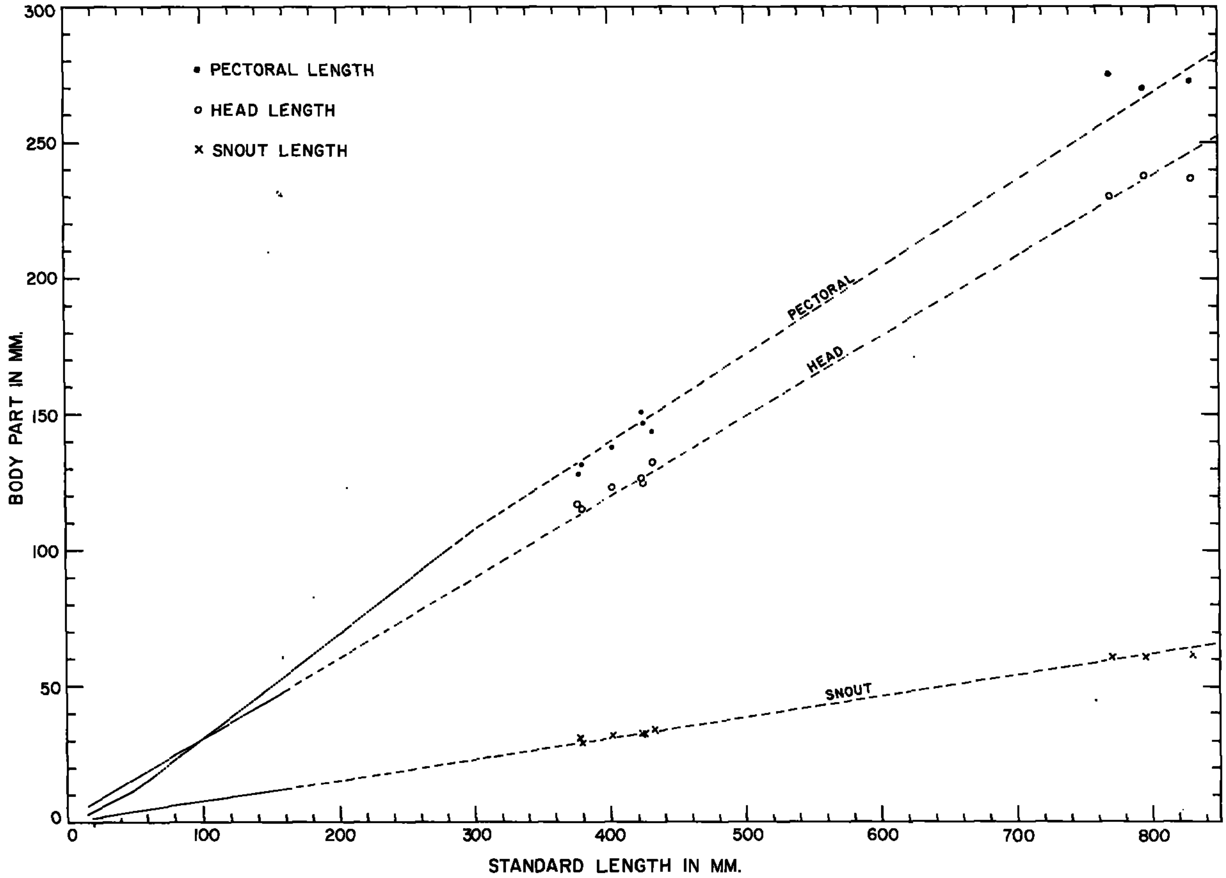

FIGURE 91.—*Caranx hippos:* Relation of pectoral length, of head length, and of snout length to standard length, showing calculated regression lines (solid lines) for specimens smaller than 300 mm. standard length and coordinates of and estimated regression lines (dashed lines) fitted to specimens from 377 to 830 mm. standard length.

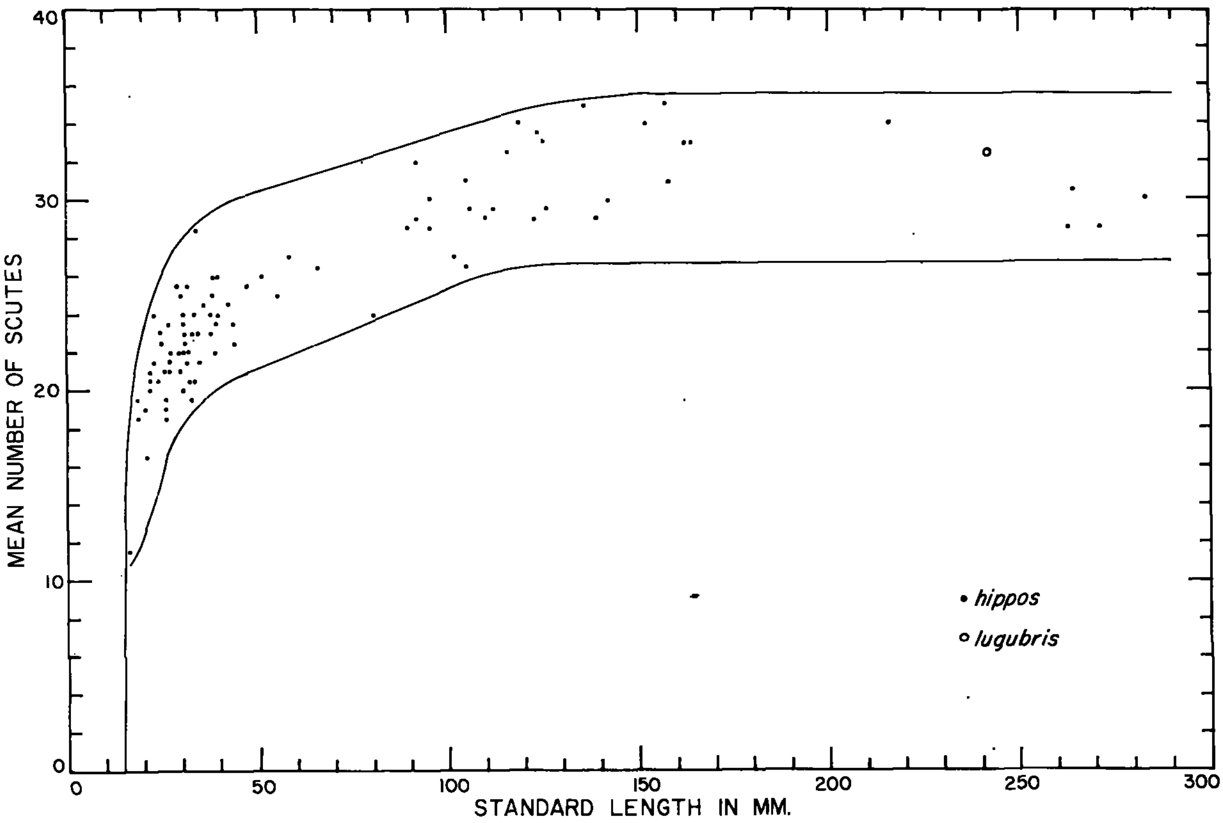

FIGURE 92.—*Caranx hippos* and *C. lugubris*: Relation of the mean number of scutes to standard length.

mm. and 22.0 mm. and at 22.5 mm. and above. The lengths of the preopercular-angle spine associate with the probable trend of decrease in spine length of the "*latus* and/or *hippos*" group (fig. 94). Preopercular upper-limb spines were absent in all specimens. Preopercular lower-limb spines, missing on the damaged 12.7-mm. specimen, numbered 3 at 20.4 mm.; 4 at 18.6 mm., 21.8 mm., and 22.1 mm.; 5 at 18.7 mm. and 20.8 mm.; and 6 at 15.3 mm. and 16.3 mm. (table 1).

Pigmentation.—Three of the juvenile complement of five (rarely four or six) body bars are present at 15.3 mm.; the fourth and fifth bars are an undivided pigment mass at this size. The covering of the brain case above the eye and the upper portion of the operculum possess pigment accumulations. A pigmented area of the body at the upper edge of the operculum has probably been termed an additional body bar by some authors. The first dorsal is densely pigmented, the pigment extending to the eighth spine. Pigment spots are present on the anal spines and their interspinous membranes and on the pelvic fins. The other fins are unpigmented (fig. 81).

Five body bars are present on a 16.3-mm. specimen. With rare exceptions, probably due to fading after preservation, the bars are present on specimens up to 164 mm.; and specimens 248 mm. and above lack bars. The bars are slightly wider than the interspaces. They extend nearly to the base of the anal fin to about 60 mm., and begin to shorten toward the straight lateral line above this size (figs. 81 to 84). An area of pigmentation develops on the top of the peduncle at about 30 mm. (fig. 83) and is very dark on specimens of more than 100 mm.

The pigment area over the eye elongates posterodorsally to form the nuchal band between 20 mm. and 30 mm. A pigmented area below the eye suggests a bending and continuation of the nuchal band through the eye (figs. 82 and 83). Massing of pigment on the operculum between 20 mm. and 30 mm. forms the opercular spot (figs. 83 and 84).

Pigmentation on the first dorsal fin decreases

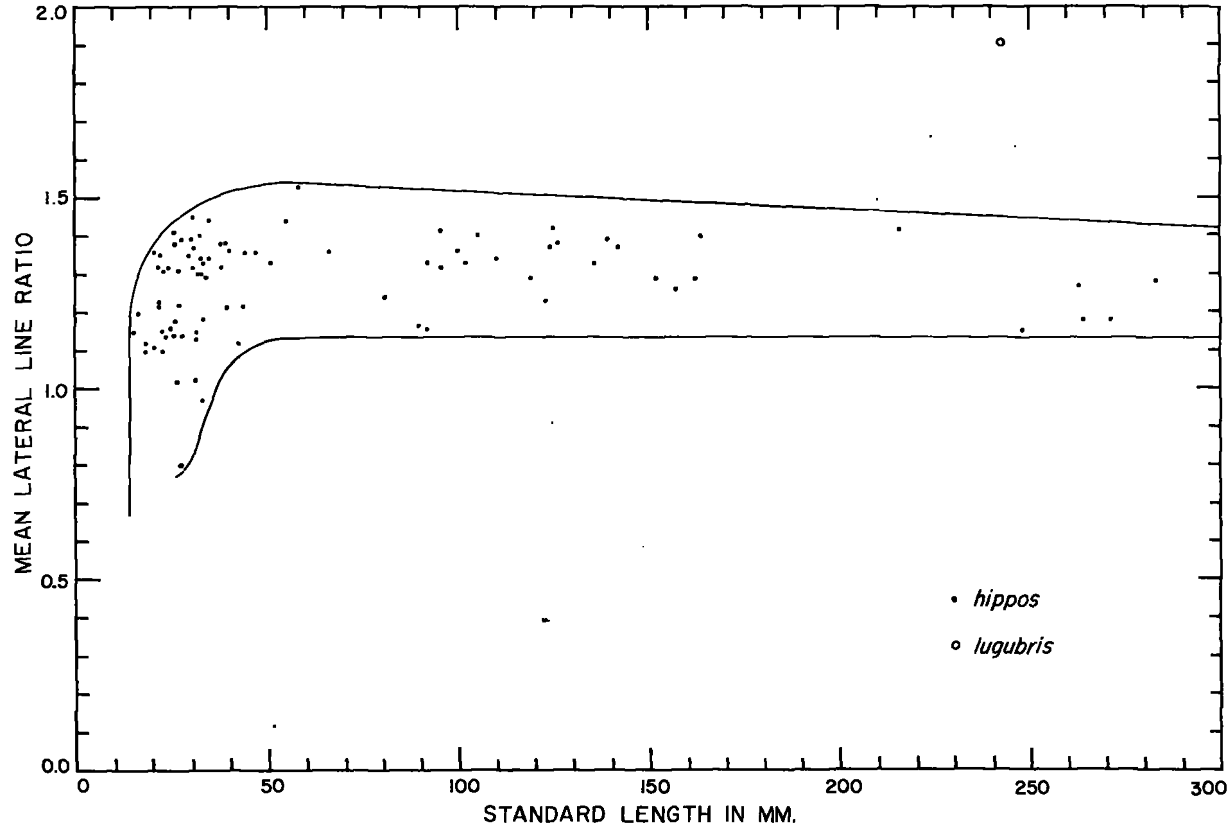

FIGURE 93.—*Caranx hippos* and *C. lugubris:* Relation of the mean lateral-line ratio to standard length.

above 30 mm. Pigment appears on the second dorsal fin at about 30 mm. (fig. 83) and migrates to the edge of the fin along the ninth spine and the tips of the soft-rays by about 40 to 50 mm. (fig. 84). The anal soft-rays and their connecting membranes are pigmented, and the pigment spots on the anal spines and their membranes disappear above 35 mm. The pelvic is unpigmented above 20 mm. The pectoral spot develops midway along the lower rays of the fin at about 120 mm. and 140 mm. Pigmentation of the caudal rays develops at about 30 mm. (fig. 83).

Distribution off Southeastern Atlantic Coast of the United States

Specimens have been reported from the following specific localities within this area: Gulf Stream off Bimini, Bahamas, by Nichols (1937b: 237); Biscayne Bay, Fla., by McCormick, *in* Smith (1896: 175); Eden, Stuart, and Lake Worth on Indian River, Fla., by Evermann and Bean (1898: 236); Indian River, Fla., by Goode (1882: 34); New Smyrna, Fla., by Lönnberg (1894: 122); mouth of St. Johns River, Fla., by Goode (*circa* 1897: 112); James Island Creek, Sullivans Island, Porcher's Bluff, Seabrook's Beach, Edisto Island, Morris Island, Magnolia Beach, and Magnolia Bluff, S. C., by Fowler (1945: 190, ChM specimens); Pamlico Sound, N. C., by Higgins and Pearson (1927: 42); and Beaufort, N. C., by Yarrow (1877: 208), Bean (1881: 90), Linton (1905: 365), Smith (1907: 205), and Nichols (1938b: 1).

Figure 95 shows the location of specimens taken on the *Gill* cruises (dip-netted off Cape Hatteras, N. C., and from the stomach of a *Sphyraena barracuda* above Great Harbor Key, Berry Islands, Bahamas, and from the stomach of a *Thunnus atlanticus* (Lesson) from northwest of the Berry Islands), specimens taken by the *Combat* off southern Florida, USNM specimens examined (Cape Lookout, N. C., and St. Andrews Sound, Ga.), ChM specimens examined (at and below Charleston, S. C., the same specimens reported by Fowler 1945: 190), and specimens in the SAFI collection (Jekyll Island, Jekyll Causeway Marsh, Doboy Sound, St. Simons Island, Sapelo Marsh, and off

Brunswick, Ga., and Mayport, Fla.) (tables 2 and 23). Of the records of capture of *hippos* shown on the chart, that at Mayport, Fla., is composed of fish 248 to 432 mm. standard length which may have been adult; and the others were juveniles.

In the waters of the Atlantic Ocean and the Gulf of Mexico off the coast of the United States, I believe that *hippos* has an offshore larval existence that may be associated with offshore currents; it may migrate inshore during the early juvenile stage; and it probably selectively inhabits inshore waters during the late juvenile stage. The following evidence supports this theory:

1. Some or all of the "*latus* and/or *hippos*" specimens taken offshore (fig. 95) may be *hippos*.
2. An 18.7-mm. specimen and the 12.7-mm. early juvenile reported by Nichols (1939: 7), BOC 3418, were taken from 11°15′ N., 81°50′ W., about 98 miles offshore east of Port Limon, Costa Rica.
3. Three of the smaller juveniles examined (15.3 mm., 16.3 mm., and 20.4 mm.) were taken at two stations, about 39 miles and 51 miles offshore, east of Tampico, Mexico.
4. Four small juveniles (18 to 21 mm.) were taken about 52 miles offshore southeast of South Pass, La. (Mississippi Delta).
5. The foregoing records of early juveniles are all from offshore waters (the small specimen from the stomach of a barracuda taken in the Bahamas is not conclusive in speculation on habitat).
6. No records of larvae or of juveniles smaller than 21 mm. standard length exist for inshore waters, and no such small specimens other than those previously listed were available from the many collections canvassed. Absence of larval *hippos* and of juveniles smaller than 21 mm. in the many inshore collections that have been made would seem to preclude their presence in inshore waters. Collections of the *Gill* were concentrated in waters off the southeastern Atlantic States from near the beaches to beyond the axis of the Gulf Stream and furnished only one record of *hippos*, an early juvenile taken inshore. SAFI collections have been maintained biweekly in the vicinity of Brunswick, Ga., at surf, marsh, and river stations, and collections here yielded only juvenile *hippos* 21 mm. and larger, although other

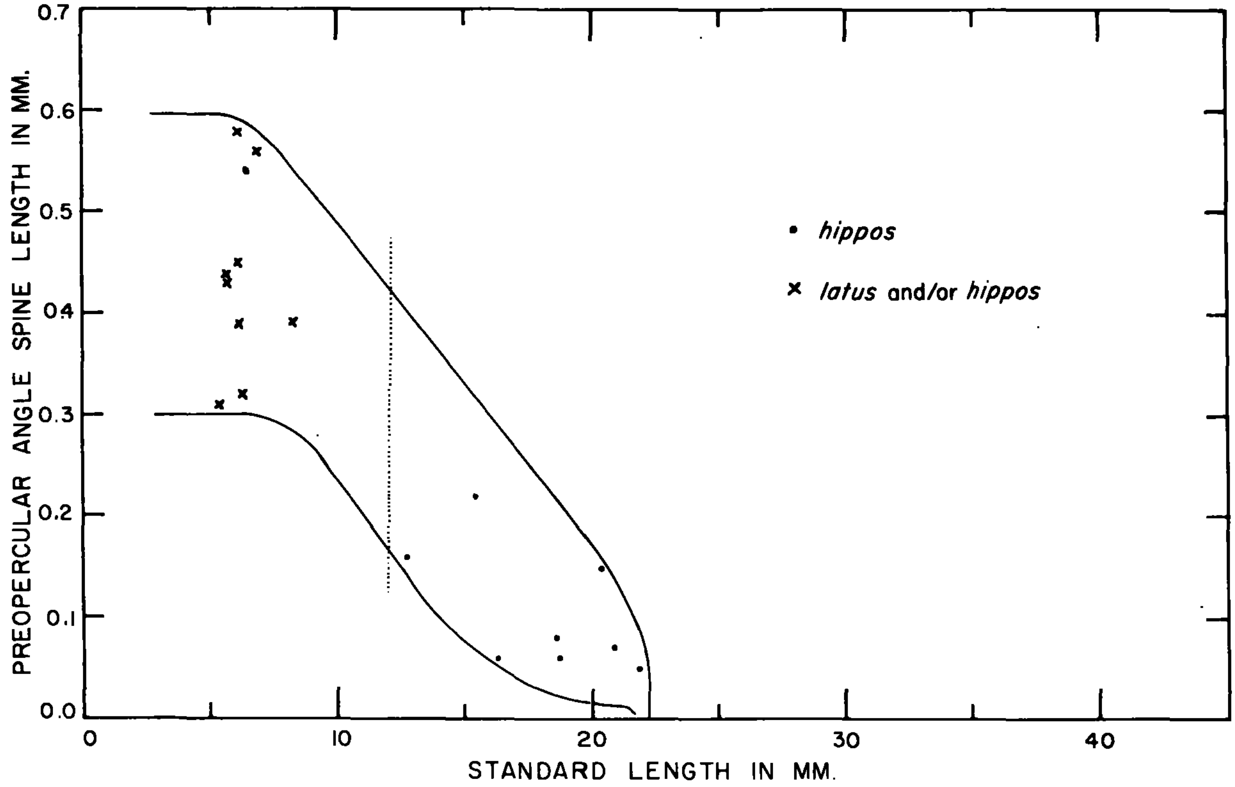

FIGURE 94.—*Caranx hippos* and *Caranx* sp. ("*latus* and/or *hippos*"): Relation of length of the preopercular-angle spine to standard length. Dotted line separates the two forms.

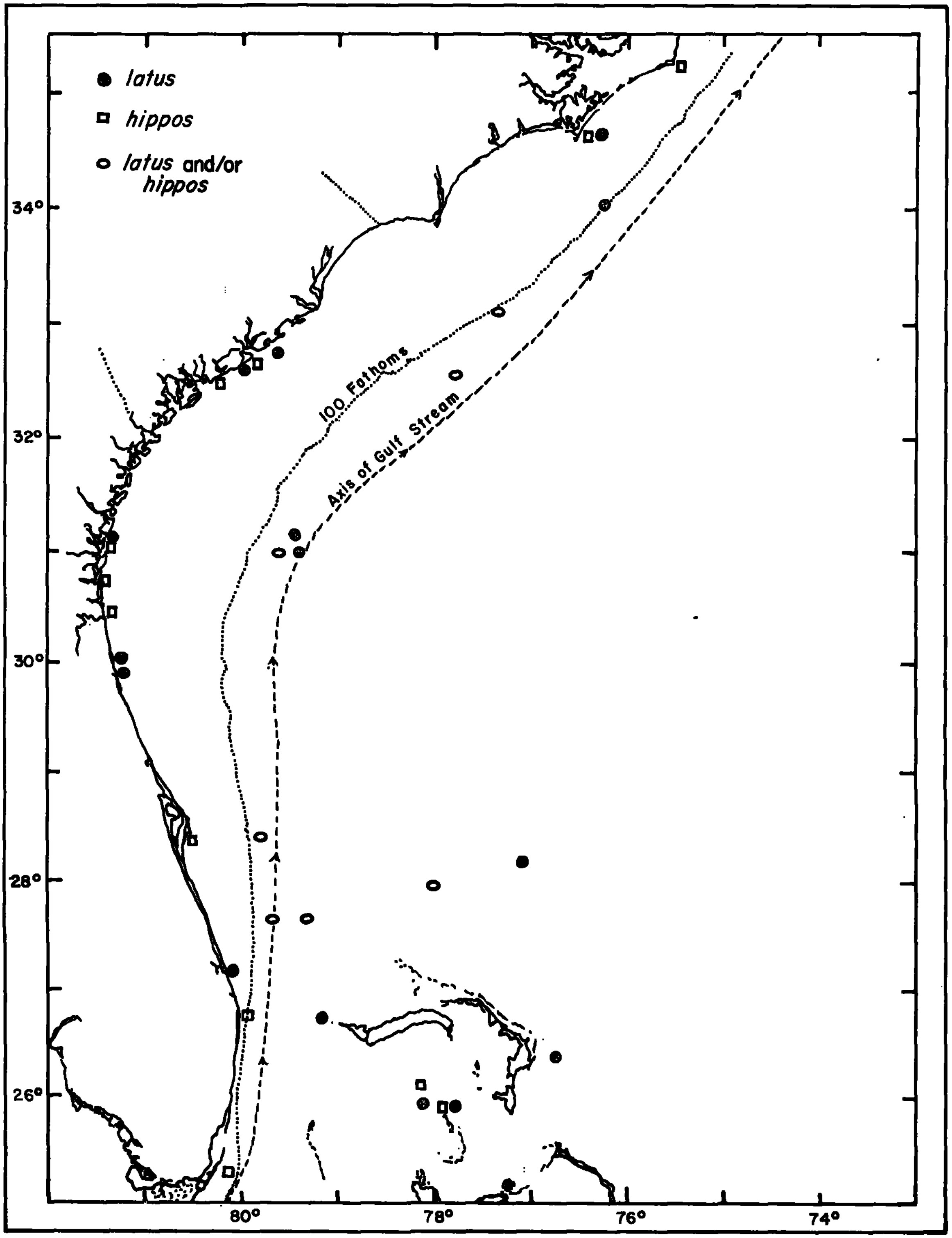

FIGURE 95.—*Caranx hippos, C. latus,* and *Caranx* sp. ("*latus* and/or *hippos*"): Locations of capture off the southeastern Atlantic coast of the United States.

small carangids (*Trachinotus* and *Oligoplites*) down to 10 mm. standard length were frequently seined.

7. Thirty-two early juveniles (24 to 39 mm.) were taken from about 52 to 66 miles offshore east to south-southeast of South Pass, La., in 1955 and 1956 at 10 collecting stations of the M/V *Oregon*. Ten of these were taken with four of the smaller specimens (18 to 21 mm.) previously described.

8. There are many records of capture of larger juvenile *hippos* from inshore waters along the Atlantic and Gulf coasts of the United States. A 21.0-mm. specimen from St. Simons Island, Ga., a 22.0-mm. specimen from Magnolia Beach, S. C., and a 22.5-mm. specimen from Plantation Key, Fla., are the smallest juveniles from inshore waters that I have examined. Smith (1898: 98) recorded young an inch long from Woods Hole, Mass., about July 1 (1 inch total length converts to about 21.5 mm. standard length; but, since Smith's measurements apparently were not critical, the young he reported may have been more than 21.5 mm.). Juvenile specimens about 39 to 41 mm. (converted) were reported by Vladykov (1935: 4) from Musquodoboit Harbor, Nova Scotia, in summer (the most northern record for the genus in the Western Atlantic).

9. The distribution records of juvenile and adult *hippos* in the Western Atlantic, Gulf of Mexico, and Caribbean point to a habitat association with continental waters or larger islands. While commonly reported from the eastern coasts of North, Central, and South America and from the Greater Antilles, the only records from the Bahamas are from the analysis of the stomach contents of two large fish and a report by Nichols (1921a: 22) from Turk Island.

There is a possible association between an expected movement of early juveniles to inshore waters and the loss or absorption of the preopercular spines. Specimens as large as 20.8 mm., 21.8 mm., and 22.1 mm. standard length taken from offshore waters still possessed small preopercular spines, while the smallest specimens

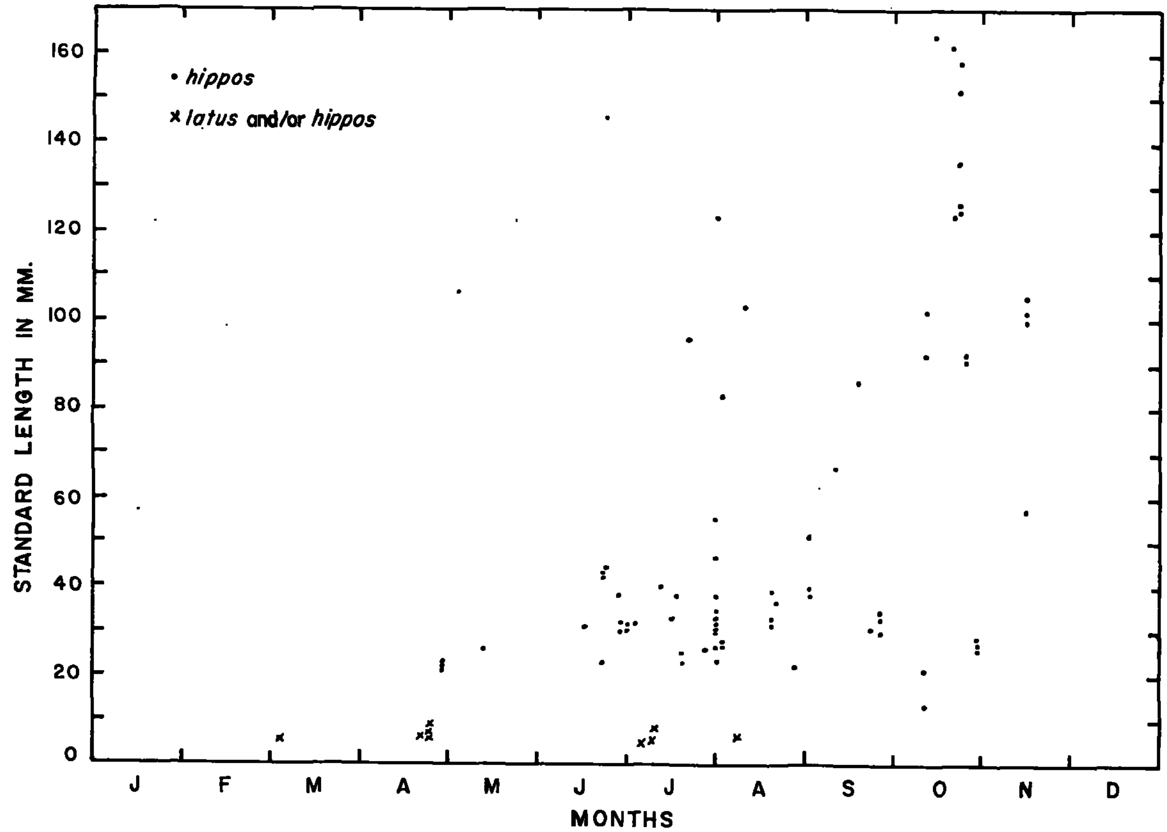

FIGURE 96.—*Caranx hippos* and *Caranx* sp. ("*latus* and/or *hippos*"): Size distribution, by months, of specimens taken off the southeastern Atlantic coast of the United States.

TABLE 23.—Caranx hippos: *Location and date of capture, number and size range of 178 specimens examined*

[See pp. 417 and 419 for explanation of abbreviations used; measurements in standard length]

Location	Date captured	Collection	Number of specimens	Size (mm.)
ATLANTIC OCEAN:				
Plantation Key, Fla	June 12, 1956	UF 7089	2	22.4–23.5
25°16′ N., 80°07′ W	July 26, 1957	SAFI, *Combat* 457	1	26
26°47′ N., 79°53′ W	July 28, 1957	SAFI, *Combat* 459	1	38
Indian River, Fla	July 3, 1954	UF 4709	1	32.1
Cape Canaveral Anchorage, Fla	Apr. 29, 1957	SAFI, *Combat*	3	22.3–22.9
Mayport, Fla	Apr. 25, 1956	SAFI	11	248–432
Cumberland River Sound, Ga	Oct. 23, 1930	USNM 119238	2	91.5–92
St. Andrews Sound, Ga	Nov. 19, 1956	SAFI	1	105
Off Jekyll Island, Ga	Sept. 5, 1956	do	2	118–141
Commercial trawling area, Brunswick, Ga	Oct. 4–5, 1956	do	1	158
Do	Oct. *13–14*, 1955	do	*1*	164
Do	Oct. 20, 1955	do	2	124–162
Do	Nov. 13, 1956	do	2	106–116
Jekyll Island Causeway, Ga	Sept. 26, 1957	do	2	33.5–34
Do	Oct. 25, 1957	do	2	25.5–26
St. Simons Sound, Ga	July 20, 1957	do	1	95.5
Do	Oct. 16, 1957	do	1	170
Off Parsons Creek, Brunswick, Ga	Nov. 7, 1956	do	1	112
Off St. Simons Island, Ga	Oct. 3, 1956	do	1	158
Do	Oct. 23, 1955	do	5	125–157
St. Simons Island, Ga	June 22, 1955	do	1	23.1
Do	July 10, 1956	do	1	25.9
Do	Aug. 19, 1955	do	2	30.6–38.7
Do	Aug. 27, 1957	do	1	22.0
Do	Sept. 7, 1956	do	1	30
Do	Sept. 26, 1957	do	1	30
Do	Sept. 29, 1956	do	2	34–37.5
Do	Oct. 11, 1956	do	1	29.5
Do	Oct. 11, 1957	do	2	92–102
Do	Oct. 25, 1957	do	1	29
Do	do	do	3	21.0–32
Do	Oct. 29, 1954	do	3	25.9–28
Do	Nov. 16, 1955	do	4	58–105
Do	Nov. 20, 1956	do	1	33.5
Doboy Sound, Ga	Aug. 2, 1957	do	1	83
Do	Aug. 9, 1957	do	1	103
Sapelo Marsh, Ga	Aug. 19, 1955	do	1	32.6
Do	Sept. 19, 1955	do	1	80.5
South end of Edisto Island, S. C	Sept. 25, 1933	ChM 33.284.4	1	30.5
Seabrook's Beach, S. C	June 30, 1932	ChM 32.100.5	2	30–32.1
Morris Island, S. C	July 19, 1934	ChM 34.190.1	2	23.3–25
James Island Creek, S. C	June 16, 1936	ChM 38.180	1	30.9
Sullivans Island, S. C	Aug. 20, 1931	ChM 31.192	1	36.2
Porcher's Bluff, S. C	Sept. 2, 1931	ChM 31.196.11	3	39.4–50.5
Do	Sept. 10, 1931	ChM 31.208.2	1	66
Magnolia Beach, S. C	Aug. 1, 1934	ChM 34.239.5	11	23–123
Do	Oct. 1934	ChM 34.316.9	1	110
Isle of Palms, S. C	Sept. 8, 1950	ChM (no number)	1	27.6
Murrell's Inlet, S. C	July 13, 1943	USNM 132083	1	39.9
35°14′ N., 75°34′ W	May 11, 1953	SAFI, *Gill* 2, Cape Hatteras Bight	1	26.2
Fort Macon, Beaufort, N. C	Aug. 2, 1915	USNM 111778	2	26.7–27.5
Do	July 16, 1913	USNM 111781	1	32.7
Do	June 30, 1932	USNM 111782	3	24.6–31.4
North River at bridge, Beaufort, N. C	June 21, 1932	USNM 111783	3	42.5–44
Beaufort, N. C	July 18, 1913	USNM 111780	1	38.2
Do		USNM 86257	2	95.5–119
Below Yorktown, Va	Oct. 11–13, *1921*	USNM 144025	1	95.5
Woods Hole, Mass		USNM 20672	2	33.5–35.2
GULF OF MEXICO:				
22°30′ N., 96°57′ W	May 24, 1954	UF 3803, *Oregon* 1070	1	20.4
22°43′ N., 97°10′ W	do	UF 3815, *Oregon* 1072	2	15.3–16.3
Havana market, Cuba	Jan. 7, 1956	SAFI	1	216
Tortugas, Fla	June-Aug., 1926	USNM 164530	1	33
Do	June 30, 1932	USNM 164531	3	24.6–31.4
Off Cape Sable, Fla		USNM 39874	1	89.5
Bayport, Fla	Sept. 25, 1954	UF 3743	2	139–142
28°17′ N., 88°37′ W	Aug. 25, 1955	GFEGR, *Oregon* 1380	2	30–35
28°21′N., 88°42′ W	Dec. 5–6, 1956	SAFI, *Oregon* 1614	4	23.5–30.5
28°47′ N., 87°56′ W	July 23, 1956	UF 3928, *Oregon* 1589	2	26–28
28°47′ N., 87°57′ W	Aug. 15, 1955	GFEGR, *Oregon* 1367	2	28.5–33.5
28°47′ N., 87°58′ W	July 24, 1956	UF 3929, *Oregon* 1591	4	28–31.5
28°48′ N., 87°50′ W	Aug. 14, 1955	GFEGF, *Oregon* 1365	14	18–31.5
28°50′ N., 87°58′ W	July 26, 1956	UF 3927, *Oregon* 1593	6	24.5–34
28°50′ N., 87°50′ W	Aug. 13, 1955	GFI, *Oregon* 1303	1	24.5
28°55′ N., 87°30′ W	June 21, 1957	SAFI, *Oregon* 1835	3	30.5–31.5
28°55′ N., 87°50′ W	Aug. 10, 1955	GFEGR, *Oregon* 1356	1	24.5
28°55′ N., 87°57′ W	Aug. 21, 1955	GFEGR, *Oregon* 1372	2	27.8–38.7
29°01′ N., 87°48′ W	Aug. 22, 1955	GFEGR, *Oregon* 1374	2	29.6–34.2
Destin, Fla	Sept. 3, 1957	SAFI	3	770–830
East Beach, Galveston, Texas	May 24, 1956	GFI	1	26
Aransas County, Texas	June 7, 1954	UF 4259	2	24–27
Do	June 8, 1954	UF 4241	2	30.5–39.3
30°00′ N., 87°43′ W	June 19, 1957	SAFI, *Oregon* 1831	3	20.1–26.1
CARIBBEAN SEA:				
11°15′ N., 81°50′ W	Feb. 15, 1934	BOC 3418, *Atlantis* 1952	1	18.7

taken inshore, 21.0 mm., 22.0 mm., and 22.5 mm., did not have these spines. The angle produced by the preopercular-angle spine was present on the 21.0-mm. specimen, but the spine was completely covered by skin.

Records of juvenile and adult *hippos* from inshore waters along the Atlantic coast of the United States from April through November and the scarcity of such records from December through March indicate that the species either migrates to the south during the colder months or moves to warmer, offshore waters.

An affinity to brackish or even fresh water may account for an inshore migration of early juvenile *hippos*. The species has been recorded from Homosassa Springs, Fla., in water of very low salinity, by Carr, *in* Gunter (1942: 311) and by Herald and Strickland (1949: 109); and juveniles and adults were recorded from Texas by Gunter (1945: 57) in waters ranging in salinity from 4.8 to 36.4 parts per thousand.

Spawning

The spawning season that contributes young *hippos* to this area may be estimated, from the smallest specimens taken in May (26.2 mm.) and in October (12.7 mm.), to extend from early March to early September (fig. 96; tables 2 and 23).

Hildebrand (1939: 26) recorded specimens with "large or developing roe" from the Gatun Locks on the Atlantic side of the Panama Canal. These specimens were taken February 20 to 24. A sample from a group of more than 500 fish from the middle locks was composed of 11 males, about 540 to 690 mm. (converted), only 4 of which had undeveloped testes, and 8 females, about 524 to 768 mm. (converted). A sample from about 250 fish from the lowest chamber of the canal consisted of 4 males, about 528 to 650 mm. (converted), and 7 females, about 595 to 784 mm. (converted). This evidences that females may average a larger size than males. Beebe and Tee-Van (1928: 107) recorded a female of about 406 mm. (converted) from Haiti taken March 11 in which "the eggs were well-developed, and the ovary measured 110 by 60 mm." Erdman (1956: 320) noted *hippos* in spawning condition in May at Puerto Rico. Evermann and Bean (1898: 236), writing of the fishes of Indian River, Fla., said of *hippos*, "It probably spawns in salt-water lagoons and bays during the summer, as schools of young have been seen going out in the fall." Actually, the place of spawning is unknown. An offshore larval existence, as previously discussed, indicates an offshore spawning. If the larvae are associated with a northward movement in the Gulf Stream, many of the juveniles that have been taken on the Atlantic coast of the United States may have been spawned to the south of this area.

Caranx dentex (Bloch and Schneider)

(Figure 97)

? *Scomber adscensionis* Osbeck, 1771, p. 94 (Ascension Island).

Scomber cordila (*non* Linnaeus), Bonnaterre, 1788, p. 139, pl. LVIII, fig. 229 (America).

Scomber dentex Bloch and Schneider, 1801, p. 30 (Brazil).

Trachurus imperialis Rafinesque, 1810, p. 42 (Palermo).

Caranx luna Geoffroy Saint-Hilaire, 1809, pl. XXIII (Egypt).

Citula banksii Risso, 1826, p. 422, pl. 6, fig. 13 (Nice).

Caranx dentex, Cuvier, *in* Cuvier and Valenciennes, 1833, p. 87 (Rio-Janiero, Brasil).

Caranx solea Cuvier, *in* Cuvier and Valenciennes, 1833, p. 86 (Brasil).

Caranx analis Cuvier, *in* Cuvier and Valenciennes, 1833, p. 88 (Sainte-Helene).

Selenia luna, Bonaparte, 1846, p. 75.

Caranx guara (*nomen nudum*, based on the French vernacularism of Bonnaterre, 1788) Jordan and Evermann, 1896, p. 926 (tropical Atlantic; Mediterranean; coasts of Africa, Brazil, and Madeiras; South Pacific; doubtless in West Indies).

Caranx cheilio Snyder, 1904, p. 524, pl. 8, fig. 14 (Honolulu market).

Carangus cheilio, Jordan and Evermann, 1905, p. 196, pl. 33, fig. 1 (Honolulu market).

Uraspis cheilio, Jordan, 1925, p. 16 (Honolulu market).

Caranx ascensionis (Osbeck), Fowler, 1928, p. 145 (in part; Honolulu and ? Johnson material; excluding other records and synonymy; not pl. XII B).

Caranx adscensionis (Osbeck), Smith, 1949, p. 215 (Cape and Natal, South Africa; all tropical waters).

Nomenclature

The name that has most commonly been applied to this species for the past 50 years, *Caranx guara* (Bonnaterre), is invalid. Linnaeus (1758: 298; 1766: 493) described *Scomber cordyla,* which is currently recognized under the name of *Megalaspis cordyla* (Linnaeus), an Indo-Pacific species with dorsal and anal finlets. Bonnaterre (1788: 139) described *Scomber cordila,* associated it with the vernacular name of "Le Guare," and referred this to page 492 of Linnaeus' Systema Naturae (1766). This indicates that Bonnaterre's *cordila* is a trans-

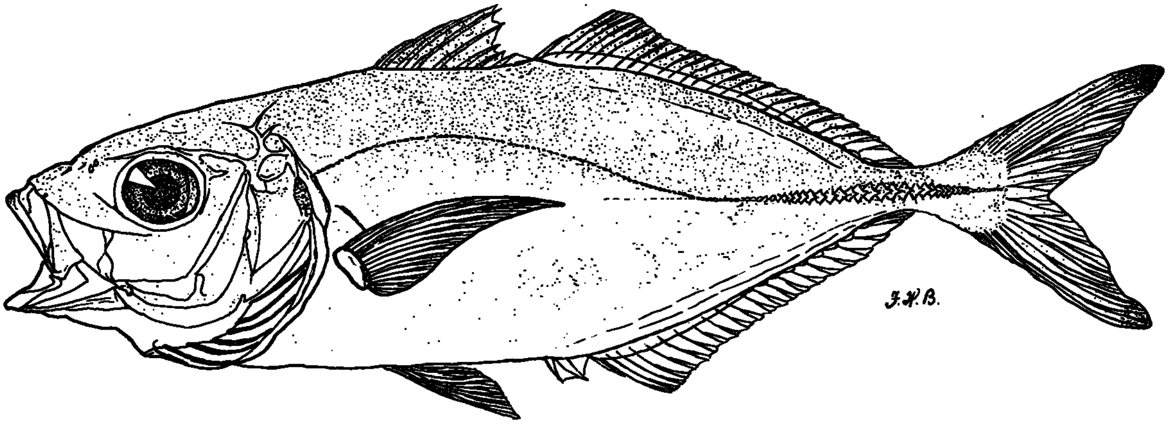

FIGURE 97.—*Caranx dentex* juvenile, 89.5 mm. standard length (AMNH 19994).

literation of Linnaeus' *cordyla*, although the specimen described by Bonnaterre may have been *C. dentex*. In synonymizing *C. dentex* (Bloch and Schneider) with Bonnaterre's description, Jordan and Evermann (1896: 926) lifted the vernacular name to apply to the species, calling it *Caranx guara* (Bonnaterre). This was pointed out by Dr. John C. Briggs, University of Florida, in a personal communication and by Padoa, *in* Padoa et al. (1956: 554).

Nichols (1951: 4) placed *Caranx cheilio* Snyder in the synonymy of *C. dentex* (under the name of *C. guara*), and specifically distinguished these from *C. georgianus* Cuvier (= *C. chilensis* Gay).

Recent authors have used *Caranx ascensionis* (Osbeck) as Fowler (1936: 699) or *C. adscensionis* (Osbeck) as Smith (1949: 215), to designate this species. Jordan and Evermann (1896: 926) included *Scomber adscensionis* Osbeck 1771 in questionable synonymy of *C. dentex*, under the name of *C. guara*, and stated that Osbeck's description might apply to *Selar crumenophthalmus* (Bloch) or *C. ruber*. I have not seen Osbeck's description, but according to Fowler (1936: 701) Osbeck gives the following characters: "Dorsal VIII–25; anal 25; pectoral 20; ventral 5; scutes 27, 49. Body narrow. Head obtuse. Mouth oblong, lower jaw longer. Teeth small. Pectoral bent. Ventral half of pectoral. Body grayish above, white below. Length 304 mm." This insufficient description cannot specifically designate any species of carangid. Instead, the identical number of dorsal and anal soft-rays, admittedly a possible miscount, discredits any possible identity with the genus *Caranx*. Published accounts and my observations indicate that *Caranx* species always have more dorsal soft-rays than anal soft-rays (from 2 to 5 more in Western North Atlantic species).

Material

Four specimens were examined (the smallest that could be located): 87 mm., 89.5 mm., 108 mm., and 132 mm., AMNH 19990, 19991, and 19994, from Bermuda. The following brief descriptions apply mainly to these specimens. Measurements are recorded on the graphs with *crysos*, the species they most closely resemble meristically.

Two specimens of *bartholomaei* from Boca Chica, Key West, Fla., ANSP 70973–74, at least one of which was identified as *dentex* (under the name of *guara*) by Fowler (1945: 292, fig. 307), and two specimens of *bartholomaei* from northwest of Cay Sal Bank, ANSP 72693, which Fowler (1950: 70, fig. 3) identified as *dentex* (under the name of *guara*), are discussed under *bartholomaei* (p. 472).

Three specimens reported as young *dentex* from New Orleans by Günther (1860: 441) are not this species, but are probably *ruber* and are discussed under that species (p. 458).

Characters

Dorsal spines.—VIII and I. The third spine is the longest. Lengths of the third spine are shown in figure 25. The first and second dorsal fins are not connected by an interspinous membrane.

Anal spines.—II and I. The second spine is longer than the first. The second and third spines are not connected by an interspinous membrane.

Dorsal soft-rays.—25 or 26 (fig. 1). Bean

(1906: 47) listed 27 rays; Tortonese (1952: 302) gave a range of 24 to 27. The first ray is the longest, except in the 89.5-mm. specimen, which has a distorted first ray. Lengths of the first soft-ray are shown in figure 25. The first ray is shorter than the third dorsal spine.

Anal soft-rays.—21 to 23 (fig. 1). Tortonese (1952: 302) gave a range of 20 to 22. The first and second rays are the longest and nearly equal, and are shorter than the first dorsal soft-ray.

Interneural and interhemal spines.—Posterior lateral projections of these spines are not extended above the body surface (as occurs in *latus* and *hippos*).

Caudal.—9+8 principal rays; about 9+10 secondary rays.

Pectoral.—I–19 or 20. Falcation is pronounced. Pectoral lengths are shown in figure 26.

Pelvic.—I–5.

Body depth.—The depth at pelvic and depth at first anal spine are similar at 87 mm. and 89.5 mm.; the latter is slightly greater at 108 mm. and 132 mm. Measurements of depth at pelvic are shown in figure 27.

Head.— Measurements of head length are shown in figure 27.

Eye.—Measurements of eye diameter are shown in figure 28.

Snout.—Measurements of snout length are shown in figure 28.

Gill rakers.—Lower limb, 26 to 28; upper limb, 11 to 13; total, 37 to 41 (fig. 2). Meek and Hildebrand (1925: 349) gave a count of 21 lower-limb gill rakers, exclusive of rudiments, for a specimen 515 mm. total length; Tortonese (1952: 302), also working with larger specimens and presumably excluding rudiments, gave a range of 21 to 25. The terminal gill raker at the origin of the lower limb of the 132-mm. specimen is the only one that is appreciably shorter or rudimentary. Judging from this specimen and the two accounts cited, the terminal gill rakers tend to become rudimentary with an increase in body size, and complete counts including rudiments might be expected to be higher than indicated by Meek and Hildebrand or by Tortonese.

Scutes.—Range of mean number of all specimens: 22 to 29 (fig. 29). Tortonese (1952: 302) gave a range of 23 to 30.

Lateral line.—Range of mean lateral-line ratio: 0.87 to 0.83 (fig. 30).

Preopercular spines.—None.

Pigmentation.—The four specimens are very faded. The only distinctive pigmentation is the very dark tip of the upper caudal lobe of the 89.5-mm. specimen (end of upper lobe missing from 87-mm. specimen). In addition, the two smaller specimens appear vaguely dark above the lateral line (fig. 97).

Beebe and Tee-Van (1933: 103), Bean (1906: 47), Meek and Hildebrand (1925: 349), and Jordan and Evermann (1896: 927) described a black opercular spot, but no records exist of body bars.

Distribution

C. dentex has not been reliably reported from the Atlantic and Gulf coasts of the United States nor from the eastern coast of Central America, the Bahamas, or the Lesser Antilles. Two records exist from the Greater Antilles, at Port-au-Prince, Haiti, by Fowler (1952b: 99) and from Puerto Rico by Erdman (1956: 327); from Bermuda by Günther (1880: 9), Bean (1906: 47), Beebe and Tee-Van (1933: 103), Nichols (1919: 98; and 1921b: 45), and Mowbray (1949: 13); from Brazil (Fowler 1941b: 154, see synonymy), the Azores and West Africa (Fowler 1936: 699, see synonymy), the Mediterranean by Tortonese (1952: 310), and from the Pacific and Indian Oceans by many authors. This is an offshore species, frequently associated with offshore islands.

Spawning

The time and place of spawning are unknown. The 87-mm. specimen is the smallest that I have been able to obtain. Schnakenbeck (1931: 18, figs. 13 to 16) questionably identified 5-mm. and 6-mm. total length specimens from the Mediterranean as this species, but they can not adequately be associated with *dentex*.

Caranx lugubris Poey

(Figure 98)

Scomber ascensionis (*non* Osbeck), Bloch and Schneider, 1801, p. 33 (Ascension Island).

Caranx ascensionis (*non* Osbeck), Cuvier, *in* Cuvier and Valenciennes, 1833, p. 102 (Ascension Island).

Caranx lugubris Poey, 1860, p. 222 (Cuba).

Caranx frontalis Poey, 1860, p. 222 (Cuba).

Carangus lugubris, Poey, 1866, p. 14.

Carangus ascensionis (*non* Osbeck), Streets, 1877, p. 88 (Fanning Islands).

Caranx ishikawai Wakiya, 1924, p. 193, pl. XXVI (Bonnin Islands; Formosa).

Caranx tenebrosus Jordan, Evermann, and Wakiya, *in* Jordan, Evermann, and Tanaka, 1927, p. 656 (Sulphur Bay, Clarion Island, Revillagigedo Islands).

Xurel lugubris, Jordan, Evermann, and Clark, 1930, p. 273 (tropical Atlantic; West Indies).

Xurel tenebrosus, Jordan, Evermann, and Clark, 1930, p. 273 (South Seas; Revillagigedos; Hawaii).

Caranx adscensionis (*non* Osbeck), Harry, 1953, p. 128 (Raroia, Tuamotu Archipelago).

Nomenclature

Caranx lugubris Poey has been recognized as an Atlantic and Pacific species since Jordan and Gilbert (1883: 201) compared specimens from both oceans. Interoceanic comparisons of specimens have also been made by Meek and Hildebrand (1925: 352) and Woods, *in* Schultz et al. (1953: 514). These three studies were made with small numbers of specimens, and all workers noted slight differences in Atlantic and Pacific forms. It is possible that comparisons of larger numbers of specimens will determine specific or subspecific differences, but at this time the Atlantic and Pacific forms should be considered merely as conspecific.

Material

Only one specimen was examined: USNM 167425, from Onotoa, Gilbert Islands, 242 mm. standard length. This is the smallest USNM specimen so identified and the smallest available from the many collections that were canvassed. Presumably it could be the same specimen collected and described by Randall (1955: 88), but his minimum length of three specimens taken does not quite coincide with mine, and some of his ranges differ from the counts I obtained on the one specimen. The measurements of this specimen are included and distinguished on the graphs with *hippos*.

Comparison of figure 98 with the photograph of a larger specimen (exact size not given, but between 343 and 545 mm. standard length) in Schultz et al. (1953, pl. 46, A) shows that the larger fish has a more-indented profile in front of the eye, shorter dorsal and anal fin lobes, and is narrower and more elongated from the origins of the soft-rayed fins to the caudal base. These are believed to be normal growth changes. An elongation of the posterior part of the body also occurs in comparable-sized specimens of *hippos*.

The specimen identified as *lugubris* from Tortugas, Fla., by Longley, *in* Longley and Hildebrand (1941: 78), was not this species. It probably was *Uraspis heidi* Fowler and is discussed under the account of that species (p. 526).

Characters

Dorsal spines.—VIII and I. The third spine is the longest, 24.5 mm. (fig. 86). The eighth and ninth spines are not connected.

Anal spines.—II and I. The second spine, 10.3 mm., is longer than the first and both are well separated from the third.

Dorsal soft-rays.—22. Meek and Hildebrand (1925: 352) and Woods, *in* Schultz et al. (1953: 514) gave a range of 21 or 22. Walford (1937: 76) gave a range of 21 to 23. The first ray is the longest, 75.7 mm. This measurement is too large to be placed on the graph of the first dorsal soft-

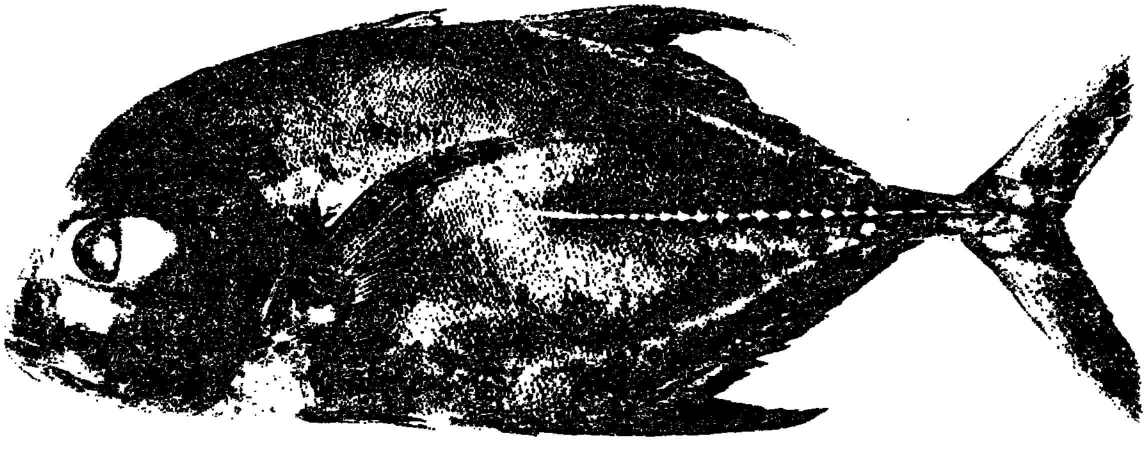

FIGURE 98.—*Caranx lugubris*, 242 mm. standard length (USNM 167425).

ray–standard length relation of *hippos*; it exceeds the first dorsal soft-ray length of a comparable 248-mm. *hippos* by 30 mm.

Anal soft-rays.—19. A range of 17 to 19 was given by Meek and Hildebrand (1925: 353). Woods, *in* Schultz et al. (1953: 514) gave a range of 17 to 20. Poey (1875: 76) gave the following combined counts for 5 specimens: D.21, A.18 (2); D.21, A.19(1); and D.22, A.18(2). The first ray is the longest, 61 mm.

Interneural and interhemal spines.—Posterior lateral projections of these spines do not extend above the body surface on the specimen examined.

Caudal.—9+8 principal rays; secondary rays not discernible without dissection.

Pectoral.—I–19. 87.5 mm. (fig. 87).

Pelvic.—I–5. 32.5 mm.

Body depth.—Depth at first anal spine (100 mm.) is greater than depth at pelvic (94 mm.) (fig. 88).

Head length.—73 mm. (fig. 88).

Eye diameter.—17 mm. (fig. 89).

Snout length.—22.5 mm. (fig. 89).

Gill rakers.—Upper limb, 6; lower limb, 20. One gill raker at the origin of the lower limb and two gill rakers on the upper limb are small or rudimentary. Meek and Hildebrand (1925: 352) gave a range on the lower limb of 17 or 18 exclusive of rudiments. Woods and Kanazawa (1951: 632) gave a count of 7+1+19 (7+20 by my combination). Woods, *in* Schultz et al. (1953: 514) gave a (combined) range of 7+20 or 21.

Scutes.—Right side, 32; left side, 33 (fig. 92). Meek and Hildebrand (1925: 352) gave a range of 26 to 30 for six specimens of 335 to 500 mm. total length. Woods and Kanazawa (1951: 632) recorded 27 for a specimen of 635 mm. standard length. Woods, *in* Schultz et al. (1953: 514) gave a range of 29 to 33 for specimens 343 to 535 mm. standard length.

Lateral line.—Mean lateral-line ratio: 1.91 (fig. 93). Woods, *in* Schultz et al. (1953: 514) gave a range for this ratio of 1.36 to 1.70.

Preopercular spines.—None.

Pigmentation.—Head, body, and fins almost uniformly brown with a black tint (fig. 98). Woods and Kanazawa (1951: 632) described the color in alcohol-preserved specimens as rich dark brown and the fresh color as grayish brown to blackish. Jordan and Evermann (1896: 925) described the color as sooty black.

Distribution

This species has not been reliably reported from the Atlantic or Gulf coasts of the United States. Poey's type specimen (1860: 222) was from Cuba, and Howell y Rivero (1938: 187) reported on the type of the synonymous *C. frontalis* Poey from Cuba. Additional Cuban records were given by Jordan (1886b: 36) and Meek and Hildebrand (1925: 352). The species has been reported from Bermuda by Woods and Kanazawa (1951: 631); from West Caicos Island, Bahamas, by Parr (1930: 45); from Puerto Rico by Erdman (1956: 327); and from Trinidad by Nichols and Murphy (1914: 263). It has been recorded by Springer and Bullis (1956: 74) from the *Oregon* collections in the Gulf of Mexico from about 110 miles and 125 miles north of Yucatan and from about 50 miles south of South Pass, La. It has been listed from Brazil by Fowler (1941b: 154, see synonymy), the Eastern Atlantic by Fowler (1936: 699, see synonymy), and from the Pacific and Indian Oceans by many authors.

Spawning

The time and place of spawning are unknown. The specimen of 635 mm. standard length reported by Woods and Kanazawa (1951: 631) from offshore Bermuda, August 8, was described as a ripe male.

Hemicaranx fasciatus (Cuvier)

Caranx fasciatus Cuvier, *in* Cuvier and Valenciennes, 1833, p. 70 (Gulf of Mexico off Mexico).
Caranx secundus Poey, 1860, p. 223 (Cuba).
Carangops secundus, Poey, 1866, p. 15 (Cuba).
Hemicaranx secundus, Jordan and Evermann, 1896, p. 914 (Cuba).
Xurel fasciatus, Jordan, Evermann, and Clark, 1930, p. 272 (Cuba; Atlantic coast of Mexico).

Since one objective of this study is to consider the species of *Caranx* that might occur off the southeastern Atlantic coast of the United States, and because the last major taxonomic treatment of *Hemicaranx fasciatus* (Jordan, Evermann, and Clark, 1930: 272) would cause it to be considered in the genus *Caranx*, a brief notation of its relationships is necessary.

Caranx fasciatus was described by Cuvier, *in* Cuvier and Valenciennes (1833: 70) from a drawing by Mocigno and Sesse of a specimen from the Atlantic off Mexico. *Caranx secundus*, described from Cuba by Poey (1860: 223), was placed in the synonymy of *Xurel fasciatus* (Cuvier) by Jordan, Evermann, and Clark (*op. cit.*) and by Howell y Rivero (1938: 187). However, Jordan and Evermann's genus *Xurel* (1927: 505) is taxonomically unsound and has been disregarded, and most of the species placed in this genus have been returned to the genus *Caranx*. This would superficially indicate that *C. fasciatus* Cuvier should be in the genus *Caranx*.

Mrs. M. M. Dick, Museum of Comparative Zoology, kindly examined Poey's cotypes of *C. secundus* and furnished information on four of the characters commonly used to separate the genera *Caranx* and *Hemicaranx*. In one character there is a resemblance to *Caranx:* the greatest width of the maxillary is greater than the diameter of the pupil; however, this character may be expected to vary with growth. The other three characters are all of *Hemicaranx* affinity: there are no vomerine teeth; all teeth in the jaws are approximately equal in size, none enlarged; and there are no bilaterally paired fleshy keels on the peduncle. In view of the evidence, this form should be currently considered as *Hemicaranx fasciatus* (Cuvier). Cuvier is recognized as the sole author of the name in accord with Bailey (1951: 249).

A comparison of Poey's cotypes with *Hemicaranx amblyrhynchus* (Cuvier) of comparable sizes, if available, should be made to determine the relationship of these two forms.

Uraspis heidi Fowler

Uraspis heidi Fowler, 1938, p. 150 (Manasquan, N. J.).
? *Caranx lugubris* (*non* Poey), Longley, *in* Longley and Hildebrand, 1941, p. 78 (Long Key, Tortugas, Fla.).

Only two definite published records exist for this species: the type, 273 mm. standard length (320 mm. total length), from Manasquan, N. J., Sept. 3, 1938, was described by Fowler (1938: 150) and later illustrated (1952a, fig. 1). The species was corroborated and further described by Ginsburg (1952: 99, pl. 5, fig. b) from a specimen 207 mm. total length, from *Oregon* station 131, 29°20′ N., 88°35.5′ W., about 25 miles east of Pass a Loutre, La., Sept. 24, 1950.

A third known specimen, from off North Carolina in September 1954, is cataloged as USNM 163884. It agrees with the foregoing descriptions: standard length 192 mm.; total length 238 mm. Dorsal VIII, I–29. Anal I, I–22 (first anal spine covered by skin). Pectoral I–22. Gill rakers 6+14 (both sides). Scutes 36 (both sides; about 25 of the scutes on each side have forward-directed spines).

The specimen identified by Longley, *in* Longley and Hildebrand (1941: 78) as *C. lugubris* was probably this species. He described the specimen, about 80 mm. long and found in the waste of Long Key (Tortugas, Fla.) tern colony, as having strongly antrorse or forward-directed spines on the scutes of the posterior half of the straight lateral line, a leaden color, and a shorter snout and larger head than possessed by other *Caranx* species at Tortugas. All of these characters are distinctive of *U. heidi* and, since the specimen is apparently no longer available, Longley's record should be placed in the questionable synonymy of *U. heidi*.

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ADDENDA

Subsequent to submission of the manuscript for publication, additional specimens were examined and records obtained that warrant comment.

Six specimens of *crysos* between 210 mm. and 240 mm. standard length, that were caught from a pier at Pensacola Beach, Fla., July 1, 1958, had enlarged gonads (3 males and 3 females); but the gonads were not as large or as well-developed as *crysos* taken offshore in the Gulf of Mexico. Body bars were visible on the two smallest fish, 210 mm. and 220 mm., when they were caught, but the fish were dead and the bars had disappeared within 5 minutes after the fish had been pulled out of the water.

An 11.0-mm. specimen of *ruber* (SAFI collection) is slightly smaller than the smallest specimen previously known to be available. It is similar in proportions and pigmentation to the 12.4-mm. *ruber* of figure 34.

Comparison of measurements of four large specimens of *latus*, 259 mm. (UF collection), 319 mm. (CNHM 39717), 478 mm. (CNHM 46773), and 602 mm. standard length (CNHM 46772), with growth trends of the smaller specimens indicates that: The third dorsal spine length-standard length regression is generally stable from about 130 to 319 mm. standard length, but a decrease in spine growth rate has occurred by 478 mm. The first dorsal soft-ray length-standard length regression is essentially unchanged from 40 to 602 mm. The body depth at pelvic-standard length regression is changed with a decrease in depth growth rate occurring between 170 mm. and 259 mm. The snout length-standard length regression remains generally stable from 16 to 602 mm. The eye diameter-standard length regression is apparently changed between 170 mm. and 259 mm. with a subsequently slower eye growth rate.

The recent acquisition of three small specimens, 11.0 mm. (SAFI collection), 12.8 mm. (UF collection), and 14.2 mm. standard length (SAFI collection), will be useful in later analysis of differences in larval and early juvenile *latus* and *hippos*; but a larger series still is needed: (1) The 11.0-mm. specimen is identified as *Caranx* sp. ("*latus* and/or *hippos*"). Depth at pelvic, 6.2 mm. Third dorsal spine length, 1.94 mm. Second anal spine length, 1.0 mm. Preopercular-angle spine length, 0.35 mm. Dorsal and anal soft-rays, 20 and 16. Preopercular upper-limb and lower-limb spines, 0 and 4. The straight part of the lateral line is prominent, but the curved part is indistinct. No "completely developed scutes" are present. The interneural and interhemal spines have not protruded above the body surface. The body is densely pigmented except for areas below and beneath the pectoral, pigmented between spines 1 and 5, there are a few melanophores between spines 5 and 7, and the fin is unpigmented between spines 7 and 8. (2) The 12.8-mm. specimen is questionably identified as *hippos*. Depth at pelvic, 7.45 mm. Preopercular-angle spine length, 0.44 mm. Dorsal and anal soft-rays, 20 and 16. Preopercular upper-limb and lower-limb spines, 0 and 5. The lateral line is formed. No "completely developed scutes" are present. Projections of the interneural and interhemal spines have protruded above the body surface. The first three body bars are present, but the fourth and fifth are represented by a single broad pigment mass. (3) The 14.2-mm. specimen is identified as *hippos* because of its similarity to the 15.3-mm. specimen of *hippos* previously discussed, especially in body depth at pelvic (7.8 mm.) and mean lateral-line ratio (0.97). Preopercular-angle spine length, 0.27 mm. Dorsal and anal soft-rays, 20 and 17. Scutes, 9 right side and 10 left. Preopercular upper-limb and lower-limb spines, 0 and 5. The five body bars are completely formed.

The 12.8-mm. specimen is questionably identified as *hippos* only because it cannot be adequately distinguished from *latus*. This is the smallest specimen of either of these species to be recorded from inshore waters. It was seined from the surf on Plantation Key, Fla. If, as suspected, *Caranx* of this small size normally inhabit offshore waters, this specimen probably was carried inshore by currents from the nearby Gulf Stream.

A 65.5-mm. standard length specimen of *dentex* (CNHM 4936) from Bermuda has been examined, and is the smallest juvenile of this species to be reported. Dorsal and anal soft-rays, 26 and 23. Gill rakers, 14 + 27. Scutes, 30 right side and 26 left. Third dorsal spine length, 8 mm. First dorsal soft-ray broken, but apparently was shorter than third dorsal spine. Mean lateral-line ratio, 0.80. All counts and measurements of this specimen correspond to trends or ranges of other specimens of *dentex* examined and reported in the literature, except that its upper-limb gill-raker count (14) extends the range for this character. Pigmentation had faded completely.

Measurements of the 650-mm. standard length specimen of *lugubris* (CNHM 48389) from Bermuda, previously described by Woods and Kanazawa (1951: 631), and of the 602-mm. specimen of *latus* (CNHM 46772), were compared with the estimated regression lines on the graphs accommodating the large specimens of *hippos* (figs. 90 and 91). The following comparative features were indicated for these three species around the 600- to 650-mm. size range: First dorsal soft-ray length (*lugubris*, 168 mm.; *latus*, 114 mm.) and depth at pelvic (*lugubris*, 240 mm.; *latus*, 185 mm.): *latus* and *hippos* are similar, but *lugubris* has a much longer soft-ray and greater depth than either of these. Third dorsal spine length (*lugubris*, 58 mm.; *latus*, 49 mm.) and snout length (*lugubris*, 65 mm.; *latus*, 54 mm.): *lugubris* has a longer spine and snout than *hippos*, and *latus* may be intermediate between the two in these characters. Eye diameter (*lugubris*, 36 mm.; *latus*, 47 mm.): *latus* has an appreciably larger eye than the other two. Head length (*lugubris*, 183 mm.; *latus*, 190 mm.): the three species are generally similar, but *latus* may have a significantly longer head than *lugubris*, with *hippos* intermediate between these two. Pectoral length (*lugubris*, 233 mm.; *latus*, 202 mm.): the three species are generally similar in this character. The mean lateral-line ratio of the 650-mm. *lugubris* (1.64) is distinct from the predicted range of *hippos*, but is within that of *latus*.

A recent publication by McKenney, Alexander, and Voss (1958, Bull. Marine Sci. Gulf and Caribbean, 8 (2): 167–200, figs. 1–7) described juvenile *crysos* and larvae, identified as this species, as small as 2.6 mm. (snout to tip of urostyle). Their series of 148 specimens is fairly complete from 3.8 mm. to over 50 mm., but there is a small discontinuity in their series between 3.8 mm. and the three smallest larvae, 2.6 mm., 2.7 mm., and 2.8 mm. No indication is given as to how these larvae may be distinguished from other carangid larvae. Their figures and descriptions bear several minor discrepancies to my figures and accounts for *crysos*. Differences in pigmentation descriptions might be due to fading or individual variation. Development of their 4.2-mm. larva (their fig. 1c) had not progressed to the stage of the 3.8-mm. specimen (my fig. 16) that I suspect to be a larval *crysos*. They noted that the preopercular spines reach their greatest relative size in the 4.0- to 5.0-mm. group and then decline in importance—my less-complete data had suggested that the preopercular-angle spine ceased to increase in length at some size around 7 mm. (fig. 31) and that the number of upper-limb and lower-limb spines began to decrease in number at about 20 to 25 mm. (table 1). They stated that the terminal dorsal and anal soft-rays were not formed on some specimens until the fish were 6.0 mm. long, but that one 5.0-mm. specimen had these rays—my data indicated that the adult complement of all fin rays had begun ossification by about 8.0 mm. Their ranges of dorsal and anal soft-rays coincided with my tabulations. They mentioned that the procumbent spine of the dorsal fin is an interneural spine (see under Definitions, p. 420). A useful listing of stomach contents of the larval and juvenile specimens is given. The authors suggested that *crysos* may spawn throughout the year with the main spawning occurring from January through August—specimens taken off the southeastern Atlantic coast had produced my estimation that the spawning season contributing young *crysos* to this area extended from April into September. They listed specimens of 12.1 to 24.2 mm. from inshore at Matecumbe Key, Fla.—these are the smallest *crysos* to be recorded from inshore waters, but they could have been carried inshore from the nearby Gulf Stream (Florida Current) by temporary currents.

Specimens were obtained from the following sources in addition to those previously acknowledged: Earl E. Deubler, Jr., University of North Carolina (UNC); Donald C. Scott, University of Georgia (UG); Loren P. Woods, Chicago Natural History Museum (CNHM); Bernard Lewis, Institute of Jamaica (IJ).

SPECIMENS EXAMINED

Caranx crysos

Atlantic Beach, Carteret Co., N. C., 27 Oct. 1956, (1 specimen), 126 mm. standard length, UNC 806, group No. 42.—30°00′ N., 80°10′ W., *Silver Bay* sta. 476, 18 June 1958, (1) 14.5 mm., SAFI collection.—29°54′ N., 80°11′ W., *Silver Bay* sta. 481, 19 June 1958, (7) 15.5 to 25 mm., SAFI.—29°48′ N., 80°12′ W., *Silver Bay* sta. 470, 17 June 1958, (2) 17.5 mm. and 22 mm., SAFI.—29°38′ N., 80°14′ W., *Silver Bay* sta. 460, 13 June 1958, (6) 14.4 to 31 mm., SAFI.—29°38′ N., 80°09′ W., *Silver Bay* sta. 471, 17 June 1958, (8) 13.1 to 25 mm., SAFI.—Gulf of Mexico, *Oregon* sta. 2198, (15) 20.5 to 50 mm., SAFI.

Caranx ruber

32°13.5′ N., 64°32.5′ W., off Bermuda, 6 Aug. 1948, (1) 94 mm., CNHM 49168.—30°00′ N., 80°10′ W., *Silver Bay* sta. 476, 18 June 1958, (6) 32 to 63 mm., SAFI.—29°54′ N., 80°11′ W., *Silver Bay* sta. 481, 19 June 1958, (9) 14.1 to 20 mm., SAFI.—29°48′ N., 80°12′ W., *Silver Bay* sta. 470, 17 June 1958, (13) 11.0 to 53.5 mm., SAFI.—29°38′ N., 80°16′ W., *Silver Bay* sta. 461, 13 June 1958, (2) 24.5 mm. and 25.5 mm., SAFI.—29°38′ N., 80°14′ W., *Silver Bay* sta. 460, 13 June 1958, (5) 15.5 to 22.5 mm., SAFI.—29°38′ N., 80°09′ W., *Silver Bay* sta. 471, 17 June 1958, (17) 14.8 to 59 mm., SAFI.—29°19′ N., 79°58′ W., *Silver Bay* sta. 454, 12 June 1958, (2) 20 mm. and 23 mm., SAFI.—27°53′ N., 79°09′ W., *Silver Bay* sta. 442, 9 June 1958, (5) 20 to 25 mm., SAFI.—Gulf of Mexico, *Oregon* sta. 2196, (7) 18.5 to 23 mm., SAFI.—Gulf of Mexico, *Oregon* sta. 2198, (22) 19 to 74 mm., SAFI.—Southwest Cays, Glover Reef, Caribbean Sea, 16 Jan. 1940, (1) 160 mm., CNHM 39813.

Caranx bartholomaei

Flatts Inlet, Bermuda, (1) 61 mm., CNHM 48629.—Offshore between Beaufort Inlet and Cape Lookout, N. C., Sept. 1956, (1) 156 mm., UNC 896.—30°00′ N., 80°10′ W., *Silver Bay* sta. 476, 18 June 1958, (3) 20.5 to 38.5 mm., SAFI.—29°38′ N., 80°16′ W., *Silver Bay* sta. 461, 13 June 1958, (1) 24 mm., SAFI.—29°38′ N., 80°09′ W., *Silver Bay* sta. 471, 17 June 1958, (3) 28.5 to 33.5 mm., SAFI.—29°22′ N., 80°05′ W., *Silver Bay* sta. 227, 24 Nov. 1957, (1) 24 mm., SAFI.—East end of Kingston Harbor, Jamaica, 14 May 1957, (1) 62.5 mm., UF collection.

Caranx sp. ("*latus* and/or *hippos*")

29°48′ N., 80°12′ W., *Silver Bay* sta. 470, 17 June 1958, (1) 11.0 mm., SAFI.

Caranx latus

Flatts Inlet, Bermuda, (1) 52 mm., CNHM 48629.—Richardson's Cove, Bermuda, 2 Sept. 1948, (2) 55 mm. and 64 mm., CNHM 48356.—Flatts Inlet, Bermuda, 31 Jan. 1933, (1) 41.5 mm., CNHM 48652.—Little River at Calabash, N. C., 23 Oct. 1957, (2) 40 mm. and 61 mm., SAFI.—St. Simons Island, Ga., 18 Aug. 1958, (1) 65 mm., SAFI.—Jekyll Causeway, Brunswick, Ga., 4 Aug. 1958, (2) 114 mm. and 124 mm., SAFI.—Garden Key, Tortugas, Fla., 20 Mar. 1951, (7) 116 to 155 mm., UG collection.—Alacran Rocks, Campeche Banks, Gulf of Mexico, *Oregon*, 27 Aug. 1951, (1) 478 mm., CNHM 46773.—Alacran Rocks, Campeche Banks, *Oregon*, 27 Aug. 1951, (1) 602 mm., CNHM 46772.—Southwest Cays, Glover Reef, Caribbean Sea, 16 Jan. 1940, (1) 319 mm., CNHM 39717.—Runaway Bay, Eaton Hall, Jamaica, about 12 June 1958, (1) 259 mm., UF collection.

Caranx hippos ?

Plantation Key, Fla., 12 June 1956, (1) 12.8 mm., UF collection.

Caranx hippos

Great Egg Harbor, N. J., 10 July 1958, (2) 34 mm. and 41 mm., SAFI.—Ocean View, Va., (1) 105 mm., CNHM 1164.—Little River at Calabash, N. C., 23 Oct. 1957, (2) 35.5 mm. and 50 mm., SAFI.—East shore of Scuppernong River, Albemarle Sound, about 3.5 miles northwest of Columbia, N. C., 7 Aug. 1956, (1) 60 mm., UNC 345.—Jeremy Creek, McClellansville, S. C., 21 Aug. 1956, (2) 126 mm. and 127 mm., SAFI.—Jeremy Creek, Cape Romain, S. C., 2 Nov. 1956, (2) 45.5 mm. and 53.5 mm., SAFI.—Mays River drainage, 5 miles west of Bluffton, S. C., 16 July 1956, (1) 83 mm., SAFI.—Atlantic Ocean off St. Catherines, Blackbeard, and Sapelo Islands, Ga., 15 Oct. 1949, (2) 110 mm. and 119 mm., UG coll. No. 125.—St. Simons Island, Ga., 3 July 1958, (4) 25 to 30.5 mm., SAFI.—St. Simons Island, Ga., 18 Aug. 1958, (11) 25.5 to 36 mm., SAFI.—Jekyll Causeway, Brunswick, Ga., 20 June 1958, (12) 25 to 38 mm., SAFI.—Same area, 3 July 1958, (3) 42 to 47 mm., SAFI.—Same area, 21 July 1958, (1) 50 mm., SAFI.—Same area, 1 Aug. 1958, (1) 68 mm., SAFI.—Same area, 3 Aug. 1958, (4) 87.5 to 109 mm., SAFI.—Same area, 4 Aug. 1958, (11) 95 to 111 mm., SAFI.—Same area, 2 Sept. 1958, (1) 43.5 mm., SAFI.—Cumberland River, near Cumberland Island, Ga., 21 Aug. 1958, (1) 104 mm., SAFI.—Halifax River, at Karona Crossing, Fla., 28 June 1957, (1) 36 mm., SAFI.—North River, Vilano Beach, near St. Augustine, Fla., 21 Aug. 1950, (1) 32 mm., UG coll. No. 180A.—30°00′ N., 80°10′ W., *Silver Bay* sta. 476, 18 June 1958, (1) 15.5 mm., SAFI.—29°56′ N., 80°10′ W., *Silver Bay* sta. 483, 20 June 1958, (1) 28 mm., SAFI.—29°54′ N., 80°11′ W., *Silver Bay* sta. 481, 19 June 1958, (1) 27 mm., SAFI.—29°48′ N., 80°12′ W., *Silver Bay* sta. 470, 17 June 1958, (2) 16.7 mm. and 16.9 mm., SAFI.—29°38′ N., 80°09′ W., *Silver Bay* sta. 471, 17 June 1958, (5) 17.6 to 20.2 mm., SAFI.—29°38′ N., 80°14′ W., *Silver Bay* sta. 460, 13 June 1958, (1) 14.2 mm., SAFI.—Garden Key, Tortugas, Fla., 20 Mar. 1951, (1) 163 mm., UG coll. No. 196.—Ft. Pickens, Santa Rosa Island, Fla., 5 July 1958, (4) 32.5 to 38.5 mm., SAFI.—Ocean Springs vicinity, Miss., (1) 114 mm., UG coll. No. 506.—28°17′ N., 87°52′ W., *Oregon* sta. 1145, 26 July 1954, (1) 28 mm., CNHM 61349.—27°34′ N., 89°00′ W., *Oregon* sta. 1134, 22 July 1954, (5) 19 to 27 mm., CNHM 61348.—Porto Bello, Panama, 24–28 Apr. 1911, (1) 105 mm., CNHM 20335.—Simmons Bay, St. Thomas, Jamaica, 4 Oct. 1951, (1) 103 mm., IJ collection.—Pernambuco, Brazil, (1) 94.5 mm., CNHM 3830.—Santos, Brazil, (1) 147 mm., CNHM 3362.

Caranx dentex

Bermuda, (1) 65.5 mm., CNHM 4936.

Caranx lugubris

South of Ariadne Bank, offshore, Bermuda, 5 Aug. 1948, (1) 650 mm., CNHM 48389.