

REVISION OF THE SAURIES (PISCES, SCOMBERESOCIDAE) WITH DESCRIPTIONS OF TWO NEW GENERA AND ONE NEW SPECIES

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ABSTRACT

The extant members of the Scomberesocidae are: 1) *Scomberesox saurus saurus* of the North Atlantic, ranging into the Arctic north of Europe, and *Scomberesox saurus scombroides*, of disjunct occurrence in the Southern Hemisphere; and 2) *Cololabis saira* of the North Pacific (with one record attributed to release of bait in the Indo-Pacific tropics), two dwarf species, *Nanichthys simulans*, new genus and species, of the central Atlantic and the Indian Oceans, and *Elassichthys (new genus) adocetus*, of the eastern central Pacific. Some other names applied to Miocene fossils from southern California have been referred, we believe erroneously, to the Scomberesocidae. *Elassichthys adocetus* is particularly dwarfed but both dwarfs are distinguished by having no gas bladder and by having a single ovary which, at maturity, very largely fills the body cavity with few large ova. All members of the group are epipelagic, and they constitute a major element of that assemblage over a large share of the tropical and temperate world ocean.

Fishes of the family Scomberesocidae form a well-defined unit, due principally to the presence of separated finlets posterior to the dorsal and anal fins (as commonly found in scombroid fishes) and in having a slender, pikelike body with these median fins set far back (Figure 1). We interpret the scomberesocids as more or less akin to the Belonidae, Hemiramphidae, and Exocoetidae, largely on the basis of having the lower pharyngeal bones united, and the lateral line low, near the ventral profile, rather than (as in most fishes) high on the lateral aspect of the body.

The ordinal classification of the family has been variously interpreted since the turn of the century. For example, it was placed in a division called the "Scomberesocidae microsquamatae" by Schlesinger (1909); in the subfamily Scomberesocinae of the Exocoetidae by Regan (1911); in the family Scomberesocidae of the order Synentognathi by Jordan (1923) and by others of his school; in the Scomberesocidae of the suborder Microsquamati of the order Synentognathi by Nichols and Breder (1928); in the suborder Scomberesocidae, including also the Belonidae, in the Beloniformes by Berg (1940); and, more recently, in the family Scomberesocidae of the superfamily Scomberesocoidea in the suborder Exocoetoidei and order Atheriniformes by Rosen (1964) and by

Greenwood et al. (1966), who deleted the superfamily. Bailey et al. (1970) in general followed Greenwood et al., as did Nelson (1976). Gosline (1971) preferred to recognize the order Beloniformes, suborder Scomberesocoidei, families Scomberesocidae and Belonidae, and suborder Exocoetoidei, families Exocoetidae and Hemiramphidae; Gosline did not refer to Greenwood et al. (1966). Despite varied opinions on the ordinal level, all authors retained the scomberesocid fishes as a familial unit.

The Scomberesocidae appear to comprise a compact group to which we add two new genera and one new species. The genera and their species are characterized in Table 1. *Scomberesox* and *Cololabis* are relatively large fishes (about 350-450 mm), have paired ovaries and a gas bladder, while *Elassichthys* and *Nanichthys* are dwarfed (not known to exceed 126 mm, and one species not exceeding 68 mm standard length (SL)), have a single ovary, and lack a gas bladder. Also, they have fewer pectoral and procurrent caudal fin rays, gill rakers, and vertebrae.

Several of the authorities cited above, and others, have indicated that the Scomberesocidae represent an evolutionary line highly specialized for active life at the surface. The modifications of the posterior dorsal and anal rays into finlets, as in various scombroids, is evidence for this view. As a corollary, it seems obvious that a strong swimmer like *Cololabis saira* or *Scomberesox saurus*, rather than the smaller, probably weaker *Elassichthys*

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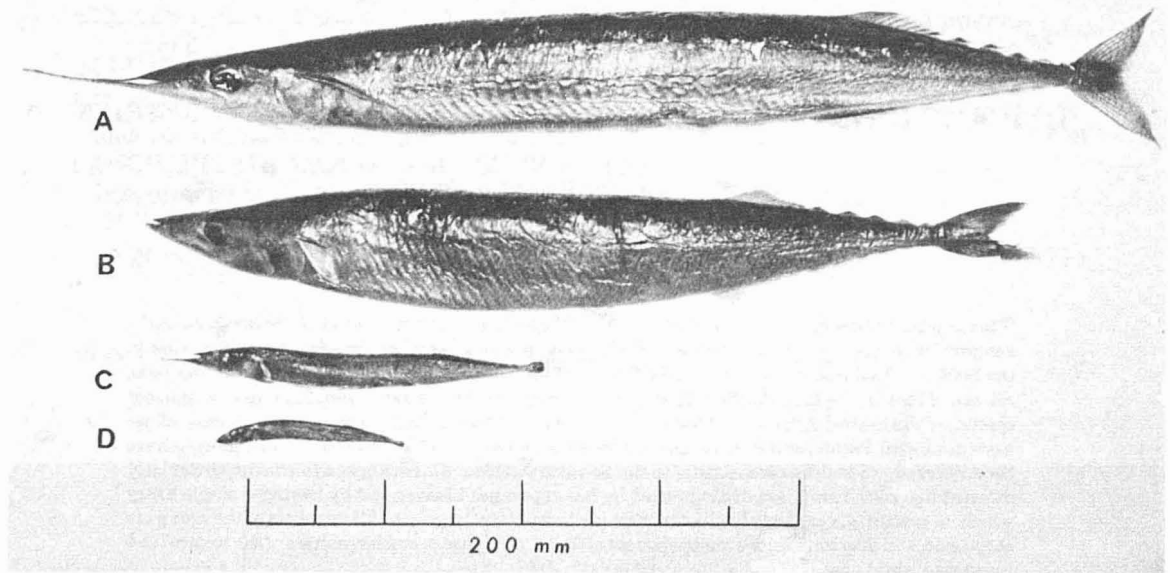


FIGURE 1.—Adults of the four genera and species of scomberesocid fishes: (A) *Scomberesox saurus*; B *Cololabis saira*; (C) *Nanichthys simulans*; (D) *Ellassichthys adocetus*.

TABLE 1.—Differential characters of the four genera and species of Scomberesocidae.

| Characters | <i>Cololabis saira</i> | <i>Scomberesox saurus</i> ¹ | <i>Nanichthys simulans</i> | <i>Ellassichthys adocetus</i> |
|---|---|--|--|--|
| Ovaries (Figure 8) | Paired; bilateral | Paired; bilateral | Single; median | Single; median |
| Testes (Figure 9) | Paired, bilateral; neither overtopping other | Paired, bilateral; neither overtopping other | Paired but forming coherent mass; left overtopping right | Paired but forming coherent mass; left overtopping right |
| Gas bladder | Large; thin-walled | Large; thin-walled | Completely lacking | Completely lacking |
| Maximum known length | Ca. 400 mm | Ca. 450 mm | 68 mm | 126 mm |
| Developed gonads | Dorsolateral to gut; attached to wall of coelom | Lateral to gut; attached to wall of coelom | Dorsolateral to gut; unattached | Dorsolateral to gut; unattached |
| Filaments on eggs | Many at pole, single distant one | None | None | None |
| Upper beak | Pointed, short, stout; overlapped slightly by lower | Greatly produced, very fragile; slightly overlapped by lower | Moderately produced, fragile; ca. half length of lower | No beak; upper jaw broadly curved |
| Lower jaw (in adult) | Pointed, short, stout | Greatly produced, ca. equal to postorbital head length | Much produced, ca. twice length of upper jaw | Very short, bluntly pointed, tubercular at tip |
| Teeth on upper jaw | All uniserial | Biserial on beak; uniserial behind | Uniserial behind; biserial forward | Uniserial, few, widely spaced |
| Teeth on lower jaw | Obsolete, except developing forward only in adults; uniserial | Well developed throughout life; biserial on beak, uniserial behind | Biserial near gape; uniserial forward | Essentially uniserial, fewer anteriorly |
| Cartilaginous loops between mandibular rami | Few, but very well developed | Numerous over long area | Few over short area | Wholly lacking |
| Intermandibular tissue | Covered by upper jaw | Covered by upper jaw | Covered by upper jaw | Tissue largely exposed |
| Lateral line | Extending to over anal finlets | Extending to over anal finlets | To slightly past pelvic base ² | Completely lacking |
| Tubes and pores of head | Numerous and much branched | Numerous and much branched | Intermediate | Few, little branched |
| Fiber bundles of body muscles (Figure 7) | Fine | Fine | Moderately coarse | Relatively very coarse |
| Caudal peduncle ³ | Short | Short | Long | Long |
| Procurent caudal rays | 5-7 | 5-7 | 4, rarely 3 or 5 | 2-3 |
| Gill rakers ⁴ | 37-38 (32-43) | 45 ⁵ (39-51) | 22-24 (19-26) | 17-18 (15-21) |
| Pectoral rays ⁴ | 12-14 (12-15) | 13-14 (12-15) | 10-11 (10-11) | 9-10 (8-11) |
| Vertebrae ⁴ | ⁶ 65-67 (64-69); 63-67 (62-68) | 65-67 (64-70) | 59-62 (58-62) | 56-57 (54-59) |
| Scales, lateral midline | 128-148; rather firmly attached | 107-128; rather firmly attached | 77-91; very caducous | 70-88; very caducous |

¹Except for gill rakers (5), characters refer to both subspecies.

²The lateral lines are incomplete on all our specimens except on the 121.2 mm one from Funchal, Madeira.

³Length of caudal peduncle, measured as interval between bases of last finlet and first precaudal ray, is either "short" (about equal to depth of peduncle) or "long" (about twice that depth).

⁴Minimum and maximum values; the most common values first with total ranges in parentheses.

⁵Values in parentheses are those for *S. s. scombroides*.

⁶First values for western Pacific, mean 66.05 (for 248 counts); second values for eastern Pacific, mean 65.11 (for 3,060 counts).

adocetus or *Nanichthys simulans*, is the basic type of the family, and that the dwarf forms are derivative.

DEVELOPMENT OF BEAK

In their early ontogeny, the Scomberesocidae, like other synentognathous fishes, pass through changes in physiognomy (Figure 2), involving especially the upper and lower beaks. The degree of metamorphosis varies greatly among the four species.

The most dwarfed scomberesocid, *E. adocetus*, exhibits the least change, retaining rather heavy, little-produced jaws throughout life. The upper jaw remains relatively short, and rounded in top view, and the lower jaw increases with growth of the fish only very slightly in production and slenderizing.

Next in degree of age changes is *C. saira*, in which the premaxillaries become more pointed forward and the dentaries become slightly produced and slenderized, but not to a degree fully warranting the designation of either jaw as a beak. In contrast with *Scomberesox* and *Nanichthys*, the snout does not further increase in relative length after the fish reaches the standard length of about 50 mm (Figure 2). In contrast, the snout increases in relative length throughout the life span of *Nanichthys* and in *Scomberesox* until a length of about 200 mm has been attained.

Next in the series we may rate the largest, and in many other respects the most extreme form, *S. saurus*. Very small juveniles have a short muzzle, with the lower jaw, as in all the species, the heavier (Figure 2). Very early the jaws both become sharper forward and begin to elongate. The process is initially somewhat more accelerated in the lower jaw, but at no stage do the developing beaks simulate the condition found in halfbeaks, for the developing upper beak is always much more than half as long as the lower. Lütken's (1880) indication to the contrary resulted from his inclusion of *N. simulans* into what he treated as the developmental series of *S. saurus* (see p. 533). In fact, the relative projection of the lower jaw decreases but little with age (Figure 2).

The most extreme ontogenetic changes in physiognomy are displayed by the next-to-most dwarfed form, *N. simulans* (Figure 2). Until it reaches about 30 mm SL the jaws are scarcely produced. Soon, however, the premaxillaries become pointed forward and begin to elongate, but

slowly. The dentaries become very slender and, in juxtaposition, elongated forward far beyond the slender conjoined tips of the premaxillaries. When the standard length has reached 60 mm, the lower beak of *Nanichthys*, in contrast with *Scomberesox*, is more than twice the length of the upper. *Nanichthys* thus displays the closest approach to the halfbeak condition, but it can hardly be said to pass through a halfbeak stage, as do the belonids and two genera commonly (*Oxyporhamphus*) and/or regularly (*Fodiator*) placed in the Exocoetidae (Lütken 1880; Nichols and Breder 1928; Breder 1932, 1938; Hubbs 1933; Parin 1961). The projection of the lower jaw as a proportion of length of fish increases sharply with age, at least for the usual standard lengths of about 90 mm in the specimens available to us.

PHYLOGENY

Only two extant genera of the family Scomberesocidae, *Scomberesox* Lacépède 1803, and *Cololabis* Gill 1895, have been recognized. They have been differentiated primarily on the basis of the degree of development of the jaws into beak-like structures; in *Scomberesox* each jaw is definitely prolonged, very slender, fragile, and elongate, whereas in *Cololabis* the jaws remain short, less fragile, and only moderately pointed (Figures 1, 2). In each genus the lower jaw projects slightly beyond the upper. Both genera comprise slender, elongate fishes, bearing, as do the unrelated Scombridae, a file of separated finlets that largely fill the interval between the caudal fin and the main parts of the dorsal and anal fins. *Scomberesox* attains a standard length rarely in excess of 450 mm, although there are undocumented reports of 500 mm. *Cololabis* reaches about 350 mm SL.

Despite the several expressed opinions to the contrary (below), we regard the merely pointed muzzle, with projecting chin, as in *Cololabis* and *Elassichthys* (Figure 2), as a primitive feature, and as also in *Arrhamphus*, *Chriodorus*, and *Melapedalion* of the halfbeaks. We also regard the beaks of *Scomberesox* and *Nanichthys* as derivative therefrom. Jordan and Evermann (1896) surmised that *Cololabis* "represents the immature state of *Scomberesox*"—a view repeated by others of that school. Schlesinger (1909) definitely treated the jaws of *Cololabis* as secondarily foreshortened. Nichols and Breder (1928) went so far as to characterize *Cololabis* as "... a recogniz-

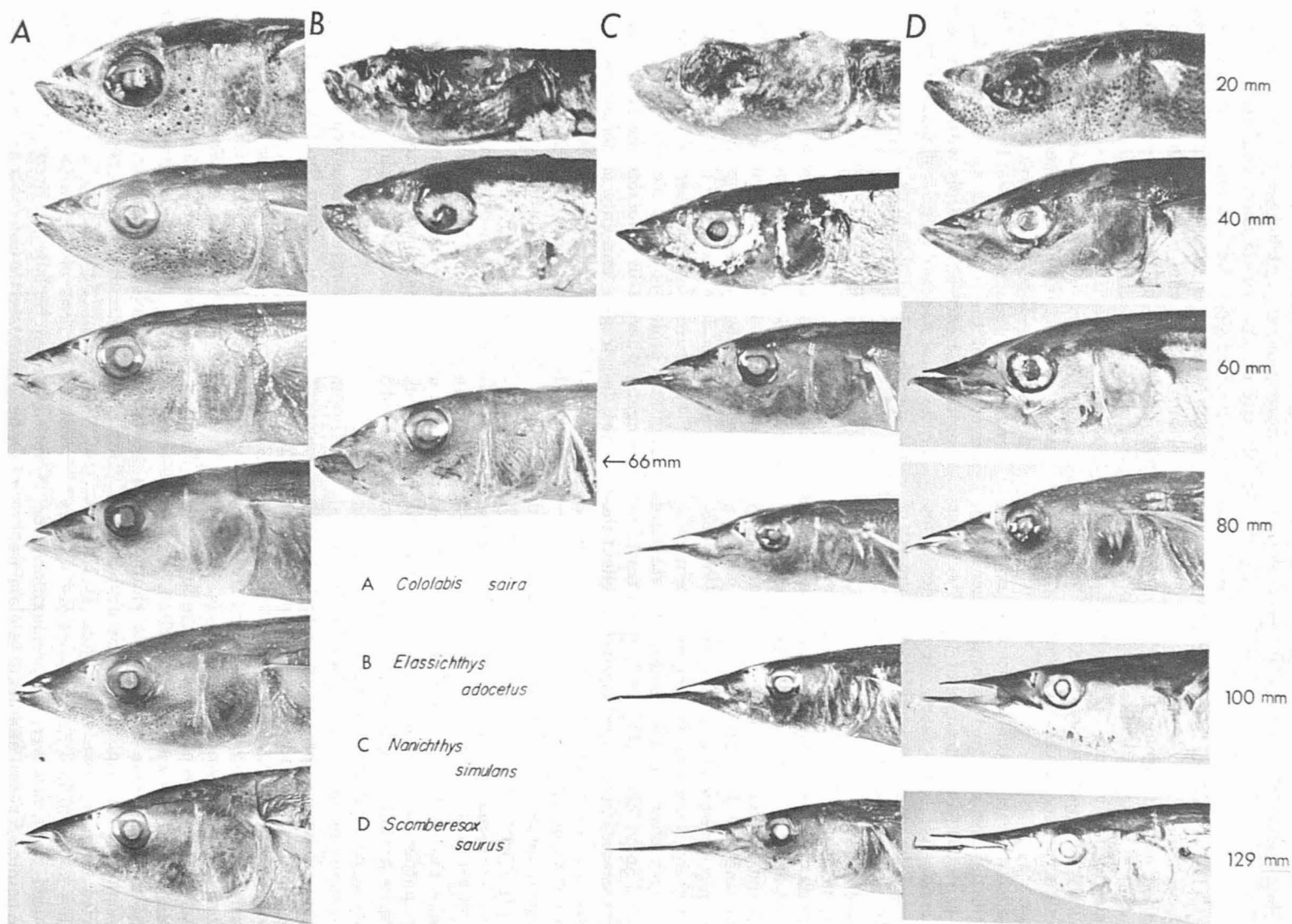


FIGURE 2.—Development of beaks in young of the four genera and species of scomberesocid fishes. Specimens are aligned in rows by size (standard length).

able fixed larva of *Scomberesox*." Knowing *C. saira* well as a moderately large and extremely active surface fish leads us to emphatically disregard its consideration as a larva. There is nothing in the ontogeny of the four species of the family to support the view that beaklessness arose from the beaked condition.

Thus, we arrive at the concept of a relatively large and strong, beakless, surface-swimming fish as the phyletically basic member of the Scomberesocidae: *Cololabis* alone fits this concept. We therefore assume that an immediate ancestor of *C. saira* gave rise to the other members of the family and remains as a relic in the temperate waters around the North Pacific, where it appears to replace *Scomberesox* completely.

The *Cololabis* ancestor presumably gave rise to *Scomberesox* through the development of a long beak, by the loss of filaments on the egg, and through a moderate increase in size and in average number of gill rakers and vertebrae. Perhaps a stock of the ancestor crossed equatorial waters in some past cool period and became isolated when the tropics again became warm; differentiation may then have taken place. From cool South Pacific waters the West Wind Drift may be assumed to have transported the saury to the southern parts of the Atlantic and Indian Oceans. From the Cape region of Africa it could have been carried far northward on the Benguela Current and may somehow, at some time, possibly even in the Pleistocene, have transgressed the tropics to gain the favorable waters of the North Atlantic. Such movements, however, are hypothetical.

The origin of the dwarfs from a type or types more like *Cololabis* and *Scomberesox* seems hardly subject to doubt (as is indicated above). While recognizing the many features, some deep-seated and fundamental, wherein *Elassichthys* and *Nanichthys* closely agree, and jointly contrast with *Cololabis* and *Scomberesox* (Table 1), we strongly favor, albeit somewhat intuitively, the hypothesis that they are the products of convergent evolution: that *Elassichthys* stemmed from *Cololabis* (or an immediate ancestor of that genus), and that (*Nanichthys* is an offshoot from *Scomberesox* (or its immediate ancestor).

Circumstances favoring the concept of a dual origin of the two dwarf species follow.

1) Characters held jointly by *Elassichthys* and *Nanichthys*, in contrast with *Cololabis* and *Scomberesox*, are of the sort that might well be related to dwarfing, and hence be susceptible to indepen-

dent origin. The lack of the gas bladder seems compensated for by the greatly reduced size of the fish (yielding relatively more surface and viscosity per weight), and by the apparently weaker musculature. The single ovary may be related to the minute size of the organ and the proportionately immense size of the few ova containable at any one time. The degeneration of the lateral line is a common feature of dwarfed fishes. The great reduction in number of gill rakers would be expected, as the smaller number should give adequate straining in a space so greatly reduced. Reduced number of vertebrae and rays is a feature of dwarfing, as Te Winkel (1935) showed in her study of a neotenic goby, and as she and the senior writer showed in an unpublished study of the excessively neotenic fish genus *Schindleria* (which was originally misplaced in the Synentognathi, though it is not so related—as Gosline (1959) has shown).

2) The agreement between *Elassichthys* and *Cololabis* in the mere sharpening of the jaws (the upper rounded in *Elassichthys*), without any real beak development, is a compelling reason to regard them as closely related.

3) The circumstance that the gill rakers and vertebrae are fewer in *Cololabis* than in *Scomberesox*, and about proportionately fewer in *Elassichthys* than in *Nanichthys* is at least suggestive evidence.

4) The circumstance that *Cololabis* is somewhat smaller than *Scomberesox*, and that *Elassichthys* is proportionately smaller than *Nanichthys*, seems to provide similar confirmatory evidence.

5) The mutual occurrence of *Elassichthys* and *Cololabis* in the Pacific Ocean, in part sympatrically, and the mutual occurrence of *Nanichthys* and *Scomberesox* in the Atlantic and Indian Oceans, again in part sympatrically, provides strong confirmatory evidence that *Elassichthys* is the dwarf derivative of *Cololabis* and that *Nanichthys* stemmed similarly and independently from *Scomberesox*. This hypothesis is diagrammed in Figure 3A. On this concept, dwarfing and various structural changes (diagrammed as "d g o"), including the loss of the gas bladder and the change to a single ovary, occurred twice, whereas the evolution of a beak (marked as "b") occurred only once.

No such body of evidence seems advanceable for the alternative hypothesis (Figure 3B) that dwarfing and the ancillary changes occurred but

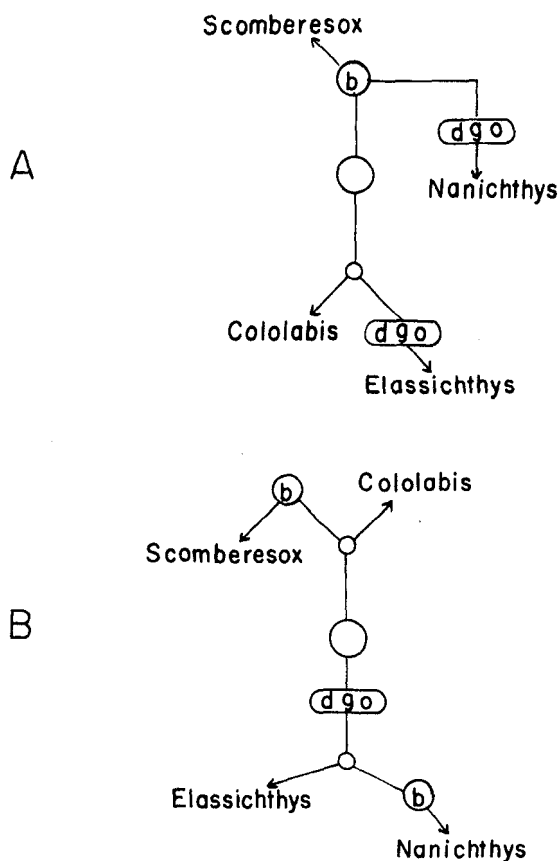


FIGURE 3.—Diagrams (A and B) of hypothetical divergent evolution within the Scomberesocidae: b—well-developed beak; d—dwarfism; g—gas bladder lost; o—ovary single. (A) The larger *Scomberesox* and the dwarfed *Nanichthys*, and the larger *Cololabis* and the dwarfed *Ellassichthys*, derived respectively from beaked and beakless ancestors; development of a beak occurred but once, dwarfism and structural changes (d g o) twice. (B) The beaked and beakless larger forms, *Scomberesox* and *Cololabis*, derived from a common ancestor, as did the beaked and beakless dwarfs, *Ellassichthys* and *Nanichthys*; development of a beak occurred twice, dwarfism and the structural changes but once.

once, so that *Ellassichthys* and *Nanichthys* are of immediate common origin. On this hypothesis, the beak would have developed independently in *Nanichthys* and *Scomberesox*. The differences between the two genera in the lengths of the upper and lower beaks could be cited as confirmatory evidence. As another item of evidence it could be stated that agreement between *Ellassichthys* and *Cololabis* breaks down when the structure of the egg is considered.

For some years we have known that there is a distinct dwarf genus (*Nanichthys*) having many

characters in common with *Scomberesox*, as well as another dwarf genus (*Ellassichthys*) having much in common with *Cololabis*. The species involved we name *Nanichthys simulans*, new species, and *Ellassichthys adocetus* (Böhlke 1951).

These conclusions have been rather widely shared with colleagues. Parin (1968a, b) in particular, has discussed these putative relationships, using the names "*Scomberesox* sp." and "*Cololabis adocetus*" for the respective dwarfs; he cited only superficial distinctions, along with reduced numbers of gill rakers and vertebrae, in the dwarf form. Dudnik (1975b), likewise using the name "*Scomberesox* sp.," also discussed *Nanichthys*; he noted one internal morphological feature, that one of the ovaries is rudimentary. We have consistently found, however, no trace of a second ovary in either *Ellassichthys* or *Nanichthys*. Our findings have been mentioned also by Collette (1966) as the second case of pedomorphism in the order, during his indication of a third case, that of a "pedomorphic or neotenic" belonid. The first case he indicated as the suggestion by Nichols and Breder (1928) that the scomberesocid genus *Cololabis* is a permanently arrested stage in the ontogenetic development of *Scomberesox*.

TABLE 2.—Numbers of gill rakers for the scomberesocid fishes.

| Gill rakers | <i>Scomberesox saurus</i> | | <i>Cololabis saira</i> | <i>Nanichthys simulans</i> | <i>Ellassichthys adocetus</i> |
|-------------|---------------------------|---------------|------------------------|----------------------------|-------------------------------|
| | <i>scombroides</i> | <i>saurus</i> | | | |
| 15 | — | — | — | — | 12 |
| 16 | — | — | — | — | 51 |
| 17 | — | — | — | — | 120 |
| 18 | — | — | — | — | 135 |
| 19 | — | — | — | 1 | 53 |
| 20 | — | — | — | 3 | 27 |
| 21 | — | — | — | 8 | 5 |
| 22 | — | — | — | 24 | — |
| 23 | — | — | — | 19 | — |
| 24 | — | — | — | 12 | — |
| 25 | — | — | — | 8 | — |
| 26 | — | — | — | 4 | — |
| 32 | — | — | 2 | — | — |
| 33 | — | — | 5 | — | — |
| 34 | — | 1 | 23 | — | — |
| 35 | — | 5 | 34 | — | — |
| 36 | — | 11 | 47 | — | — |
| 37 | — | 9 | 84 | — | — |
| 38 | — | 17 | 63 | — | — |
| 39 | 6 | 18 | 50 | — | — |
| 40 | 12 | 20 | 43 | — | — |
| 41 | 28 | 18 | 16 | — | — |
| 42 | 36 | 6 | 8 | — | — |
| 43 | 47 | 5 | 3 | — | — |
| 44 | 41 | 3 | — | — | — |
| 45 | 43 | 1 | — | — | — |
| 46 | 35 | — | — | — | — |
| 47 | 19 | — | — | — | — |
| 48 | 11 | — | — | — | — |
| 49 | 11 | — | — | — | — |
| 50 | 4 | — | — | — | — |
| 51 | 3 | — | — | — | — |
| N | 296 | 114 | 378 | 79 | 403 |
| x | 44.11 | 39.19 | 37.53 | 22.84 | 17.66 |

TABLE 3.—Numbers of pectoral fin rays (both sides counted) and of total anal and dorsal fin rays (including finlets) for the scomberesocid fishes.

| Fin rays | <i>Scomberesox saurus</i> ¹ | <i>Cololabis saira</i> | <i>Nanichthys simulans</i> | <i>Elassichthys adocetus</i> |
|------------------|--|------------------------|----------------------------|------------------------------|
| Pectoral: | | | | |
| 8 | — | — | — | 6 |
| 9 | — | — | — | 203 |
| 10 | — | — | 99 | 122 |
| 11 | — | — | 54 | 1 |
| 12 | 8 | 124 | — | — |
| 13 | 108 | 962 | — | — |
| 14 | 37 | 388 | — | — |
| 15 | 1 | 8 | — | — |
| <i>N</i> | 154 | 1,482 | 153 | 332 |
| <i>x</i> | 13.20 | 13.19 | 10.35 | 9.36 |
| Dorsal: | | | | |
| 14 | — | 3 | 14 | 31 |
| 15 | 6 | 97 | 49 | 183 |
| 16 | 45 | 422 | 16 | 136 |
| 17 | 28 | 185 | — | 19 |
| 18 | 1 | 15 | — | 6 |
| <i>N</i> | 80 | 722 | 79 | 375 |
| <i>x</i> | 16.30 | 16.16 | 15.03 | 15.43 |
| Anal: | | | | |
| 16 | — | — | — | 1 |
| 17 | 1 | — | 1 | 13 |
| 18 | 18 | 24 | 9 | 103 |
| 19 | 84 | 250 | 48 | 188 |
| 20 | 30 | 370 | 20 | 49 |
| 21 | 11 | 67 | — | 2 |
| <i>N</i> | 144 | 711 | 78 | 356 |
| <i>x</i> | 19.22 | 19.68 | 19.11 | 18.78 |

¹Counts for all fin rays of the northern and southern subspecies of *Scomberesox saurus* are combined.

The much reduced size of *Nanichthys* and the even more extreme dwarfing of *Elassichthys* strongly support the hypothesis that they exhibit neotenic or paedomorphic tendencies, certainly dwarfism; we hold that they are not neotenic, in the strict sense, but merely dwarfed. The reduced numbers of gill rakers, pectoral rays, vertebrae (Tables 2-5), scales, and procurrent caudal rays provide confirmatory evidence (no marked differences were found in the numbers of dorsal and anal rays, either in the main fin or in the finlets). The loss of one ovary (or the complete fusion of the

TABLE 4.—Numbers of vertebrae for the scomberesocid fishes.

| Number of vertebrae | <i>Scomberesox saurus</i> | <i>Cololabis saira</i> | <i>Nanichthys simulans</i> | <i>Elassichthys adocetus</i> |
|---------------------|---------------------------|------------------------|----------------------------|------------------------------|
| 54 | — | — | — | 14 |
| 55 | — | — | — | 74 |
| 56 | — | — | — | 224 |
| 57 | — | — | — | 186 |
| 58 | — | — | 2 | 52 |
| 59 | — | — | 11 | 6 |
| 60 | — | — | 30 | — |
| 61 | — | — | 46 | — |
| 62 | — | 12 | 21 | — |
| 63 | — | 115 | — | — |
| 64 | 9 | 672 | — | — |
| 65 | 73 | 1,212 | — | — |
| 66 | 149 | 840 | — | — |
| 67 | 83 | 187 | — | — |
| 68 | 20 | 21 | — | — |
| 69 | 3 | 1 | — | — |
| 70 | 1 | — | — | — |
| <i>N</i> | 338 | 3,060 | 110 | 556 |
| <i>x</i> | 66.13 | 65.14 | 60.66 | 56.37 |

¹Counts for the southern and northern subspecies are combined.

pair), and a tremendous decrease in the production of ova, the more notable in *Elassichthys*, may well be correlated with the dwarfing of the two new genera (the ova, however, have not been notably decreased in size). The less extreme dwarfing of *Nanichthys* could be interpreted as reflecting the larger size of its presumed progenitor, *Scomberesox* (Figure 1, Table 1). The concept of *Nanichthys* and *Elassichthys* being the respective derivatives of *Scomberesox* and *Cololabis* could be interpreted as being supported by their similar beak structures (Figure 2), and by the common occurrence of *Scomberesox* and *Nanichthys* in the Atlantic and Indian Oceans and of *Cololabis* and *Elassichthys* in the Pacific, north of the range in that ocean of *Scomberesox*.

Herein we describe, discuss, and differentiate the two new dwarfed genera, *Nanichthys* and *Elassichthys*, and the new species *N. simulans*, distinguish the Southern Hemisphere population of *Scomberesox* as a subspecies, for which the

TABLE 5.—Correlated counts of precaudal and caudal vertebrae of the four genera of Scomberesocidae. Counts not otherwise marked represent *Elassichthys*; counts in italics refer to *Nanichthys*; counts in parentheses represent *Cololabis*; and counts in bold face type refer to *Scomberesox*.

| Genus | Precaudal vertebrae | Caudal vertebrae | | | | | | | | | |
|---------------------------------|---------------------|------------------|----|----|----|-------|---------|--------|------|-----|--|
| | | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | |
| <i>Elassichthys</i> | 32 | — | 1 | 1 | 1 | — | — | — | — | — | |
| | 33 | 2 | 7 | 23 | 8 | — | — | — | — | — | |
| | 34 | 1 | 21 | 52 | 8 | — | — | — | — | — | |
| <i>Nanichthys</i> | 35 | — | 7 | 5 | 12 | 1 | — | — | — | — | |
| | 36 | — | — | 14 | 21 | 14 | 2 | — | — | — | |
| <i>Cololabis</i> | 37 | — | 7 | 7 | 41 | 22 | (7) | (8) | (6) | — | |
| | 38 | — | 1 | — | 7 | 3 | (37) | (64) | (21) | (1) | |
| <i>Scomberesox</i> ¹ | 39 | — | — | — | — | (3) 1 | (37) | (63) 1 | (10) | (1) | |
| | 40 | — | — | — | — | 12 | 13 (11) | (15) | (4) | — | |
| | 41 | — | — | — | 17 | 63 | 31 | 1 | — | — | |
| | 42 | — | — | — | 6 | 19 | 6 | 1 | 1 | — | |
| | 43 | — | — | — | 2 | 2 | — | — | — | — | |

¹Counts for the southern and northern subspecies are combined.

name *S. saurus scombroides* (Richardson 1842) appears to have priority, and we portray the zoogeography of the four genera of the Scomberesocidae that we now recognize. Also, we append a discussion of Miocene fossils from California referred to the Scomberesocidae.

MATERIALS AND METHODS

We have examined material from the following repositories: AMS (Australian Museum, Sydney); BCFL (Bureau of Commercial Fisheries Laboratories (now NMFS), at Brunswick, Ga.; Honolulu Hawaii (formerly POFI); Seattle, Wash.; and Woods Hole, Mass.); BMNH (British Museum (Natural History)); BU (Boston University); CAS (California Academy of Sciences); CF (Carlsberg Foundation); CFG (California Fish and Game, San Pedro); CNHM, FMNH (Chicago Natural History Museum, Field Museum of Natural History); LACM (Los Angeles County Museum); MCZ (Museum of Comparative Zoology, Harvard University); MMF (Museo Municipal do Funchal, Madeira); SAM (South African Museum, Cape Town); SIO (Scripps Institution of Oceanography); SOSC (Smithsonian Oceanographic Sorting Center); SU (Stanford University; collections now at CAS); TABL (Tropical Atlantic Biological Laboratory, Miami); UMMZ (University of Michigan Museum of Zoology); USNM (United States National Museum); UW (University of Washington, Seattle); WHOI (Woods Hole Oceanographic Institution); ZMUC (Zoological Museum, University of Copenhagen); and ZSZM (Zoologisches Staatsinstitute und Zoologisches Museum, Hamburg).

Counts of dorsal and anal rays include the succeeding finlets because the last rays of the main fin proper are often too much like those of the first finlets for definitive separation, particularly in adults; usually the last rays of the fin proper are thickened at the base and much branched and

fanlike distally—in shape much like that of the first finlet. In young and subadults a space greater than that between the last rays of the fin proper usually separates the last ray and the first finlet, but this space is often obscured by a membrane or is not apparent in large specimens, particularly of *Scomberesox* and *Cololabis*. Pectoral rays of small and juvenile fish were counted using an air jet, or when submerged. Vertebrae were counted from radiographs or stained material (the latter method was used primarily for juveniles of *Cololabis*). The urostyle was included in the count.

Numbers of gill rakers for specimens of *Scomberesox* and *Cololabis* <70 mm SL and of *Nanichthys* and *Elassichthys* <30 mm SL are not included in the tabular data because at shorter sizes the anterior rakers fade gradually into diminishing nubs of tissue that require highly subjective interpretation.

Lateral lines scales were removed from the left side within a distance no >10 mm anterior to the origin of the pelvic fin. To enhance visibility of circuli the scales were lightly stained in a weak solution of Alizarin Red S and visually monitored for adequate uptake of stain. The scales of both *Scomberesox* (particularly) and of *Cololabis* were quite tenacious, so much so that they needed to be cut away from the body and the adhering tissue manually removed. Remaining bits of tissue often were so firmly attached that they could not be pulled off with forceps; immersion in 2% KOH eroded the scales without removing the bits of tissue.

As most specimens of *Scomberesox* examined had the tips of the beaks broken off, proportions in all the species are based on body length rather than standard length. Body length is defined as the distance from the posterior margin of the orbit to the end of the hypural plate; this end point was determined by flexing the caudal fin until a crease appeared, approximately at the end of the hypural.

KEY TO SPECIES OF SCOMBERESOCID FISHES

- 1a. Gill rakers numerous (34-51), very closely spaced. Pectoral rays 12-15. Procurent caudal rays 5-7. Depth of caudal peduncle equal to or less than its length 2
- 1b. Gill rakers fewer (15-26), less closely spaced. Pectoral rays 8-11. Procurent caudal rays 2-5. Depth of caudal peduncle one-half to less than its length 3
- 2a. Both jaws produced into long, slender beaks in specimens >100 mm SL, the lower slightly longer. Maximum size about 450-500 mm SL. Known from temperate waters of North Atlantic and all southern oceans *Scomberesox saurus*

- 2b. Jaws only moderately produced into blunt beaks, the lower slightly longer. Maximum size about 400 mm SL. Native only in North Pacific Ocean *Cololabis saira*
- 3a. Jaws of adults produced as slender beaks, the lower about twice the length of upper. Gill rakers 22-24 (19-26). Procurent caudal rays 4 (3-5). Maximum size to 126 mm, usually about 100 mm. Known only from warm-temperate waters of Atlantic and Indian Oceans *Nanichthys simulans*
- 3b. Upper jaw very little produced, bluntly rounded, the lower jaw slightly more produced and more pointed at all sizes. Gill rakers 17-18 (15-21). Procurent caudal rays 2-3. Maximum size to 68 mm SL. Known only from eastern tropical Pacific and westward to Hawaii *Elassichthys adocetus*

AIDS TO IDENTIFICATION

If the specimen is determined to be one of the larger species, pertinence to *S. saurus* or *C. saira* will be obvious from the oceanic source of the material, and, for all but the very young, from the presence or absence of a beak (Figure 2); even if the long beaks of *Scomberesox* are broken off near the base the stubbed condition will be obvious. However, if the very young of one or both species should be taken in the eastern Pacific Ocean in the upwelling area along the Equator (which now seems unlikely from the distributional evidence discussed below), it would hardly be feasible to arrive at a certain identification on the basis of beak development alone until the beak begins to develop at about 40 mm SL; but the reduced numbers of pectoral and procurent caudal rays and of gill rakers (rather short and widely spaced) readily distinguish *Elassichthys* from *Scomberesox* and *Cololabis*. The development of the beak is the most trenchant distinction between *Scomberesox* and *Cololabis*; counts (Tables 2-5) and morphometric values (Table 6) overlap widely.

If the specimen is determined to be a dwarf, its pertinence to *E. adocetus* or *N. simulans* will probably always be determinable from the locality of capture, and, for specimens longer than about 50 mm, from the incipient to full development of the beak (Figure 2); in fact, in *Elassichthys* the upper jaw never becomes really beaklike, only broadly rounded, not moderately pointed as in *C. saira* of comparable size (Figure 4). If further check is desired, separations may be attained by counting gill rakers, pectoral rays, or vertebrae (Tables 2-5). Ueyanagi and Doi (1971) showed that in young of *Elassichthys* (≤ 30 mm) the depth of the caudal peduncle was one-half or less of its length, but was about equal in *S. saurus* and *C. saira*. We find (original data) *N. simulans* to have a ratio of depth to length of caudal peduncle similar to that of *E. adocetus*. These ratios hold for all sizes of the four species.

The scomberesocid fishes inhabiting the Atlantic or Indian Oceans may be either *N. simulans* or *S. saurus*, determinable by the meristic counts (Tables 2-4). At lengths greater than about 60 mm, the relative development of unbroken beaks should ordinarily be decisive (Figure 2).

TABLE 6.—Selected body proportions from 36 specimens each of the four species of scomberesocid fishes (thousandths of body length).

| Body proportion | <i>Scomberesox saurus saurus</i> (26-223 mm) | | <i>Scomberesox s. scombroides</i> (63-300 mm) | | <i>Nanichthys simulans</i> (32-77 mm) | | <i>Elassichthys adocetus</i> (29-60 mm) | | <i>Cololabis saira</i> (50-239 mm) | |
|---|--|---------|---|---------|---------------------------------------|---------|---|---------|------------------------------------|---------|
| | \bar{x} | Range | \bar{x} | Range | \bar{x} | Range | \bar{x} | Range | \bar{x} | Range |
| Orbit length | 49 | 36-39 | 45 | 37-59 | 52 | 41-64 | 50 | 43-58 | 43 | 35-53 |
| Postorbital head length | 104 | 82-124 | 105 | 92-120 | 99 | 88-111 | 89 | 80-102 | 113 | 103-126 |
| Body depth at origin of pelvic fin | 132 | 109-160 | 126 | 115-139 | 113 | 95-135 | 115 | 95-131 | 136 | 121-153 |
| Distance from origins of dorsal and anal fins | 127 | 105-143 | 123 | 111-137 | 108 | 98-119 | 107 | 93-116 | 127 | 111-147 |
| Posterior margin of orbit to origins of: | | | | | | | | | | |
| Pelvic fin | 513 | 474-525 | 501 | 475-536 | 460 | 444-487 | 447 | 417-485 | 478 | 457-502 |
| Anal fin | 661 | 611-692 | 669 | 642-707 | 621 | 604-645 | 628 | 606-654 | 643 | 620-668 |
| Dorsal fin | 684 | 650-715 | 685 | 658-723 | 648 | 631-672 | 652 | 630-673 | 679 | 661-707 |
| End of hypural to origins of: | | | | | | | | | | |
| Pelvic fin | 512 | 487-538 | 515 | 483-542 | 549 | 529-565 | 560 | 529-586 | 529 | 518-546 |
| Anal fin | 354 | 317-396 | 343 | 314-371 | 388 | 363-406 | 380 | 351-400 | 361 | 326-381 |
| Dorsal fin | 330 | 298-369 | 322 | 281-350 | 359 | 341-379 | 357 | 330-374 | 329 | 312-350 |



FIGURE 4.—Upper—Dorsal view of bluntly rounded tip of upper beak of adult *Elassichthys adocetus*, 59.0 mm SL. Lower—Dorsal view of moderately pointed tip of upper beak of juvenile *Colobaxis saira*, 58.0 mm SL.

DESCRIPTION OF NEW TAXA

Nanichthys Hubbs and Wisner, new genus

New genus, Hubbs and Wisner.—Collette 1966:4, 6, 7, 20 (reduced counts; neotenic [this seems to be the only published reference to *Nanichthys* as a genus]).

Genotype, *Nanichthys simulans*, new species.

Diagnosis.—A dwarfed scomberesocid (maximum known standard length 126 mm), agreeing with

Elassichthys in having a single median ovary, when ripe largely filling the expanded coelom, and the testis folded together into a single median band. Gas bladder completely obsolete. Lateral line developed only anteriorly. Premaxillary and mandibular tooth rows closely approximated at front. Upper jaw produced as an extremely slender beak about half as long as in *S. saurus* and much slenderer (in both lateral and dorsal aspects) than the much stronger but still slender lower beak, which is only about half as long as, and much less attenuate than, that in adult *S. saurus*. The major

counts are much reduced: vertebrae 58-62, transverse scale rows along midlateral line 70-88, procurrent caudal rays 4 (rarely 3 or 5), pectoral rays 8-11, rakers on first gill arch 19-25 (usually 22-24).

Derivation of generic name.—From the Greek *vâvoσ* (nanos), a dwarf, and *ιϑύσ* (ichthys) a fish.

Nanichthys simulans Hubbs and Wisner,
new species Figure 5

Derivation of species name.—From the Latin, *simulans* (imitating).

Holotype.—SIO 63-546, an adult male 89.5 mm SL, dipnetted at surface under a light in the south central Atlantic Ocean at 24°02.5' S, 15°32.0' W, on 9 June 1963; deposited in the Marine Vertebrate Collection of the Scripps Institution of Oceanography.

Paratypes.—All dipnetted in the southern Atlantic Ocean at night under a light. Marine Vertebrate Collection of the Scripps Institution of Oceanography: SIO 63-545, 8 (46-69 mm), 12 June 1963, 29°51.5' S, 11°07' W; SIO 63-546, 17 (47-90 mm), 19 June 1963, 24°02.5' S, 15°32.0' W; SIO 63-548, 16 (20-76 mm), 20 June 1963, 23°42.0' S, 12°12.5' W; SIO 63-549, 6 (55-87 mm), 22 June 1963, 21°21.0' S, 11°34.5' W; SIO 63-550, 7 (45-80 mm), 24 June 1963, 20°10.5' S, 11°30.5' W; SIO 63-553, 4 (67-90 mm), 26 June 1963, 17°39.0' S, 12°22.0' W; SIO 63-555, 11 (38-66 mm), 28 June 1963, 15°48.0' S, 16°50.0' W; SIO 63-571, 2 (38 and 44 mm), 22 July 1963, 11°35.0' S, 44°01.0' W.

USNM 204257, 2 (68 and 101 mm), 15°45' S, 08°45' E; USNM 204258, 4 (42-66 mm), 32°57' N, 39°21' W.

We plan to transfer some of the Scripps paratypes listed above to USNM, MCZ, Philadelphia Academy of Natural Sciences (ANSP), CAS, and BMNH.

We do not assign paratype designation to many additional specimens, mostly very small, from the mid-Atlantic, nor to the few examples seen from the Indian Ocean, nor to two specimens, unusually large for this dwarf species, from Funchal, Madeira (these two are discussed on p. 541).

Synonymy of Nanichthys simulans

Scombresox scutellatus (not *Scomberesox scutul-*

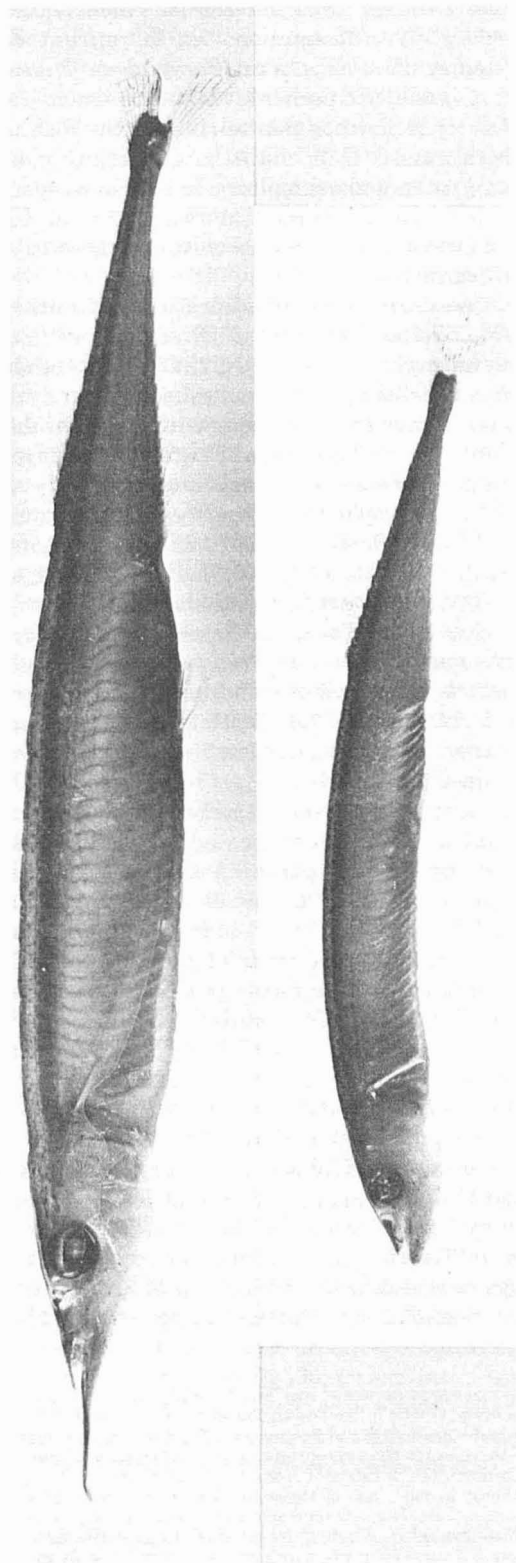


FIGURE 5.—Upper—*Nanichthys simulans*, holotype, adult male, 89.5 mm SL, SIO63-546. Lower—*Elassichthys adocetus*, adult male, 64.7 mm SL, SIOH52-380.

latum LeSueur 1822:132-133²)—Valenciennes 1846:477-479 (description: "en le retirant de l'estomac d'un coryphène (*Coryphaena equisetis*) . . . venait de pecher à vingt-cinq lieues [ca. 2.76 mi] au nord de Sainte-Hélène [St. Helena Isle, about 16° S in mid-Atlantic Ocean]; nous avons un second exemplaire de la même espèce . . . fit à l'Isle-de-France [Mauritius Island, Indian Ocean] ou pendant sa traversée de retour" [to France].

Scomberesox saurus (misidentification).—Günther 1866:257-258 ("Atlantic, 3° N of the line"; St. Helena; probably also 20° N, 22°53' N and other series); 1889:34 (" . . . fry and young . . . belong to most common forms of pelagic life . . . from the Atlantic . . .").³ Sauvage 1891:526 (listed from near Madagascar, between 3° and 26° S, 42° and 65° E; presumed from locality). Murray and Hjort 1912:89, 90, 94, 607, 613 (14 stations listed), 633, 635, 644, 670, 741, 747-748, figs. 541-542, all in part or questionable, listed both as "*Scomberesox*" and as "*Scomberesox saurus*," from open Atlantic in area between Iceland, Morocco, and Newfoundland; size to 50 cm. Barnard 1925:259, fig. 16b (St. Helena record only). Cadenat 1950:298 (presumed from locality off Iles du Cap Vert).

Scomberesox saurus (misidentification).—Lütken 1880:564-569, 1 fig., repeated by Murray and Hjort, see above (in part: in Atlantic Ocean from 11°30' to 48° N, 9° to 40° W, and from 12° to 40°32' S, 52° W to 16°30' E; in Indian Ocean from 27° to 38°20' S, and from 24°30' to 101°40' E; measurements and counts presumably also in part). Regan 1916:142 (postlarvae from south of Azores, at 29°10' N, 33°36' W, identification dubious). Bigelow and Welsh 1925:166, fig. 71 (range, 11°-12° to 40° N in Atlantic (presumably in part), figure repeated from Murray and Hjort, see above). Hildebrand and Schroeder 1928:151-152 (range, in part, and description of young, from Bigelow and Welsh 1925). Sivertsen 1945:6 (in part, St. Helena record only). Bigelow and Schroeder 1953:170-171, fig. 83 (in part, doubtful, description; young—100 to 150

mm "hemiramphus stage," most numerous in open Atlantic between 11° or 12° and 40° N). Smith 1955:308 (presumptive, listed from Al-dabra Island). Fowler 1956:141-142 (reference to Borodin's 1930 dubious (unverified) Red Sea record; South Africa, description taken from New England and New York material of *S. saurus* and not "Indo-Pacific" entry). Briggs 1958:264 (presumptive, in part, western Atlantic from Newfoundland and Bermuda to Argentina, 35° to 30° S). Rodríguez-Roda 1960:115 (presumed from locality; southern Spain, Strait of Gibraltar). Hotta 1964:4-5 (in part, presumptive, distribution). Leim and Scott 1966:168 (in part, presumptive, in western Atlantic south to West Indies; fry abundant between 11° and 40° N; jaws do not reach full length until fish are 4 to 6 in long). Sauskan and Semenov 1969:250-252, fig. 157 (two populations inferred in North Atlantic, 32° to 36° N, 50° to 70° W, and near Azores; feeding migration) (in part, presumed from locality). Zilanov and Bogdanov 1969, fig. 158 (size groups, migrations, northeast Atlantic, 30° to 60° N, 8° to 40° W) (in part, presumed from locality). Hartmann 1970 (2.0 mm eggs in 68 mm scomberesocids from northeastern Atlantic can refer to only *N. simulans*).

Scomberesox sp.—Parin 1968b, fig. 31 (planktonic, records mapped in tropical eastern Atlantic and north of Madagascar, Indian Ocean); 1968a, fig. 1 (undescribed species under study by Hubbs and Wisner). Parin and Andriashev 1972 (dwarf Atlantic species, along 26° W between 24° and 30° S, and in western cruise track off South America in area of 32° S, temperature 20.4° to 22.4° C). Parin 1973 (reference to Parin 1968a; to be described by Hubbs and Wisner; abundant, epipelagic, Atlantic off Madeira, Canaries, Morocco, Portugal, to 40° N). Ueyanagi et al. 1972, fig. 1, 2 (sizes graphed, distribution in Atlantic mapped). Suda 1973, fig. 7 (life history presumably similar to that of *Cololabis adocetus*; not suitable for commercial fishery). Dudnik 1975b, fig. (general discussion; comparison with *S. saurus* in range and characters; one ovary developed, second rudimentary; ova sizes; spawning prolonged). Wisner 1977, fig. (description, key; compared with *S. saurus*, Belonidae, and Hemiramphidae; distribution in northwestern central Atlantic). Hardy 1978, fig. 29-34 (in part, North Atlantic; "*Scomberesox* sp." in reference to Hartmann, 1970, statement of 2.0 mm eggs in females 68 mm and over).

²LeSueur's type-specimen was "small," with upper beak about half of other; it was ". . . found in the stomach of a fresh codfish which had been brought to Boston from the Bank of Newfoundland," therefore in the appropriate range of *Scomberesox saurus* and far north of the range of *Nanichthys simulans*.

³At least in part; one of three specimens involved, but not mentioned, from Tenerife (one of the Canary Islands) has been identified for us as *N. simulans* by G. Palmer of the British Museum (Natural History), using characters outlined by us.

Discussion of Synonymy.—It has been consistently overlooked that Valenciennes [1846 (XVIII):477-479] recognizably described this dwarf scomberesocid, from 25 leagues north of Saint Helena Island in the tropical Atlantic Ocean and from Mauritius Island in the Indian Ocean or on the return journey [to France]. He misidentified this species as *Scombresox scutellatum* LeSeuer. However, *Scombresox scutellatum* LeSueur (1822) was based on a small specimen, obviously of *Scombresox saurus*, that was taken from the stomach of a cod brought to Boston from the bank of Newfoundland. The Atlantic specimen described by Valenciennes also was supposed to be a young saury that had been eaten by a dolphin fish, identified as *Coryphaena equisetis*, caught "à vingt-cinq lieues au nord de Sainte-Hélène." Assuming this to be the island on which Napoleon was confined, on the basis of 2.76 mi to a league, from the old French system, the location was approximately 14°48' S, 05°42' W (marked as an open circle on Figure 12). This location is obviously within the now known habitat of *Nanichthys simulans* and far from the range of *S. saurus*, whereas the specimen treated by LeSueur was centered within the area where *S. saurus* alone occurs, in abundance.

That Valenciennes had an example of the dwarf Atlantic saury is obvious from his description of the beak in a small specimen. Valenciennes wrote: "La brèveté du museau est aussi non moins remarquable; car le longueur du bec n'est quère moitié du reste de la tete; le bec supérieur lui-meme n'est pas beaucoup plus prolongé que celui des plusieurs hémiramphes." He further stated (p. 478), "Ce petit poisson, long de deux pouces neuf lignes. . . ." Since the old French "pouce" was 27.07 mm long, and a "ligne" one-twelfth of a pouce, we compute the length of the fish as about 75 mm. A scomberesocid of this size, with beak scarcely half the length of the head behind the beak, and with snout comparable with that of a hemiramphid, could scarcely be other than a *Nanichthys*. Since the specimen collected at "l'Isle-de-France" [Mauritius], or on the return journey, was described as of the same size and of the same species, and since *N. simulans* is now known to occur in the southern Indian Ocean, it has seemed highly probable that it also pertains to that species. This assumption has been verified for us, very kindly, by Marie-Louise Bauchot⁴ who has found that the two

specimens, respectively 66.9 and 67.1 mm SL, have 11 and 10 pectoral rays, 23 and 22 gill rakers, and 59 and 60 vertebrae (within the range for *N. simulans* but far below the range for *S. saurus*).

It is now clear that Lütken (1880:564-569, fig. a-h) unknowingly included *N. simulans* as well as *Scombresox s. saurus* in his account of *S. saurus*. This is evident from his statement of latitudinal distribution in the Atlantic Ocean from 11°30' to 48° N and from 12° to 40°32' S, and in the Indian Ocean from 27° to 38°20' S, as well as from his figures; figures c, d, and e represent fish 51, 60, and 100 mm TL from tip of mandible to caudal-fin fork (corresponding to standard lengths of about 47, 55, and 89 mm, from tip of upper jaw to base of caudal fin). Beaks of specimens f-h (170 mm to full adult) pertain to *Scombresox*. Comparison of these three figures with our illustrations of growth changes in the four species (Figure 2) demonstrates agreement only with *N. simulans*. The divergent approach toward hemiramphine beak structure in this developmental series of *Nanichthys* apparently did not disturb Lütken, for he showed in the same compilation of figures the development of *Belone vulgaris* from the beakless very young through the halfbeaked juveniles to the nearly full-beaked adult stage. In the lack of locality data it is not clear which species are represented by Lütken's figures a and b, which represent prejuveniles, 16 and 30 mm in fork length, with almost no beak development.

The epochal treatise of Atlantic epipelagic fishes by Murray and Hjort (1912), expanding that of Lütken (1880), recognized the preponderance of Scomberesocidae in the mid-Atlantic but failed to distinguish between *S. saurus* and *N. simulans*. Evidence in these classics, however, renders it clear that both accounts dealt with both species. Murray and Hjort's figure 541 of a 6.2 cm saury (on p. 747) almost surely represents *N. simulans* by reason of the better development of the beaks at that size (although the body was drawn too deep). Their figure 542 is a copy of Lütken's figure 567 (discussed above). The well-filamented egg labeled "Egg of Scomberesocid" (fig. 531) was obviously misidentified and very probably represents an exocoetid (Orton 1964). The treatment of sauries by Murray and Hjort pertains almost wholly to young (the maximum size given, 50 cm, was presumably drawn from some other source); they

⁴Marie-Louise Bauchot, Fish Division, Museum National

d'Historia Naturelle, Rue Cuvier, 57, Paris, France, pers. commun. 2 May 1968.

stated that only "young scomberesocids" were taken on the cruise.

The accounts of *S. saurus* by Bigelow and Welsh (1925) and by Bigelow and Schroeder (1953) definitely also involved *N. simulans*. The figure of the young, after Murray and Hjort, definitely represents the dwarf species, as does the text account of the "young": "The most interesting phase in the development of the skipper is that its jaws do not commence to elongate until the fry have grown to about 1½ inches (40 mm.), and that the lower jaw out-strips the upper at first, so that fry of 4 to 6 (100 to 150 mm.) inches look more like little halfbeaks ('Hemiramphus' stage) than like their own parents" (quoted from Bigelow and Schroeder). These confusions were also expressed by Hildebrand and Schroeder (1928).

Inclusion of *Scomberesox s. saurus* (Günther 1889) in part, in the synonymy of this species, and the inclusion of this species in the British Museum collection, have been verified for us by G. Palmer⁵ by examination, with our findings at hand, of the following specimens: six young, 31-61 mm, from St. Helena; three, 64-68 mm, from "Atlantic" (Godfrey); three, 29-93 mm, collected by Jones; one of 96 mm of the two without locality collected by Haslar; one of 69 mm taken by Vallentin at 18°32' N, 29°09' W; one of 52 mm, with two of *S. s. saurus*, taken at Tenerife (Canary Islands) by the *Challenger*; and one of 131 mm (total body length—see p. 541) by G. Maul in Funchal Harbor, Madeira. Günther (1866, vol. 6:257) reported *Scomberesox saurus* "From 1½ to 7 inches long" from "Atlantic, 3° N. of the line," which, on distributional grounds, assuming correct latitude, would be expected to be *Nanichthys*. However, G. Palmer reports an extant specimen 156 mm long, listed with three of 66-98 mm, from "Atlantic (Godfrey)" that is probably the 7-in specimen, but Palmer finds it to be *Scomberesox*.

Zoogeographical considerations might lead to the citation in the synonymy of *Nanichthys simulans* of the material recorded as *Scomberesox saurus* by Arnoult et al. (1966) from off Liberia and Equatorial Guinea [Iles Principe], but Marie-Louise Bauchot (see footnote 4) has informed us that a reexamination of the five specimens involved led her to reidentify them as *Strongylura senegalensis* (Valenciennes) and *Platybelone argalus* (LeSueur).

Although Valenciennes (1846) applied the name *Scomberesox scutullatus* to what now seems surely to be *Nanichthys simulans* (q.v.), we regard the original *Scomberesox scutullatum* LeSueur as having been based on *S. s. saurus*. The locality "Bank of Newfoundland" is in the range of that form and probably far outside the range of its dwarfed relative. The one pertinent key character given, that of 13 pectoral rays, confirms pertinence to *Scomberesox*.

Elassichthys Hubbs and Wisner, new genus

New genus, Hubbs and Wisner.—Collette 1966:4, 6, 7, 15, 20 (reduced meristics; neotenic [this seems to be the only published reference to *Elassichthys* as a genus]).

Genotype, *Cololabis adocetus* Böhlke 1951.

Diagnosis.—A greatly dwarfed scomberesocid (maximum known standard length ca. 68 mm), agreeing with *Nanichthys* in having a single median ovary largely filling, when ripe, the expanded coelom, and the paired testes folded together into a single median band with the division on the right side. Gas bladder and lateral line scales obsolete. Upper jaw very broadly and evenly rounded in dorsal aspect and only moderately pointed in lateral view; lower jaw only moderately pointed at the tuberculate tip (Figure 4). Premaxillary and mandibular tooth rows very broadly separated at front. Counts minimal for the family: vertebrae 52-59, usually only 56 or 57; transverse scale rows along midlateral line 70-78; procurrent caudal rays reduced to only 2 or 3; rakers on first gill arch 15-21, usually 17 or 18.

Derivation.—From the Greek, ἐλάσσων, smaller, less, and ἰχθύς, a fish.

Elassichthys adocetus Böhlke 1951 Figure 5B

Scomberesox sp.—Kendall and Radcliffe 1912:84, 167 (in part).⁶

⁶Young of *Scomberesox saurus scombroides* may well have been included; only three specimens (in Museum of Comparative Zoology), among those listed, have been examined by us and all were found to be *E. adocetus* from Albatross stations 4657 (07°12'30" S, 84°09' W), 4708 (11°40' S, 96°55' W), and 4730 (17°19' S, 100°52'30" W). *Scomberesox s. scombroides* also occurs in these areas.

⁵G. Palmer, Department of Zoology, British Museum (Natural History), Cromwell Road, London SW7, England, pers. commun. 3 May 1968.

Cololabis saira (misidentification).—Schaefer and Reintjes 1950:164 (between California and Hawaii at 28°22' N, 137°12' W; 25°14' N, 144°41' W; 23°52' N, 148°41' W; 23°04' N, 153°19' W; compared with "*Cololabis adocetus*," these records thought [erroneously] to confirm reference of *Cololabis brevirostris* to *C. saira* by Hubbs 1916:157 and by Schultz 1940:270). Ramírez Hernández and Gonzáles Pagés 1976:74 (reference to Perú only).

Cololabis sp.—Clemens 1955:165 (3°31' S, 81°11' W [presumptive identification due to locality]). King and Iversen 1962:301, tables 19-20, appendix table 8 (one 86 mm specimen taken in Equatorial Counter Current) [identification presumed from locality].⁷

Scomberesocidae.—Mais and Jow 1960:131 (02°54' S, 99°37' W) [identification presumed from locality].

Cololabis adocetus.—Böhlke 1951:83-87 (original description; comparison, phylogeny; from 160 mi southwest of San Juan, Perú (17° S, 76°50' W) (holotype); and off Perú at 10°01' S, 80°05' W; west of Chinchá Isles, Perú, 13°35' S, 76°50' W; arrested development). Knauss 1957:236 (in oceanic front at about 3° N, 120° W). Gosline 1959:73 (neotenic); Gosline and Brock 1960:128, 318 (Hawaii; compared with *C. saira*). Chyung 1961:277 (reference to Böhlke 1951). Koepcke 1962:197 (references; known only from Perú, 10° to 17° S). Clemens and Nowell 1963:251-255 (records off Ecuador, Perú, Chile). Hotta 1964:4, fig. 22 (distribution off Perú). Orton 1964:144-145, 148-149 (description of pelagic and ovarian eggs from off Perú, 8°07' to 10°51' W; range overlaps that of *S. saurus*; vertebral numbers). Lindberg and Legeza 1965:209 translation, 1969:201 (Perú). Collette 1966:3, 15 (neoteny; meristic reduction; phylogeny; generic status). Ebeling 1967:599 (distribution mainly in central water mass in eastern Pacific Ocean). Parin 1967b:150 (117 in translation) (larvae may be caught near surface at any time of day); 1967a: many pages (distribution in very warm water). Rass 1967:58, 60, 63-66, 129 (distribution). Parin 1968b: many pages (an epipelagic fish said to be limited to tropical waters of eastern Pacific and near Hawaii); 1968a: many pages, fig. 2, 3, 5

(comparisons, relationships; distribution and ecology). Chirichigno F. 1969:40 (vernaculars in Perú, Chile). Parin 1969a:715, 719, fig. (epipelagic); distribution, dwarf fish, false pike; eastern tropical Pacific); 1969b:577 (462 in translation), fig. 2 (northern part of area surveyed off west side of South America; numerical abundance charted; as many as 1,000 trawled in 20 min with pleuston net south of Galápagos Islands). Ueyanagi et al. 1969:6-7, fig. 12 (occurrence off Perú). Ueyanagi and Doi 1971:17-21, fig. 15 (distribution in southeastern Pacific mapped; characters distinguishing juveniles of *C. adocetus* from *C. saira* and *S. saurus*). Ahlstrom 1972:1192, 1196, fig. 14 (occurrence of larvae in eastern tropical Pacific). Suda 1973:2134-2135, fig. 7 (range in eastern Pacific; dwarf species; not suitable for a commercial fishery). Chirichigno F. 1974:318-319, 331, fig. 628 (characters in key; Perú, 10° to 12° S). Nelson 1976:172 (neotenic). Parin 1975:314-316 (records near Equator at about 97° W).

The Southern Subspecies of *Scomberesox saurus*

We have found that the disjunct, widespread, circumglobal Southern Hemisphere population of *Scomberesox saurus* is slightly differentiated from the topotypic Northern Hemisphere Atlantic form, as Parin (1968a) has tentatively suggested. Before presenting the evidence we list, with annotations, the rather complicated synonymic references that apply distinctively to the southern form, and here eliminate references in which the names used are synonyms of the North Atlantic subspecies *Scomberesox saurus saurus*, namely *Scombresox*, *Scomberesox*, or *Scombresose*, *equirostrum* or *aequirostrum*, *Scombresox* or *Scomberesox rondeletii*, or *Scomberesox storeri*. We have, however, retained carded citations to those references.

Scomberesox saurus scombroides (Richardson 1842)⁸

Esox saurus.—Schneider in Bloch and Schneider 1801:394 (in part; "J. R. Forster MSS. II. 63"; New Zealand).

⁷The general area of the Equatorial Countercurrent, in which the small specimen was taken, is stated as between about 05° and 10° S (fig. 12). No coordinates were given for the capture but the area sampled within this current extended from about 108° to 160° W (fig. 4).

⁸The synonymy of what we treat as the Southern Hemisphere subspecies of *Scomberesox saurus* lists in sequence of first usage the varied names that have been applied thereto, whether originally based on the Northern Hemisphere form or on Southern Hemisphere material.

Scombresox saurus.—Günther 1866, vol. 6:257 (in part; records from Cape of Good Hope only). McCoy 1888:135, fig. 2 (description; Queensland). Jordan and Evermann 1896:726 (in part; reference for *S. forsteri* only). Gilchrist 1901:152 (occurrence off South Africa). Miranda-Ribeiro 1915:22 (reference to C. Berg's original account of the species in South America); 1918:16 (characters and range, in part; Montevideo; no Brazil locality included). Barnard 1925:259-260, fig. 16 (in part; references; characters; St. Helena Bay, Table Bay, and Cape Point to Mossel Bay, South Africa; New Zealand; Australia; synonymy; general remarks). Ehrenbaum 1936:75 (Pacific and Indian Oceans only). Barnard 1950:72 (characters; St. Helena Bay to Mossel Bay in South Africa, southern Australia, and New Zealand; large schools near surface; leaping; prey).

Scomberesox saurus.—Berg 1895:25 (in part; Montevideo). Schreiner and Miranda-Ribeiro 1902:37 (in part; habitat: Atlantic from coast of North America to Montevideo (Berg), Africa and Europe). Gilchrist 1904:145-147, 152, pl. 10 (eggs and larvae; off Cape Point, South Africa). Devincenzi 1924:190 (reference to Berg; counts; apparently rare in Uruguay). Devincenzi and Baratini 1928:152, pl. 18, fig. 4, 5 (Uruguay). Hildebrand and Schroeder 1928:152 (in part; New Zealand). Pozzi and Bordané 1935:159 (35°30' S to Argentina, habitat). Fowler 1936:436-438, fig. 216 (in part; synonymy; description based on North Atlantic material; South Africa record from Barnard 1925); 1942a (Brazil)⁹. Sivertsen 1945:6 (in part; description; from stomach of *Diomedea*; North Atlantic; St. Helena, South Africa, New Zealand, S. Australia). Lozano Rey 1947:597 (in part; New Zealand and South Africa in range). Smith 1949 (and 2d ed., 1953):129, fig. 224 (along most of South Africa; remarks). De Buen 1950:92 (in part; reference to Montevideo reports). Fowler 1956:141-142 (characters; in part; South Africa; Indo-Pacific). López 1957:145-151, fig. 1-8 (synonymy and records for South American

Atlantic; mouth of Río de la Plata at 36°52' S, 54°02' W; development of beak; mucus canal system of head; digestive canal). Briggs 1958:264 (Atlantic, Indian, and western Pacific Oceans; in western Atlantic to Argentina). Wheeler and Mistakidis 1960:334 (in part; Tristan da Cunha, record only). Clemens and Nowell 1963:253-255 (17°30' S, 71°30' W; 20°25' S, 70°43' W). Hotta 1964:4-7, fig. g. 2-5, table 1 (in part; distribution mapped, southern oceans). Parin and Gorbunova 1964:224 (translation, 1966:237) (Indian Ocean; mentions *S. saurus* having pelagic eggs in open ocean, reference to Haeckel 1855 and Sanzo 1940). Parin 1967a (translation 1971): many pages (in part; epipelagic fish; distribution in Pacific; development); 1967b:150 (117 in translation) (among most plentiful fishes in moderately warm waters of both hemispheres; larvae common at surface day and night). Penrith 1967:524, 544-545 (Tristan da Cunha, at 37°05' S, 17°40' W [error for 12°17' W]; surface-living). Rass 1967:58-66, fig. 10 (in part; distribution in Pacific; general remarks). Parin 1968b (and translation 1970): many pages (in part; world distribution in epipelagic zone); 1968a:275-290, fig. 2-5 (in part; development and numbers of gill rakers; distribution, with records; synonymy); 1969a:719, fig. (in part; place in high-seas fauna; distribution mapped in North Atlantic and in Southern Hemisphere); 1969b:577, 579 (462, 464 in translation), fig. 2 (in part of area surveyed off west coast of South America; numerical abundance charted). Ueyanagi et al. 1969:6-7, fig. 12 (occurrence in all southern oceans). Tortonese 1970:366 (in part; temperate region of whole ocean). Ben-Tuvia 1971:10, 29, 35 (cosmopolitan [in part]). Ueyanagi and Doi 1971:17-21, fig. 15 (distribution in southeastern Pacific mapped; characters distinguishing juveniles of *Cololabis adocetus*, *C. saira*, and *S. saurus*). Parin and Andriashev 1972:963 (866 in translation) (along 26° W between 37° and 39° S, and along west profile off South America between 34° and 45° S; temperature from 14.3° to 20.4° C). Chigirinsky 1972:151-165, fig. 1-13 (size and composition in southeastern Pacific); 1973:198-215, fig. (in part; "winter" range 5°-7° S in southeastern Pacific; spawning intermittent throughout year; stock and catch estimated). Ueyanagi et al. 1972:15-19, fig. 1-2 (size of fish graphed; distribution in Atlantic Ocean mapped). Parin 1973:261-262 [in CLOFNAM] (in part; southern

⁹Fowler entered, under the species name, merely "Brasil (Ribeiro, 1915)," but Miranda-Ribeiro (1915), in his *Fauna Brasiliense*, Scomberesocidae, p. 21, the 16th or 22d page of the book, gave as the basis for including the species in his treatise on Brazilian fishes the range statement: "... habita o Atlantico desde Cap. Cod. na America do Norte, costas da Europa e da Africa e foi constatado em aguas de Montevideo pelo Dr. Carlos Berg." This circumstance was probably the basis for the listing of the Scomberesocidae in Brazil by Fowler (1942b:384).

- form in synonymy; reference to Parin's (1968a) use of *S. s. scombroides*). Suda 1973:2134-2135, fig. 7-9 (in part; distribution of larvae and pre-adults; potential fishery). Kawamura 1974: many pages (in food of southern sei whale; seems to swarm at surface, probably at patches of crustacea on which it may feed). Kusaka 1974:26, 111, fig. 163 (urohyal of 318 mm specimen from off Cape Town similar to that of *C. saira*). Dudnik 1975a:203-210 (182-188 in translation), fig. 1-2 (limits of distribution of larvae, fingerlings, and juveniles in winter in South Atlantic from South America to Africa); 1975b:738-743 (503-506 in translation, in which names were misspelled *Scombresox* and *Scomberesocidae*), fig. (*S. saurus* compared with *Scomberesox* sp. Parin [= *Nanichthys simulans*]; distribution in Atlantic Ocean). Robertson 1975:7, 18, fig. 4a (planktonic egg; offshore waters around New Zealand). Smith 1975:22 (southern Africa; Afrikaans and English vernaculars). Wheeler 1975:324 (circumpolar in Southern Hemisphere; off South America, South Africa, South Australia, and across Pacific to American continent). Paxton in Allen et al. 1976:387 (references; circumglobal in Southern Hemisphere, including eastern Australia and New Zealand as *S. forsteri*; North Atlantic and Mediterranean).
- Sairis scombroides*.—Richardson 1842:26 (synonymy; valid characters adopted¹⁰ verbatim from manuscript on "*Esox scombroides*, Solander, p. 40; *Esox saurus* G. Forster [MS], ii. t. 233; J. R. Forster, MS II 65, apud Bl. Schneider, p. 394 . . . lat 39½° S, 204¼° W, [sic] between New Zealand and New Holland . . . The specimen figured by G. Forster was captured . . . in Dusky Bay [New Zealand]. The aborigines named it 'he-eeya.'").
- Scombresox scombroides*.—Scott 1962:77, 1 fig. (brief description; western and southern Australia, Victoria, New South Wales, and Tasmania; vernaculars).
- Scomberesox saurus scombroides*.—Parin 1968a:284 (tentative name for Southern Hemisphere subspecies of *S. saurus*, based on fewer gill rakers). Chirichigno F. 1974:90, 318, 349, fig. 18-19 on p. 91 (characters in key; Punta Aguga, Perú, to Chile; Isla Juan Fernández and [in error] Isla de Pascua).¹¹
- Scombresox Rondeletti* (misidentification on subspecies level).—Valenciennes 1846:475 (in part; Cape of Good Hope record only). Bleeker 1860:56 (Cape of Good Hope only).
- Scomberesox rondeletti*.—Gilchrist 1901:152 (South Africa).
- Scombresox equirostrum* (misidentification on subspecies level).—Valenciennes 1846:479-481 (description based on specimen from Chile reported by Guichenot in 1848). Guichinot 1848:318-319 (description; rarely found in Chile). Rendahl 1921:50-51 (Isla de Juan Fernández; also off Perú, New Zealand, southeast Australia, and [in error] Japan).
- Scomberesox equirostrum*.—Fowler 1940:757, fig. 27 (Valparaíso); 1944a:491 (Valparaíso and Isla de Juan Fernández, Chile); 1944b:30-31 (synonymy; republished in book form under same title, 1945:78-79). Mann 1950:25 (key; distribution, Arica to Valparaíso, Islas de Juan Fernández; found in markets of central Chile, May-July; vernaculars). Fowler 1951:282 (in key; Chile). Mann 1954a:47, 79, 169-171 (description; distribution; restricted to pelagic warm water, Arica and Islas de Juan Fernández and [in error] Isla de Pascua; vernaculars); 1954b:77 (listed off Chile in subtropical waters). De Buen 1955:154 (listed off Chile as food of *Germo alalunga*).
- Scombresox aequirostrum*.—Günther 1866:258 (references; Chile; Chilean fish described by Valenciennes may prove distinct). Reed 1897:18 (listed for Chile). Delfin 1900:4 (listed for Chile; generic name misprinted as *Scombresose*). Quijada 1912:95 (Valparaíso).
- Scomberesox aequirostrum*.—Delfin 1901:45 (synonymy; in part; Islas de Juan Fernández). Quijada 1913:84 (listed for Chile; edible; commercial importance).
- Scomberesox storeri*.—Storer 1853:268 and 1867:137-139 (status of LeSueur's "*S. equirostrum*" from Chile).
- Scombresox forsteri*.—Valenciennes 1846:481-482 (original description [indicated by "nob"]; received from Forster; New Zealand). Günther 1866:258 (synomy; diagnosis; validity doubted; New Zealand). Hector 1872:118 (rare in New Zealand waters; compared with "Half Beak").

¹⁰Not all "nomina nuda" as stated by Whitley (1968:35); applicable characters were given.

¹¹The Isla de Pascua record of a 480 mm "*Scomberesox*" listed by Wilhelm and Hulot (1957:148) was referred to *Belone (Eurycaulus) platyura* by de Buen (1963a:16), who, we presume, examined the specimen (43C).

Macleay 1881:244 (description; Melbourne and Sydney). Günther 1889:34¹² (unable to separate young of *saurus* and *forsteri*). Hutton 1872:53 (description; 12-in specimen; New Zealand); 1889:283 (New Zealand). Sherrin 1886:305 (New Zealand). Hutton 1904:50 (New Zealand). Stead 1906:70 (Australia); 1908:39 (characters; immense shoals of half-grown fish inside Port Jackson Heads). Regan 1916:134 (northern New Zealand and Three Kings Islands). Phillipps 1921:120 (food value; highly esteemed edible fish at Bay of Islands; probably spawns in mid-May). Waite 1921:64 (South Australia; often netted with garfish); 1923:88, fig. 96 (length to 15 in; surface skipping and jumping).

Scomberesox forsteri.—Brevoort 1856:281 (New Zealand; seems closest to *S. saira*). Jordan et al. 1930:197 (questioned synonymy with *S. saurus*; New Zealand). Munro 1938:55, fig. 389 (diagnosis; habitat: New South Wales, Victoria, Tasmania, South and West Australia). Berg 1939:207, and 1941 (reprint):654 (closely repeated species; New Zealand and southern Australia). Whitley 1948:15 (off Albany and Perth, Western Australia). Andriashev 1961:345, 348—as "*Scomberesox forsteri*"; 397, 422, 424, 442—as "*Scomberesox*"; 421, 426, 442, 443, 445—as "*Scomberesox* sp" (taken at "Ob" stations in southern Pacific Ocean); 1962:285 (north of 46° S in "Zone of *Scomberesox*"). Whitley 1962:52, fig. (habits; characters; southeast Australia, New Zealand, and Tasmania to West Australia, and elsewhere). Moreland 1963:18, fig. (general remarks). Parin 1963:134, 139 (attracted to light at night). Heath and Moreland 1967:16, fig. 17 ("needlefish" and other vernaculars; general remarks; New Zealand). Parin 1967a:58 (42 in translation) (doubtful status as species). Berman and Ryzhenko 1968:10, 12, fig. (young and adults off Chile and Perú; potential fishery). Whitley 1968:35 (synonymy). Scott et al. 1974:88 (description; distribution; West and South Australia, Victoria, New South Wales, and Tasmania; uncommon off South Australia).

Scomberesox saurus forsterii.—Chirichigno F. 1969:40, fig. 85 (vernaculars; Perú, Chile, Islas de Juan Fernández; detailed description).

Scomberesox stolatus.—de Buen 1959:262-264 (original description; synonymic references to *Scomberesox* and *Scomberesox equirostrum* and *aequirostrum*; types from 35°20' S, 75°23' W; vernaculars). Chirichigno F. 1962:2, 8-9, fig. 6 (Callao and Isla Chincha, Perú; from Arica to central zone of Chile; Islas de Juan Fernández, and [in error] Isla de Pascua; not previously known from Perú). Koepcke 1962:196-197 (references; high seas; west coast of South America from central Chile to Callao, Perú; Islas de Juan Fernández, and [in error] Isla de Pascua [see footnote 11]). De Buen 1963b:81, 83, 85 (key; brief description; Antofagasta). Medina 1965:260-261 (habitat; central Chile from Callao, Perú, and Juan Fernández Islands, and [in error] Isla de Pascua).

Cololabis saira (misidentification).—Chirichigno F. 1962:9, fig. 7 (description of young; Paita, Perú). Koepcke 1962:197 (in part; reference to Chirichigno's Paita record only). Fourmanoir 1971:492 (87 specimens, 8-30 mm, from 180 mi west of Port Macquarie, New South Wales, Australia).

Scomberesocidae.—Lönnberg 1907:15 (Straits of Magellan, "Smyth Channel, Eden Harbour"). Fowler 1942b:384 (Brazil, Patagonia, West Africa).

Scomberesox.—Böhlke 1951:85-86 (Chile; *Cololabis adocetus* compared).

Needlefish.—McKenzie 1964:14, 1 fig. (in part; vernaculars; color; size; habits; New Zealand).

Discussion of Synonymy.—The synonymy of *Scomberesox* has some complications but in general is relatively clear taxonomically and nomenclaturally. The name was spelled as *Scomberesox* twice by Lacépède (1803), hence can hardly be treated as a misprint, though in naming the species *Scomberesox Camperii* he gave the French vernacular as *Scombresoce camperien*. Many authors, beginning apparently with Rafinesque (1810), adopted the classically more correct but unacceptable (unauthorized) emended spelling *Scombresox* for the genus, and this spelling is still occasionally followed in Europe (viz. Zoological Record (Pisces), 1956-59). The type-species of *Scomberesox*, by monotypy, is *S. camperii* Lacépède, a synonym of *S. saurus saurus* (Walbaum).

¹²Günther referred the pelagic fry and young sauries ("up to 1½ inches in length"), taken in the Pacific Ocean, to *S. forsteri*, while acknowledging that he could not distinguish them from *S. saurus*. But he stated that these specimens were taken in July 1875, during which month the ship was running east from Japan near 35° N, thence due south to Hawaii (Mosely 1879:495 and track chart; also p. 750 and Sheet 36 of Part 1 of Vol. 1 of Challenger Report). Although the specimens are apparently not extant in the British Museum (see footnote 5), it seems safe to conclude that the record was based on *Cololabis saira*.

The earliest synonym, *Sayris*, was proposed by Rafinesque (1810), with the statement: "Cosrisponde al genere *Scomberesox* di Lacepede, il di cui nome essendo formato dall'unione di due altri nomi generici e talmente contra la leggi della nomenclatura zoologica, . . ." Since *Sayris* was obviously proposed as a replacement name for *Scomberesox*, it takes, according to Article 67 (i) of the International Code, the same type-species, namely *Scomberesox camperii* Lacépède. The type-species has been designated (Jordan and Evermann 1896) as *Sayris recurvirostra = camperii*," obviously on the basis of the original indication of *Sayris recurvirostra* as a replacement name for *S. camperii*. This type of designation was repeated by Jordan (1917). Jordan et al. (1930) gave the type as "*S. recurvirostra* Rafinesque = *Esox saurus* Walbaum," but *Camperii* is not an objective synonym of *saurus*.

Gramminocotus Costa (1862) is clearly a subjective synonym of *Scomberesox*. The type-species, by monotypy, is *G. bicolor*, an obvious synonym of *Scomberesox saurus saurus*. The statement by Jordan et al. (1930) that *Gramminocotus* is "said to lack the air bladder" seems to have no basis other than the erroneously indicated lack of the gas bladder as a character of *Scomberesox* in the Mediterranean, from which the 40 mm type of *G. bicolor* came. Various authors have reported on the presence or absence of a gas bladder in *S. saurus* from the Mediterranean. Valenciennes (1846) based *S. Rondeletii* on the belief that it had no gas bladder; Günther (1866:258) and Moreau (1881) accepted this action. Lütken (1880) and subsequent authors accepted the presence of the bladder, but Supino (1935) failed to find it. Scordia (1936, 1938) found it in specimens from Messina and Naples. Further supporting its presence, Enrico Tortonese¹³ stated: "Personally, I believe it is present, as I have found it in all the dissected specimens from Nice and Genoa. Its walls are thin and easily broken; this may perhaps explain why it was sometimes overlooked." One of us (Wisner) has found the gas bladder in a 197 mm SL subadult from the Straits of Messina, as has N. B. Marshall¹⁴.

There was also no basis for the indication (Jor-

dan 1921) that the genus *Gramminocotus* lacks a beak (it had not yet elongated in Costa's type, "Long. corp. millim. 40"). The generic recognition by Jordan and by Golvan (1962, 1965) was an anachronism.

JUSTIFICATION OF SUBSPECIFIC SEPARATION

Parin (1968a) reported differences in the numbers of gill rakers of *Scomberesox saurus* between 7 specimens from the North Atlantic and Mediterranean (average 40.75) and 64 specimens from the Southern Hemisphere (average 44.67). On this rather limited basis he concluded that the two populations may be separable, at least at the subspecific level, and, if so, the southern subspecies should be named "*S. saurus scombroides* (Richardson)." Parin also stated: "There are no significant morphological differences between populations inhabiting southern regions of the Atlantic, Indian and Pacific oceans." We concur in this latter statement and include populations from the Northern Hemisphere (not included by Parin, perhaps due to limited material, seven specimens). Furthermore, we agree with Parin that the populations of the two hemispheres may be separable as subspecies and that the name *Scomberesox saurus scombroides* (Richardson 1842) is applicable to the Southern Hemisphere form.

While we are aware of the highly subjective criteria for subspecific separations, and despite the extensive overlap in counts of gill rakers between populations of the two hemispheres (Table 7), we favor the distinction of the two populations as subspecies. We base this action both on probably highly significant statistical differences (untested) in numbers of rakers and on the presently known distribution of the genus (see below). We cannot conceive of any recent intermingling across the equatorial region of the Atlantic Ocean, at least since the glacial period; the species does not occur in the North Pacific, and, presumably, the northern Indian Ocean is too warm for it.

The statistical reasoning on which we base subspecific distinction involves both a method of graphical analysis of variation (Hubbs and Perlmutter 1942, revised by Hubbs and Hubbs 1953) (Figure 6) and a value, "coefficient of difference (C.D.)," from Mayr et al. (1953); this latter value is derived by dividing the difference between means by the sum of their standard deviations.

¹³Enrico Tortonese, Director, Museo Civico di Storia Naturale, 16121 Genova, Via Brigata Liguria N. 9, Italy, pers. commun. 8 July 1968.

¹⁴N. B. Marshall, Curator of Fishes, British Museum (Natural History), Cromwell Road, London SW7, England, pers. commun. 21 June 1968.

TABLE 7.—Numbers of gill rakers, by areas, for the two *Scorberesox saurus* subspecies.

| Gill rakers | <i>Scorberesox saurus saurus</i> | | | | <i>Scorberesox saurus scombrooides</i> | | | | | Total |
|-------------|----------------------------------|--------------------|----------------------------|-------|--|----------------------------|----------------------------|---------------|---------------------------|-------|
| | Northwest Atlantic ¹ | Northeast Atlantic | Mediterranean ¹ | Total | Southwestern Central Atlantic | Atlantic near South Africa | South Pacific ² | | Indian Ocean ¹ | |
| | | | | | | | New data | Parin (1968a) | | |
| 34 | — | 1 | — | 1 | — | — | — | — | — | — |
| 35 | 1 | 2 | 2 | 5 | — | — | — | — | — | — |
| 36 | 4 | 4 | 3 | 11 | — | — | — | — | — | — |
| 37 | 6 | 1 | 2 | 9 | — | — | — | — | — | — |
| 38 | 8 | 5 | 4 | 17 | — | — | — | — | — | — |
| 39 | 13 | — | 5 | 18 | — | — | 5 | 1 | — | 6 |
| 40 | 13 | 4 | 3 | 20 | — | — | 10 | 2 | — | 12 |
| 41 | 13 | 2 | 3 | 18 | — | 1 | 23 | 4 | — | 28 |
| 42 | 3 | 1 | 2 | 6 | 1 | 6 | 21 | 5 | 3 | 36 |
| 43 | 5 | — | — | 5 | 1 | 4 | 34 | 7 | 1 | 47 |
| 44 | 2 | 1 | — | 3 | 2 | 10 | 19 | 2 | 8 | 41 |
| 45 | 1 | — | — | 1 | 8 | 8 | 17 | 4 | 6 | 43 |
| 46 | — | — | — | — | 11 | 4 | 10 | 3 | 7 | 35 |
| 47 | — | — | — | — | 4 | 5 | 5 | 2 | 3 | 19 |
| 48 | — | — | — | — | 2 | 3 | 3 | 1 | 2 | 11 |
| 49 | — | — | — | — | 4 | 3 | — | 3 | 1 | 11 |
| 50 | — | — | — | — | 1 | 1 | — | 1 | 1 | 4 |
| 51 | — | — | — | — | 1 | 1 | — | 1 | — | 3 |
| N | 69 | 21 | 24 | 114 | 35 | 46 | 147 | 36 | 32 | 296 |
| x | 39.70 | 38.24 | 38.58 | 39.19 | 46.29 | 45.13 | 43.01 | 44.17 | 45.28 | 44.11 |
| SD | 2.13 | 2.61 | 2.08 | 2.28 | 1.93 | 2.38 | 2.35 | 2.95 | 2.76 | 2.52 |

¹Counts by Parin (1968a:280, fig. 3) for specimens 75 mm and longer are included in the above counts for Northwest Atlantic (5 specimens) and Mediterranean (5 specimens).

²Data from Peru, Chile, Central Pacific, and Australia-New Zealand are combined since counts from each area are very similar, the means ranging from 42.87 to 43.08 gill rakers.

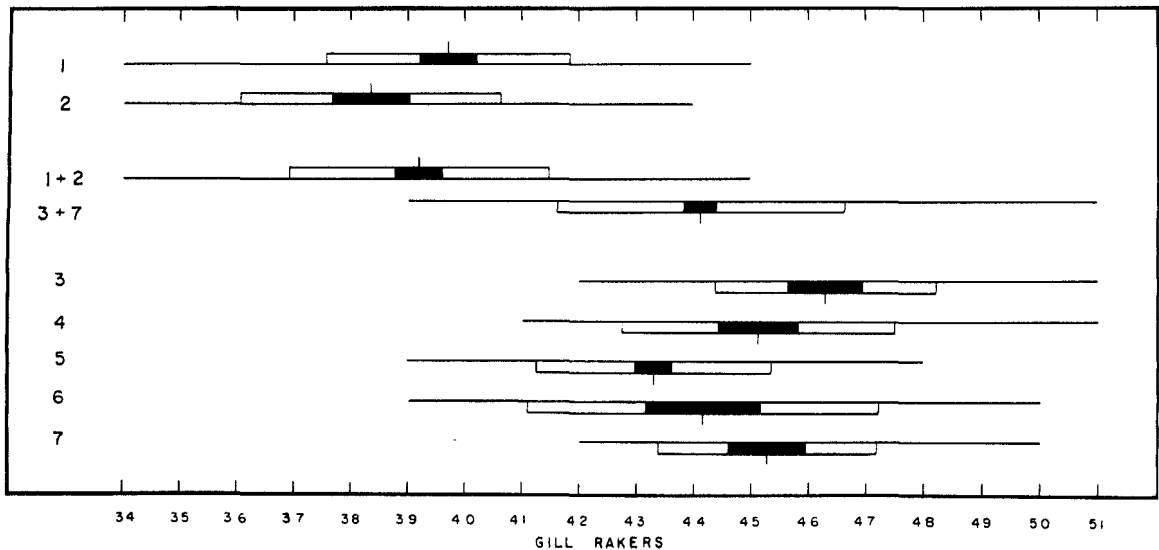


FIGURE 6.—Graphed variation in numbers of gill rakers of *Scorberesox saurus saurus* and of *S. s. scombrooides*, by area. *Scorberesox s. saurus*: 1—Northwest Atlantic, $N = 69$; 2—Northeast Atlantic and Mediterranean, $N = 45$; 1 + 2—total for Northern Hemisphere, $N = 114$. *Scorberesox s. scombrooides*: 3 + 7—total for Southern Hemisphere, $N = 296$; 3—Southwest-central South Atlantic, $N = 35$; 4—Atlantic near South Africa, $N = 46$; 5—South Pacific (new data), $N = 147$; 6—South Pacific (Parin 1968a), $N = 36$; 7—Indian Ocean, $N = 32$ (26 from Parin (1968a), 6 new data). In each sample the baseline shows the total range in variation, and the short vertical line the mean of the sample; open (white) bars delineate 1 SD on each side of the mean, and the solid (black) bars 2 SE of the mean on each side of the mean.

The difference between means for gill rakers (39.19 vs. 44.11) of the total populations of *S. s. saurus* and *S. s. scombrooides* (Table 7; Figure 6, lines 1 + 2 and 3 + 7) appears to be highly sig-

nificant, the probable odds (untested) being billions to one against the two areas comprising a single, homogeneous population. Despite a large overlap in numbers of rakers, the calculated C.D.

value is 1.025, a value approaching subspecific distinctness (as interpreted by Mayr et al.), in that it indicates a joint nonoverlap of about 85%. Of even greater significance, perhaps, is the difference in means (7.93 rakers) between populations from the southwestern-central Atlantic and the combined northeastern Atlantic-Mediterranean areas (46.29 vs. 38.36 rakers); the graphed data (Figure 6, lines 1 and 3) indicate again probable odds (untested) of billions to one that the two populations are not homogeneous; in addition, the C.D. value of 1.88 indicates about 99% joint nonoverlap in numbers of rakers—virtually that of separation at the species level.

As sampled (Table 7, Figure 6), the total population of *S. s. saurus* appears to be relatively homogeneous, but that of *S. s. scombroides* may be less so. Heterogeneity of populations in the Southern Hemisphere is indicated by a difference of 3.28 rakers between the areas of southwestern-central South Atlantic and the entire South Pacific (new data) (46.29 vs. 43.01); this may indicate that little or no intermingling occurs around the tip of South America. Conversely, the close agreement in means for rakers between specimens from the South Atlantic near South Africa and from the Indian Ocean (45.13 vs. 45.28) may indicate that considerable, if not complete, intermingling occurs around South Africa. The entire South Pacific area (as sampled) appears to contain a homogeneous population; a difference of only 0.21 rakers was found between samples of about 50 specimens each from the Peru-Chile, central, and Australia-New Zealand areas.

DESCRIPTION OF GENERA AND COMPARISONS

Inasmuch as we treat each of the four obviously distinct saury species as constituting a monotypic genus, the comparisons of these genera, as previously discussed, and epitomized in Table 1, provides a comparison of *Nanichthys simulans* with each of the three other scomberesocid species. It certainly ranks as one of the two dwarfed species. The largest specimens of this species examined by us were taken in Funchal Harbor, Madeira (126.2 mm SL, Museo do Funchal No. 2866, shown in Figure 1, and 121.2 mm SL, BMNH 1953 · 3 · 13 · 7). No other specimens >101 mm SL (USNM 204257) have come to our attention and none other among hundreds examined by us have exceeded 90 mm. Parin (1968a) recorded 90 mm SL as the

largest of his material. Dudnik (1975b) reported that the longest of about 200 specimens of "*Scomberesox* sp" was 112 mm. The occurrence of the two "giants" in Funchal Harbor leaves us to wonder if the inshore habitat may have led to increased or sustained growth. G. E. Maul¹⁵ has told us that the genus is rare near Funchal.

Nanichthys simulans, unlike *Elassichthys adocetus*, has retained the lateral line; it extends to about midway between the origins of the pelvic and anal fins, but not, as in *Scomberesox* and *Cololabis*, to opposite some one of the anal finlets. The upper and lower jaws, instead of remaining short and pointed as they do in *Cololabis*, or short and rounded (in the upper) as in *Elassichthys* (Figures 5, 6), become definitely elongated as beaks, but remain shorter than in *Scomberesox*; the upper is about half as long and produced as the lower, and much less slender and fragile than they are in *Scomberesox*.

Counts for *N. simulans* are given in Table 2 (gill rakers), Table 3 (fin rays), and Tables 4 and 5 (vertebrae), and are contrasted with similar data for *E. adocetus* and for the larger forms, *C. saira* and *Scomberesox*; numbers of gill rakers are given for both subspecies of *Scomberesox* in Table 7.

The pectoral rays of *N. simulans*, numbering 10 or 11, average more than in *Elassichthys* (8-11, usually 9 or 10), but fewer than in *Cololabis* and *Scomberesox* (12-15 in each). The procurrent caudal rays number 4, rarely 3 or 5, vs. 2 or 3 in *Elassichthys* or 5-7 in *Cololabis* and *Scomberesox*. The vertebral counts are 58-62, mean 60.68, contrasting with 54-59, mean 56.37, in *Elassichthys*, 62-69 in 3,160 specimens of *Cololabis*, with means of 66.05 for 248 counts for the northwestern Pacific and of 65.03 for 2,812 counts for the northeastern Pacific, and 66-70, mean 66.13, for 338 counts for *Scomberesox* (both subspecies).

Scale counts (lateral midline rows) number 77-91 vs. 70-88 in the other dwarf species, *E. adocetus*, as mutually contrasting with counts of 128-148 in *Cololabis* and of 107-128 in *Scomberesox*. Counts of gill rakers in *Nanichthys* (19-26, mean 22.80) average higher than for *Elassichthys* (15-21, mean 17.64), but much lower than in either *Cololabis* (32-43, mean 37.53) or *S. s. saurus* (34-45, mean 39.19) and 39-51 (mean 44.11) for *S. s. scombroides* (Table 7). The ovary, as in *Elassichthys*, is single instead of paired (as

¹⁵G. E. Maul, Curator of Fishes, Museu Municipal do Funchal, Madeira, pers. commun. 5 May 1978.

noted below in the general description of the ovary in the two dwarf species).

In life *Nanichthys* is silvery ventrally and laterally, becoming greenish with brown specks dorsally; this is also the basic coloration of the other three genera. In preserved specimens the anal fin is essentially colorless, but the dorsal, pectoral, and caudal fins bear microscopic spots of dark pigment along the edges of the outer rays. The caudal fin, in addition, is pigmented in the crotches of the first branching of the rays and sometimes in the second branching of both dwarf species (the resulting streaking shows in Figures 5, 8, 9). In preserved specimens of this (and of other) scomberesocid species, a dusky underlying streak parallels the dorsal margin of the body (evident in Figure 5). *Elassichthys adocetus* has basically the same coloration.

JUSTIFICATION OF GENERIC SEPARATION

In recognizing a separate genus for each of the four species of Scomberesocidae we are cognizant of the circumstance that we are in a period when lumping is prevalent. We hold, however, that the grounds for the recognition of the four genera are compelling, and consistent with other generic recognitions on similar grounds. The distinctive features stand out sharply in the generic comparisons (Table 1).

The complete lack vs. strong development of the gas gladder and the single vs. paired ovaries, supplemented by a series of minor characters, primarily the striking differences in body musculature (Figure 7), and bolstered by the vast difference in body size, seem to provide fully adequate grounds for distinguishing both *Elassichthys* and *Nanichthys* from either *Cololabis* or *Scomberesox*.

The sagittal sections of the four genera of scomberesocid fishes (Figure 7A-D), taken from close behind the bases of the pelvic fins, portray these striking differences. The 59 mm SL adult of *Elassichthys* and 60 mm SL adult of *Nanichthys* clearly show the lack of the gas bladder; also, there is no evidence of even a weak septum that might indicate a paired condition of the ovaries. Even in the young of *Cololabis* (59.4 mm SL) and of *Scomberesox* (59.7 mm SL) the roughly triangular gas bladder is plainly evident just above the liver and gut; these young specimens are too immature to have recognizable gonads.

Also evident and notable is a difference in the

arrangement of the myotomes; those of the young *Cololabis* and *Scomberesox* (and of adults) are separated by distinct septa. However, in the adults of the dwarf forms the myotomes are much more massive and the dividing septa are greatly reduced in number in *Nanichthys* (virtually nonexistent in *Elassichthys*). Perhaps this reduction is a reflection of the weak-swimming, surface-pelagic habits of these small fishes.

The development of filaments of a peculiar well-formed type on the egg of *Cololabis* strengthens the basis for the separation of that genus from *Scomberesox*, with unfilamented eggs. The large literature on *Cololabis* and its great commercial importance are additional incentives for retaining the familiar and well-established nomenclature; *Scomberesox* now approximates qualification in both categories.

The generic separation of the two dwarf forms also seems to be well justified. The feature of the well-developed beak in *Nanichthys* vs. its lack in *Elassichthys* (Figure 2) calls for generic separation, as it does for retaining *Cololabis* distinct from *Scomberesox*. The apparent total lack of an external lateral line in *Elassichthys* and its considerable development in *Nanichthys* provides sustaining evidence. Furthermore, the high probability that *Nanichthys* and *Elassichthys* are of separate origin (Figure 3), owing their resemblances to convergent evolution, seems to us clinching reason for generic separation.

Description of Gonads

The one ovary and the two testes of *Nanichthys* are essentially like those of *Elassichthys* (Figures 8, 9). Instead of being pendant from the dorsolateral walls of the coelom, they form, as they develop, a coherent median mass, occupying, with maturity, a very large proportion of the coelom from the middorsal line to the ventrally displaced liver, intestine, and other visceral organs. In the specimen figured for this discussion, the length of the ovary composes 38% of the standard length of the fish; the greatest depth of the ovary 20% of its length; and its greatest width 60% of its greatest depth.

The development of a single functional ovary in "*Scomberesox* sp" [= *Nanichthys simulans*] has been noted by Dudnik (1975b), who, however, mentioned that "the second [ovary] is rudimentary and can barely be discerned" [a translation]. We, however, have found not even a rudimentary

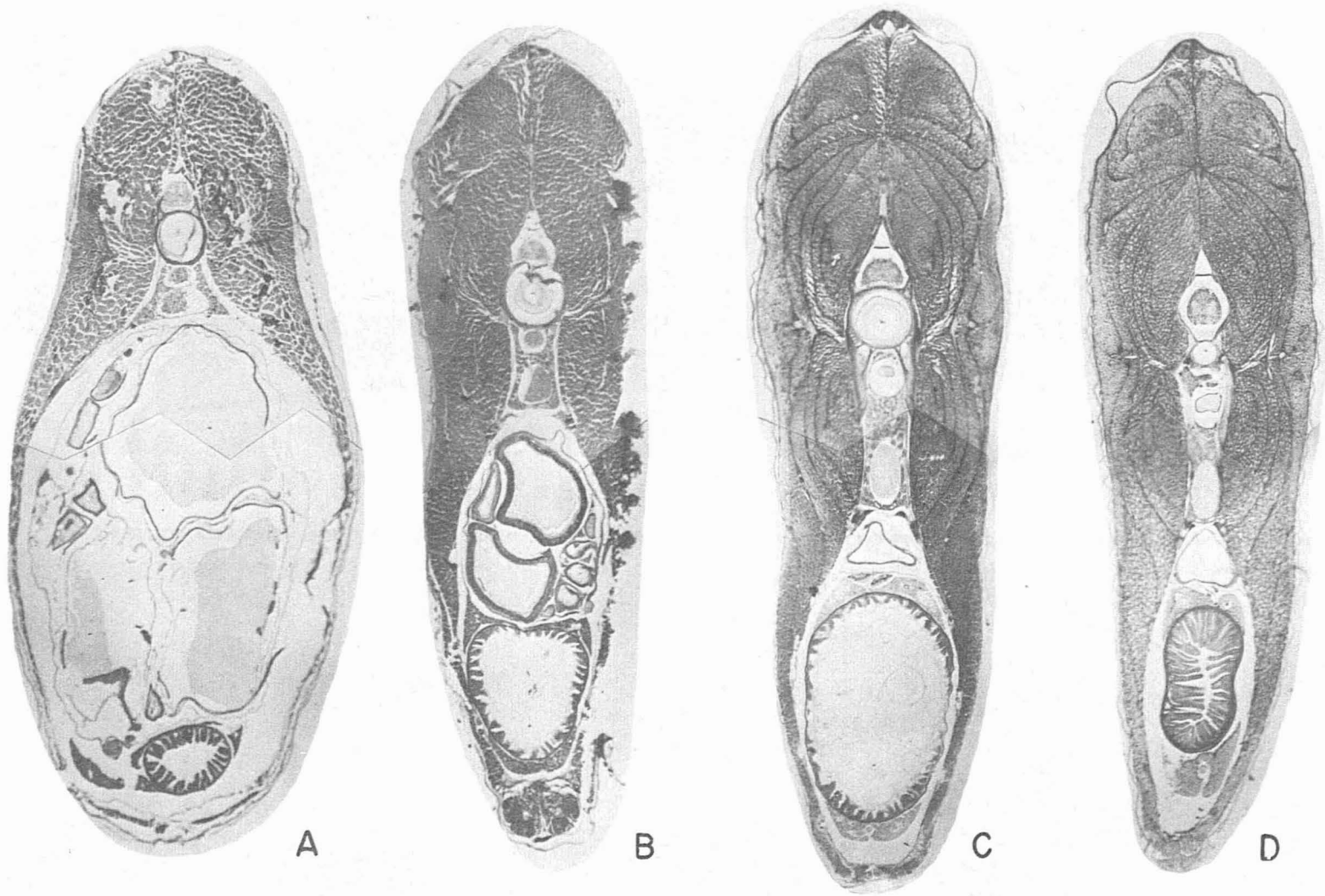


FIGURE 7.—Sagittal sections, taken from slightly behind origin of pelvic fin, of gravid females: (A) *Elassichthys adocetus*, 59.0 mm SL; (B) *Nanichthys simulans*, 60.0 mm SL; and of juveniles: (C) *Cololabis saira*, 59.4 mm SL; (D) *Scomberesox saurus*, 59.7 mm SL.

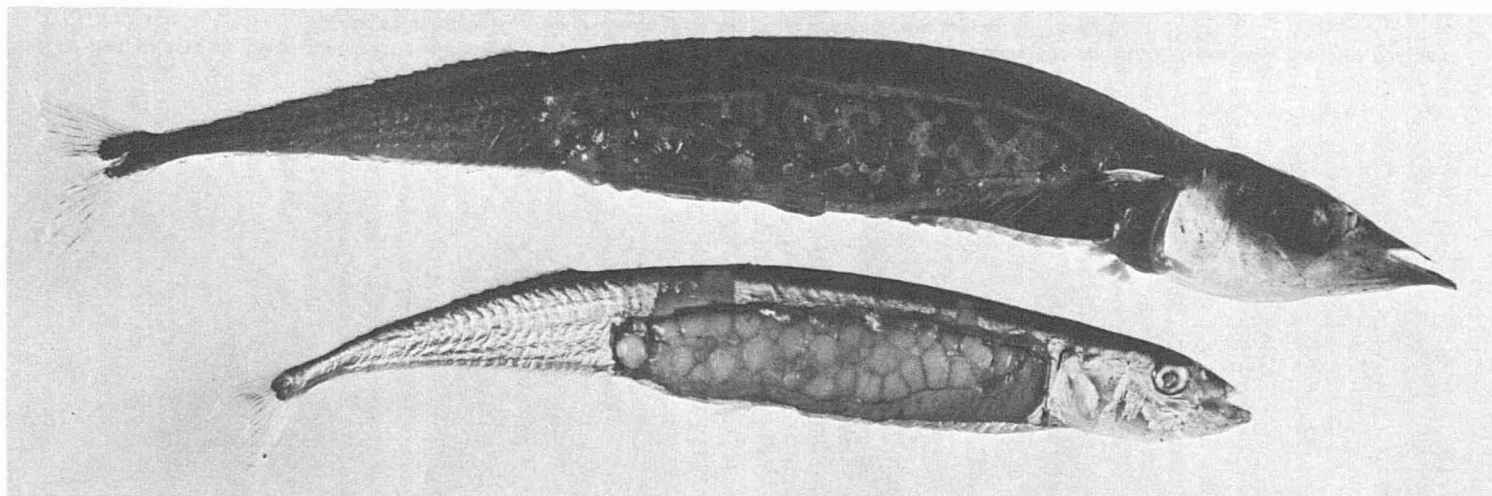


FIGURE 8.—Gravid single ovaries in situ: Upper—*Nanichthys simulans*, 85.5 mm SL; Lower—*Elassichthys adocetus*, 62.3 mm SL. Note the great range in sizes of ova.

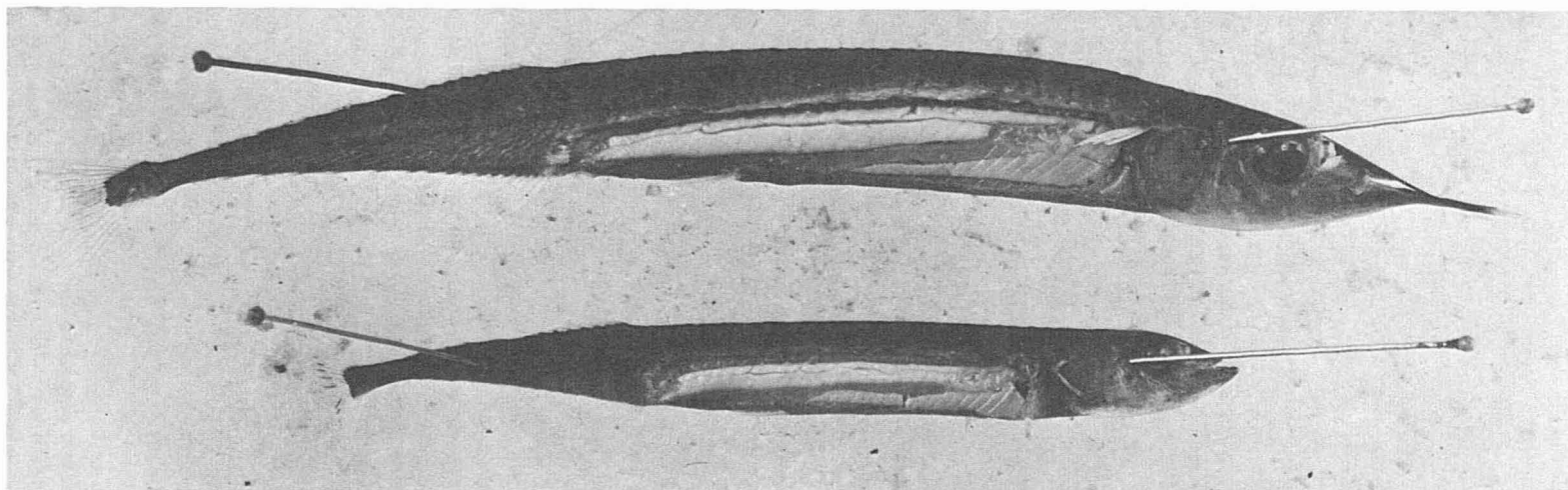


FIGURE 9.—Mature paired testes in situ: Upper—*Nanichthys simulans*, 90.0 mm SL; Lower—*Elassichthys adocetus*, 59.0 mm SL.

ovary in this species (nor in the other dwarf, *Elassichthys adocetus*).

In cross section the maturing and mature ovaries of both dwarfs are rather ovate in section. They very nearly fill the whole coelom between the much expanded body walls, particularly in *Elassichthys* (Figure 8). As they ripen, the ova fill the entire ovary so tightly that many of the ripe ova and even some of those in developmental stages are compressed into angular forms throughout the ovary. Forward, the ovary narrows dorsoventrally where the liver broadens to fill much of the coelom. Gentle probing readily discloses that the ovary lacks any structural connection with the coelom wall (except at the genital opening), although, with development, the ovary completely fills the body cavity above the visceral organs and lies closely appressed to the body wall, both dorsally and laterally. Dislodging the ova by probing discloses no trace of any internal septum.

The ova in the mature ovary of *Nanichthys* and *Elassichthys* appear on gross examination to represent at least four stages of development, but a major difference in size exists between the largest category (readily visible in Figure 8) and the next largest, as though an acceleration in growth precedes the extrusion of the brood. Since the ova of the largest category are usually markedly irregular in shape (presumably due to crowding), measurements are approximations. However, after discharge the ova are probably normally spherical rather than ovoid in shape, as the eggs of *Cololabis saira* have been described to be (Mito 1958; Mukacheva 1960). The largest egg size in the *Nanichthys* series studied ranged in diameter from 2.0 to 2.5 mm. The smaller and presumably younger size groups seemed to group around 0.80, 0.40, and 0.10 mm. Similar size groupings appeared to hold for *Elassichthys*.

The positioning of the largest eggs in the ovaries of the dwarfs seems to be quite random among the smaller ones (Figure 8). These large eggs were noted to be arranged generally mostly two abreast (three abreast once in *Elassichthys*). The random distribution of the large eggs within an ovary otherwise filled with smaller eggs invites speculation on how the anteriormost eggs of the largest size category move past the smaller ones to become extruded.

None of the eggs of the dwarfs, even of the largest and presumably soon-to-be-extruded category, show any sign of bearing filaments. Their surfaces, however, are sculptured with closely

set, round, and extremely minute tubercles which are colorless (in preservative) and produce, under strong magnification, a finely pebbled effect.

It has not been determined whether the single ovary of the two dwarfed scomberesocids is the result of the fusion of bilateral primordia or is due to the failure to develop, or to the atrophy, of one ovary. The presence of but one gonad in syntenogonath fishes has been reported. Collette (1968) indicated that in the Belonidae *Strongylura marina* differs from a closely related species, *S. timucu*, in having only the right gonad developed. Collette (1974) reported that in the freshwater needlefish, *S. hubbsi*, 48 males had both testes developed but 2 apparently lacked the left one, and of 45 females, 2 had a tiny left ovary but all others lacked any trace of a left ovary.

In contrast with the ovary, the testis of both *Nanichthys* and *Elassichthys*, at apparent maturity, occupies only about one-third instead of about three-fourths of the height of the fleshy body (Figure 9). The testis agrees with the ovary, however, in occupying virtually the entire (limited) width of the coelom, forming from body wall to body wall a compact and compressed organ of seemingly homogeneous reproductive tissue. However, close inspection and some probing with a fine dissecting needle clearly discloses that the dorsally rounded mass comprises both testes. As seen from the right side, on removing the body wall (Figure 9), a fine, somewhat wavy longitudinal line, nearer top than bottom, indicates that the essentially homogeneous structure comprises the paired testes, and gentle probing confirms the indication. The left testis is definitely the larger, but both are well developed and are obviously functional. The two are essentially coterminal along the ventral edge, but the left testis definitely and sharply overtops the right. Ventrally the two organs form, at about the same level, symmetrical ridges on a rather broad base. At front, the paired testes are clearly distinct as lobes, of which the right one ends distinctly as a point, at that side of the left one. Anterior to the end of the right organ, the left one broadens on the ventral surface and forms a pair of bilaterally paired ridges, the left one of which seems to structurally replace the lost end of the right testis.

Mucus Pores and Canals of the Head

Numbers and arrangement of mucus pores and canals of the head vary notably among the scomberesocids (Figure 10, items 1-6). Adults of the two

larger forms, *Scomberesox* and *Cololabis* (Figure 10, items 1, 4), have a much greater number and complexity of pores and canals on the side and particularly on the top of the head, than do adults of the dwarfed forms, *Nanichthys* and *Elassichthys* (Figure 10, items 3, 6). Also juveniles of the larger forms (Figure 10, items 2, 5) show a greater pore-canal development than do the adult dwarfs, although they are of virtually identical size. This reduction of pores and canals in the dwarfs may be interpreted as an arrested state of development, perhaps neotenic or paedomorphic in character, as very small (20-24 mm SL) specimens of the larger forms bear a pore-canal structure similar to those of the adult dwarfs (Figure 10, items 3, 6); or, it may be that neither numbers nor complexity of pores is necessary at such small sizes and (perhaps) less active habits.

López (1957) provided the first figure of the pores and canals of the head of an adult (size not stated) *Scomberesox saurus* (= *S. s. scombroides*) from near Nechochea, Argentina. Our specimen, from the Perú-Chile area, bears a much greater profusion of pores and complexity of canals, particularly dorsally, than shown by López.

Collette (1966) illustrated interorbital canals and pores of four species of belonid fishes. These canals, rather simple and unbranched, which he reported to be representative of the Belonidae, are basically like those of *Elassichthys* and *Nanichthys*, although those of the latter show slight branching (Figure 10, item 3). Collette (his figure 7D) figured a complete joining of the left and right canals dorsally on *Belonion dibranchodon*, with both median and lateral pores present. He reported this condition to be unlike that of any other synentognath. Despite the profusion of pores and canals atop the heads of *Scomberesox* and *Cololabis* (Figure 10, items 1, 4), no joining of the left and right canals is apparent, although some canals very closely approach the median line.

Lateral Line Scales

The lateral line scales of *Scomberesox* and *Cololabis* are basically similar, but those of the dwarfed *Nanichthys* differ notably, both in shape and in numbers and development of circuli (Figure 11A-C). We have found no trace of lateral line scales in *Elassichthys*. All scales were removed from within 1 cm anterior to the pelvic fin. The basic similarity in the scales of the three genera involves the secondary tube on each scale that

leads posteroventrally from the main tube and opens to the external surface of the scale. The primary (main) tube of each scale, in contrast, overlies the lateral line canal which extends along the body.

The lateral line scale of the adult *Scomberesox* (270 mm BL (body length); Figure 11A) lacks circuli, but they are present, though very weakly developed, on fish about 200 mm BL. Development of circuli appears to decrease as the fish grows; the circuli on scales on a 100 mm fish are notably better defined than on the 200 mm specimen. These early developed circuli occur in areas rather similar to those that are better developed in *Cololabis*. A principal feature distinguishing the *Scomberesox* scale from that of *Cololabis* is a well-developed baselike structure on the ventral aspect of the scale (Figure 11C). As the *Scomberesox* scale is much more tenacious than that of *Cololabis*, perhaps this structure serves as an anchor to the body. Another difference between the scales of *Scomberesox* and *Cololabis* is a narrow median band of tissue at about the center of the scale (and main tube) that does not absorb the weak solution of alizarin red S stain. When removing it, the highly tenacious scale usually breaks at this band. The *Scomberesox* scale figured is about 0.9 mm thick at the main tube.

The lateral line scale of the adult of *Cololabis* (262 mm BL; Figure 11B), in addition to differing in form from that of *Scomberesox*, differs in having at least weakly formed circuli on the anterodorsal and anteroventral aspects (these circuli do not show clearly, probably due to a slight canting of the scale during mounting and to the extremely short depth of focal field inherent in photomicroscopy). The scale has a thickness at the main tube of about 0.4 mm. The circuli are better developed on smaller fish and extend farther posteriad along both the ventral and dorsal aspects of the scale in about the same areas as in the adult scale. Some, but not all, lateral line scales of adults of *Cololabis* bear the nonstaining band of tissue found in *Scomberesox*, but it is much less strongly developed.

The lateral line scale of *Nanichthys* (106 mm BL; Figure 11C, from the 121.2 mm Funchal "giant") differs notably from that of its two larger relatives. The shape is quite different and the circuli are much more numerous and more strongly developed and extend over most of the scale, being absent only on the central portion of the basal (exposed) area. The thickness of the scale at the

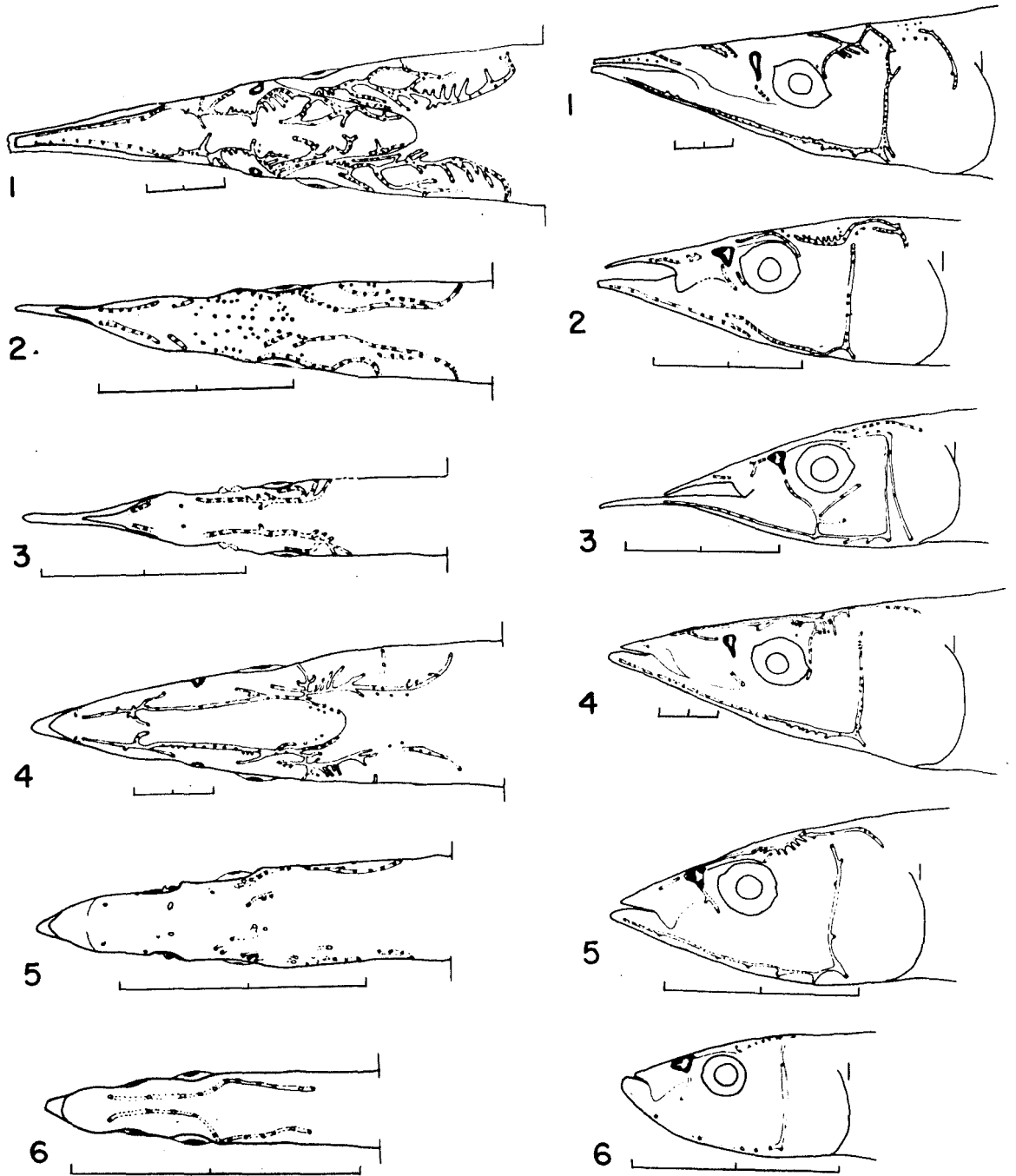


FIGURE 10.—Dorsal and lateral views of mucus pores and canals of heads of adults and young of scomberesocid fishes: (1) adult *Scomberesox saurus scombroides*, 240 mm BL; (2) young of *S. s. scombroides*, 70.8 mm BL; (3) adult of *Nanichthys simulans*, 70.0 mm BL; (4) adult of *Cololabis saira*, 243 mm BL; (5) young of *C. saira*, 54.0 mm BL; (6) adult of *Elasmichthys adocetus*, 54.6 mm BL. Each scale line represents 1 cm.

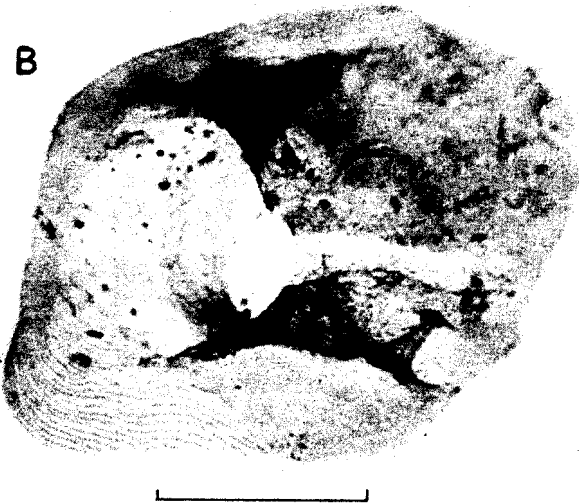


FIGURE 11.—Lateral line scales of adults: (A) *Scomberesox saurus scombroides*; (B) *Cololabis saira*; (C) *Nanichthys simulans*. The apical (covered) portion is to the left. All scale lines represent 1 mm. No lateral line scales have been found on *Elassichthys adocetus*.

main tube is about 0.1 mm. The tube is relatively more fragile than it is in the larger forms, and there is only a hint of the stain-resisting band of tissue.

Pharyngeal Bones and Teeth

The first pair of upper pharyngeal arches (bones) is absent in all the scomberesocid fishes. Also, the second pair of upper bones are so closely appressed as to appear as a single unit and are not notably larger than the third pair, which are not closely appressed; the lower pharyngeal bones are fused into one, as in the Synentognathi. Absence of the first upper pair of pharyngeals in synentognathous fishes has been reported by Collette (1966) who figured the pharyngeal bones and teeth of six species of the Belonidae: *Belonion dibranchodon*, *B. apodion*, *Potomarraphis guianensis*, *Strongylura notata*, *Pseudostylus angusticeps*, and *Xenentodon cancila*. Of these six, only *B. apodion* and *X. cancila* lack the first (lower) pair of upper pharyngeals; they also lack the second pair, retaining only the third (uppermost) pair. As figured by Collette, but not discussed, the pharyngeal teeth of these belonid species appear to have only a conical type of tooth, with no cusps or lobate features. In apparent contrast, many of the pharyngeal teeth of the scomberesocid species treated below have more or less well-developed lateral lobes or cusps, or are distinctly tricuspid.

Cololabis saira, 281 mm SL, 225 mm BL, from the Gulf of Alaska (SIO 57-198). The greatest length of the lower pharyngeal arch is 12.8 mm, the greatest width 8.6 mm. The teeth are moderately strong and curved. The marginal ones are all slender and unicuspid but those within the margin in the wider part are definitely widened, slightly to greatly, medially, with usually on each side a marginal lobe grading from rudimentary to, rarely, a rather definite cusp. There is only a trace of alignment (the arrangement is more nearly quite indefinite). Along the interior, greatly narrowed half of the length, the teeth, reduced in size, are very roughly in three or four rows. The lateral teeth do not form a definite row and are not markedly enlarged. Toward the posterior margin the teeth are large and irregularly crowded. Most of the larger teeth bear a more or less well-developed median, lengthwise, rather rounded ridge.

Each bone of the second pair of upper pharyngeals is 11.8 mm long and 3.0 mm wide. Anteriorly

and marginally the teeth are slender, moderately curved, and almost strictly unicuspid. Over the major portion of each bone, however, the teeth are, for the most part, definitely tricuspid, with the lateral cusps submedian and occasionally represented by weak to strong lobes. Between the left and right arches there is, posteriorly, a triangle of dermal ridges, medially a low ridge, and anteriorly a high ridge reaching to the surface with a strong fimbriation. As in the lower pharyngeal, the teeth are crowded and irregularly show just a trace of oblique seriation.

Each bone of the third pair measures about 2.3 × 6.7 mm. The teeth are nearly concealed in the strong fimbriation of the surface, and all are small, irregularly arranged, moderately curved, and unicuspid.

Elassichthys adocetus, 58.0 mm SL, 49 mm BL, from off Perú at 08°07' S, 84°58' W (SIO H 52-380). The lower pharyngeals are about 2.6 mm long and 1.1 mm wide. The teeth are relatively few, not more than about 10 across at the widest part of the arch. Most of the relatively large teeth in the median portion of the broad posterior region are broadened and to a varying degree tricuspid, with the central cusp much stronger than the lateral ones. The teeth along the posterior edge are rather broadly lanceolate rather than very slender as in *Cololabis*. Anteriorly, where the arch narrows, the teeth become weak. In the rows along the outer margins the teeth are relatively conical and moderately curved. The teeth across the posterior field are much larger than others and bear a median lengthwise ridge. Near the middle of the arch are only about four teeth in cross section.

Each bone of the second pair measures approximately 0.6 × 1.5 mm. The teeth are relatively robust and uniformly the sharp, definitely unicuspid tip is bent sharply. On the broad part of the bone there are only about five teeth in cross section. A membranous septum, very weakly patterned, extends the whole length between the two bones.

Each of the third pair of bones measures about 0.4 × 0.9 mm. The relatively few teeth are all unicuspid with the tips bent backward.

Scomberesox saurus scombroides, 290 mm SL, 205 mm BL, from off Chile, 34°30' S, 79°30' W (SIO 58-263). The lower pharyngeal has a midline length of 11.4 mm, a maximum width of toothed area (at posterior edge) of 7.3 mm, and a width

over teeth at midlength of 1.0 mm. The teeth are strongly heterodont and are rather definitely aligned, especially marginally, in rows. The teeth along the posterior margin number 41; those near the middle on each side are in nearly a single series alternating in proximity to the edge, whereas those toward either end tend to be arranged in oblique, separate rows of 2-4 teeth. All of these teeth are essentially erect, fairly stout, and pointed, with the tips not bent backward. The teeth along the two margins tend to form a rather even row; they are all sharply pointed, rather strongly bent backward, tend to flare outward, and are, in general, especially forward, larger and stronger than the teeth within; toward the anterior angles of the arch the marginal teeth tend to have a rather weak lobe on each side below the tip, and thus intergrade toward the median teeth. In the anterior half of the length of the arch the whole set of teeth grade from nearly triserial to uniserial, with only the very strong marginal teeth of each side occupying much of this space. After some intergradation, both anteriorly and laterally, the teeth occupying the major triangular part of the arch are dilated and bear on each side, well below the tip, a lobe or a cusp; they are strongly bent backward. Anteriorly the margins of the arch are rather strongly concave.

The length of each dental surface of the second pair is 8.9 mm; the maximum width of each, near the posterior end, is 2.7 mm. The teeth are arranged on each bone in about 16 rather regular rows extending from near the midline outward and backward in a weak curve. Teeth of reduced size, but otherwise similar, also curved, are found on a fimbriate pad immediately behind each bone. All of the teeth are bent backward. A number of teeth at the anterior end are simply conical, and especially strong. Virtually all of the other teeth, including those along the median and lateral edges, are tricuspid, with the median cusp very much stronger than the lateral pair, which arise well below the tip. The two bones are narrowly separated and a strongly fimbriate compressed membranous ridge intervenes, grading both forward and backward into several papillate rows.

The length of each bone of the third pair is 5.8 mm, the width of each 1.9 mm. The small teeth arise from a strongly papillate surface. They are directed mesiad and are strongest on the median margin, but definitely weakening laterally. They are all conical, without any trace of marginal enlargement.

Nanichthys simulans, 85.0 mm SL, 68.0 mm BL, from the central South Atlantic, 24°02.5' S, 15°32.0' W (SIO 63-546). The lower pharyngeal measures 1.9 × 3.3 mm. As in *Elassichthys*, but contrasting with the two large species, the arch is less attenuate forward and the posterior border is definitely convex instead of being slightly concave. There is no definitive alignment of the teeth, and a band about three or four teeth wide extends virtually to the front tip. The teeth rather regularly and strongly increase in size backward. About 20 teeth in one very irregular row, or in two rows, occur along the posterior margin; these are essentially erect, mostly very large, relatively, and show barely a trace of the lateral enlargements. Toward the front end the teeth are conical and less curved backward than the following teeth (excluding the posterior marginal ones). Most of the other teeth bear on each margin, well below the tip, either a lateral swelling or a definite cusp.

Each second pharyngeal measures 0.9 × 3.1 mm, with the greatest width well behind the middle. The teeth are scattered without definite alignment. Those in the narrow front end of the arch and those along the outer margin are conical or nearly so, with the tips bent backward, somewhat as in the other species. The remaining teeth, however, are vastly different, actually submolar. These rather lobular teeth seem to have been built on a much swollen and rounded version of the corresponding teeth in the other series, sometimes showing a trace of the lateral enlargements or cusps; but essentially they are irregularly rounded domes, but grading forward, outward, and backward into the more conventional, weakly tricuspid type.

Each third pharyngeal measures approximately 0.6 × 1.6 mm. The arch is widest behind the middle. The teeth are rather hidden in the papillae and all are simply conic, weakly curved backward. They are quite strong along the inner margin but grade into extremely minute ones on the outer margin.

DISTRIBUTION

The distributions of the scomberesocid fishes have been depicted by various Russian and Japanese authors. The Russian data are summarized by Parin (1968a, b, 1969a). Parin (1968a, b) received from us many of his data on "*Scomberesox* sp" (= *Nanichthys simulans*) and on *Coloblabis adocetus* (= *Elassichthys adocetus*). Dudnik

(1975a) charted the distribution of *Scomberesox saurus* (= *S. s. scombroides*) in the South Atlantic Ocean, and (1975b) of *Scomberesox* sp. in the North and South Atlantic. Ueyanagi and coauthors have reported many captures of all the scomberesocid species, primarily juveniles and postlarvae, in the Pacific and Atlantic Oceans and the Mediterranean Sea.

In Figures 12-17 we attempt to show the known captures of all four species of scomberesocid fishes. In each figure the solid circles represent material examined by us. The large open circles in the North Atlantic and southwestern Pacific Oceans refer to literature records (specimens not seen by us); we have not used this symbol for literature records from the Pacific coasts of North and South

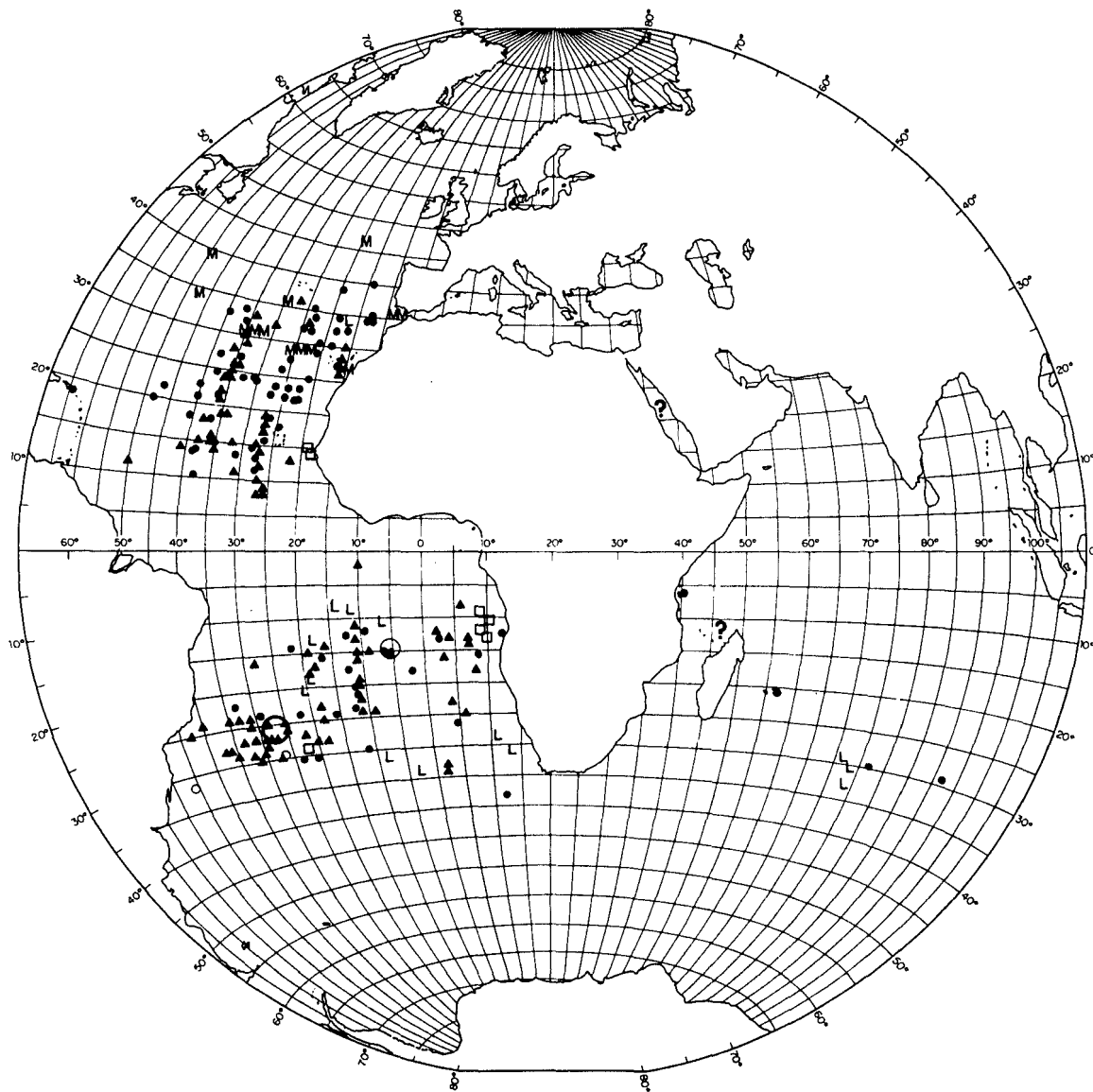


FIGURE 12.—Distribution of *Nanichthys simulans*. Solid circles represent material examined by us; solid triangles represent localities mapped by Ueyanagi et al. (1972); the large open circle in the southwestern Atlantic indicates 18 closely spaced collections (111 specimens), and the small open circles represent unpublished localities furnished by Parin; open squares refer to records mapped by Dudnik (1975b); letters L and M refer to records from Lampe (1914) and by Murray and Hjort (1912). The question mark near Madagascar represents Smith's 1955 record of *Scomberesox saurus* from Aldabra Island, which seems to represent this species. The query in the Red Sea refers to Borodin's 1930 record of a young "*Scomberesox saurus*."

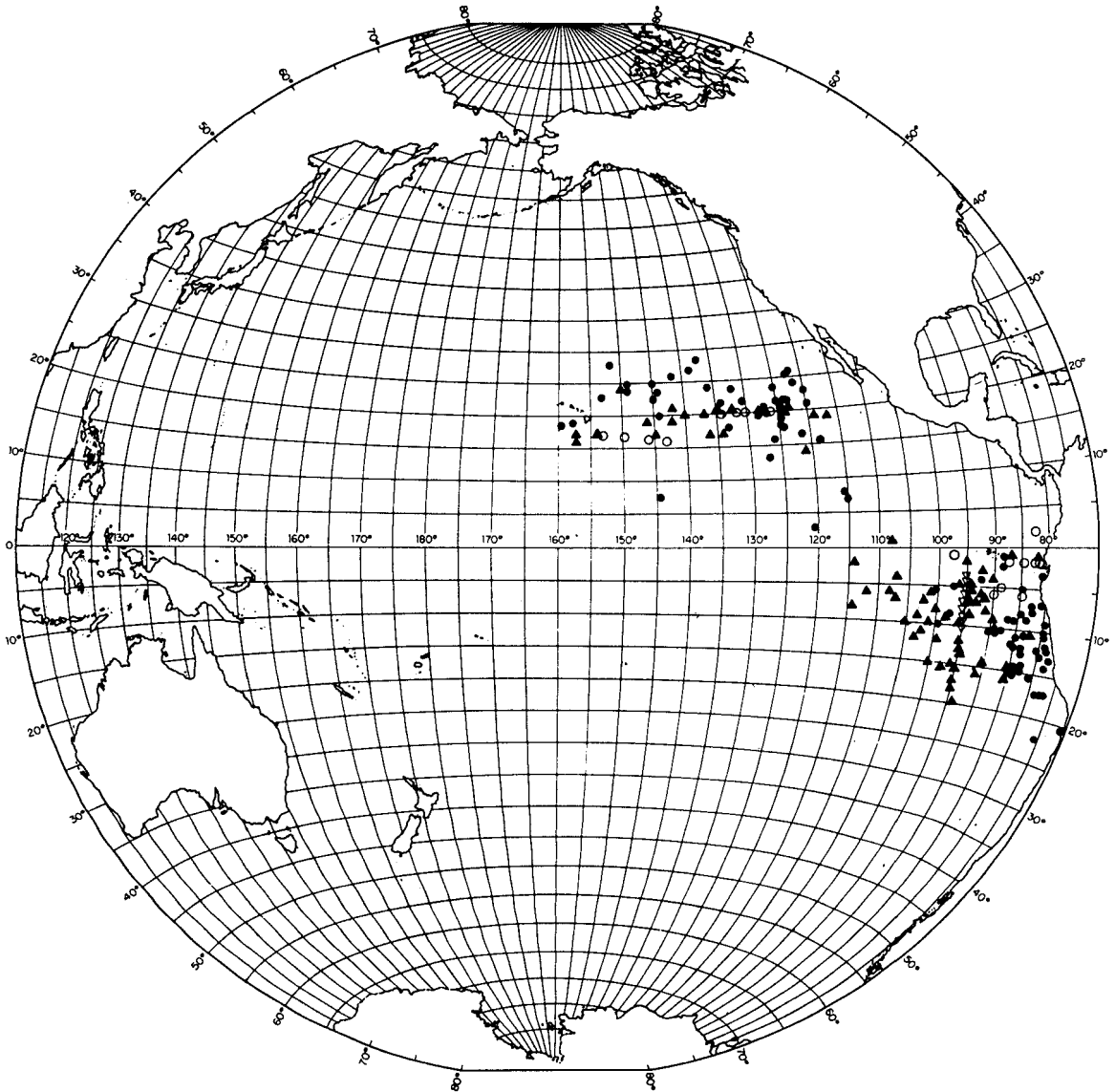


FIGURE 13.—Distribution of *Elasmichthys adocetus*. Solid circles represent material examined by us; solid triangles, records mapped by Ueyanagi et al. (1972); open triangles, localities by Ahlstrom (1972); small open circles, unpublished records furnished by Parin.

America because either we have seen many of these specimens or have numerous captures from closely adjacent localities.

The sauries are essentially antitropical in distribution. This is particularly true for two larger forms, *Scomberesox* and *Cololabis*, which mostly inhabit cold to warm-temperate waters (Figures 14, 15). The dwarf genera *Nanichthys* and *Elasmichthys* occupy much more tropical waters and occur much nearer the Equator than do their larger congeners. The one exception to this

generalization is that of the northerly extension of juveniles and young of *S. s. scombroides* along the coast of Ecuador to about 02° S (Figure 15), where these young stages and the adults and young of *Elasmichthys* have been taken together. This far northern extension of the young of *S. s. scombroides* is interpreted as due to transport by the northerly flowing Perú Current. Along the coast of Perú and northern Chile the ranges of *Elasmichthys* and *S. s. scombroides* overlap to about 22° S (Figure 17).

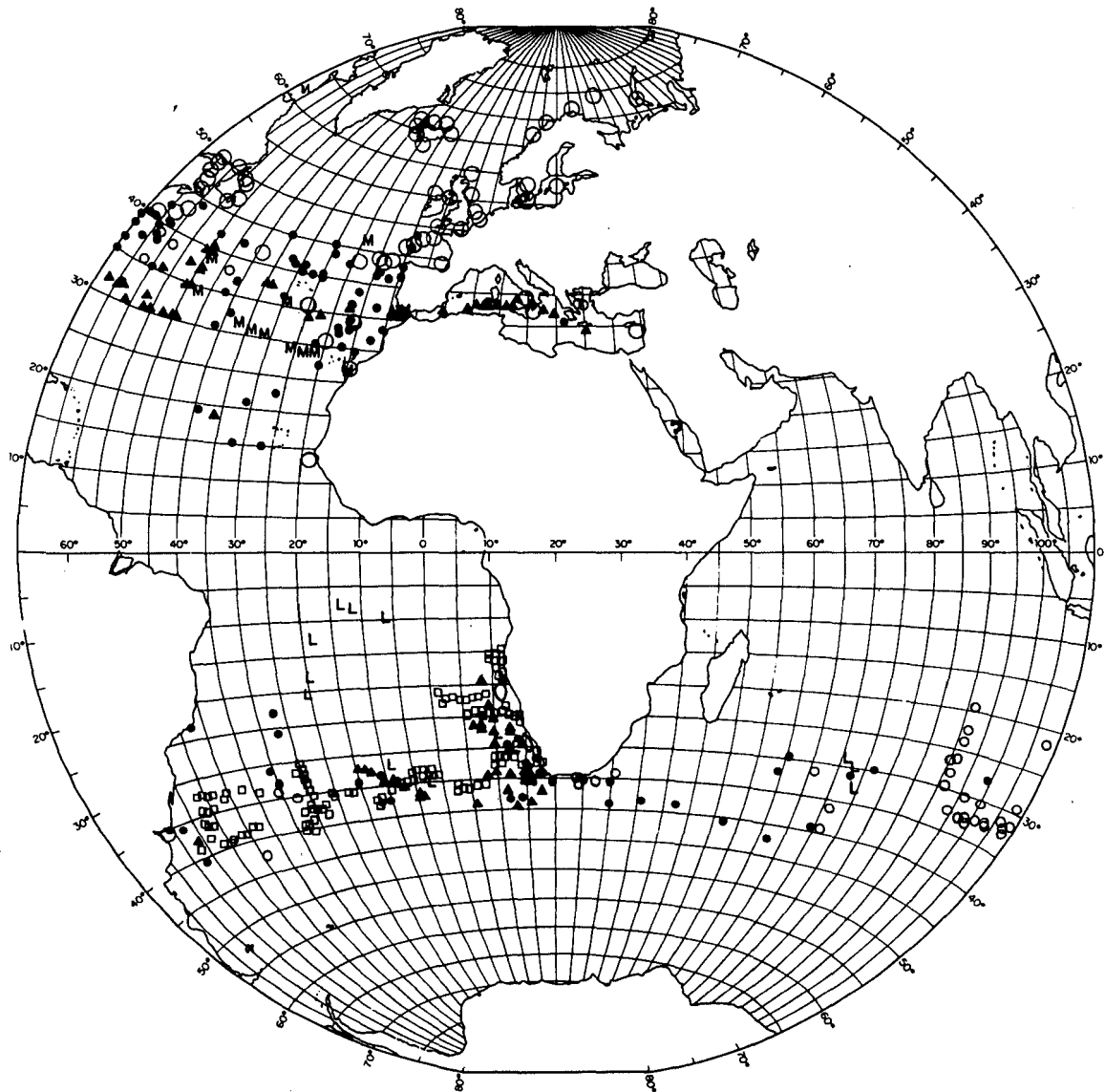


FIGURE 14.—Distribution of the northern and southern populations of *Scomberesox saurus* in the Eastern Hemisphere. Solid circles represent material examined by us; small open circles, records published by Parin (1968a); large open circles represent other published records (specimens not examined by us); solid triangles, records mapped by Ueyanagi et al. (1972); small open squares, localities mapped by Dudnik (1975a), additional and closely spaced records by Dudnik off southwestern Africa are indicated by two open ellipses. Letters L and M refer to records published by Lampe (1914) and Murray and Hjort (1912).

The far-southern locality off Chile for *S. s. scombroides*, at 47° S, 81° W (Figure 15), is based on seven juveniles (56-67 mm SL) in the Hamburg Museum (No. 10601) examined by us. This southern occurrence is not readily explained. It lies well within the portion of the West Wind Drift that forms the northerly flowing Perú Current; perhaps these specimens were waifs carried south

into the edge of this current by the counterclockwise southeastern eddy of subtropical water that extends to between about 20° to 40°-45° S and 120°-80° W. The southern localities listed by Parin (1968a) to 48° S, about 110° W, are apparently attributable to a similar extension of subtropical water (Figure 15).

The questioned locality near the Straits of

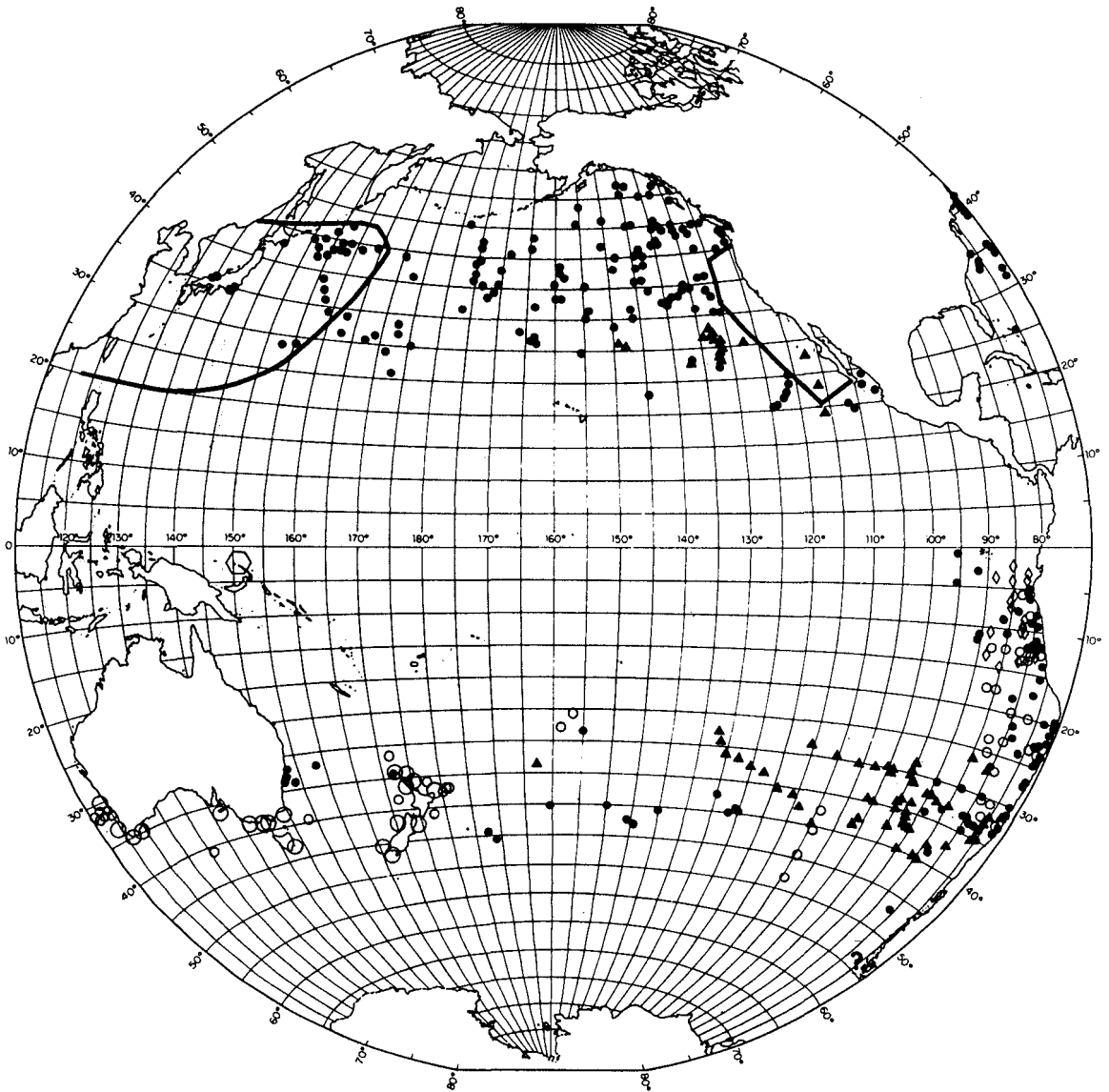


FIGURE 15.—Distribution of *Cololabis saira* and of *Scomberesox saurus* in the Western Hemisphere. Solid circles represent material of *C. saira* in the North Pacific, *S. saurus scombroides* in the South Pacific, and *S. s. saurus* in the extreme northeastern Atlantic Oceans examined by us. For the two areas bounded by heavy lines the records for *C. saira* would virtually blacken the areas and are omitted. Solid triangles refer to mapped records by Ueyanagi et al. (1972) for *C. saira* in the North Pacific and for *S. s. scombroides* in the south; small open circles represent both published and unpublished records of *S. s. scombroides* by Parin; large open circles are for other published records; open diamonds refer to records by Ahlstrom (1972). The question mark near Straits of Magellan refers to Lönnberg's (1907) record for a scomberesocid. The large open hexagon near New Guinea refers to the record of *C. saira* by Kailola (1974).

Magellan (Figure 15) refers to a statement by Lönnberg (1907) in a report on fishes from the Straits (Smyth Channel, Eden Harbor): "In der Sammlung befanden sich ausser den oben aufgeführten Spezies [*Macruronus magellanicus* n. sp.] noch Junge von mehreren Arten, die sich wegen der Jugend der Exemplare nicht bestimm-

men liessen. Unter diesen fanden sich auch einige Repräsentanten für *Scomberesocidae*, so dass sich die Zugehörigkeit dieser Familie zu der magalhaensischen Fauna als sicher annehmen lässt." We question Lönnberg's identification of "Scomberesocidae" at a locality so far south, but we are at a loss to know with what other species his

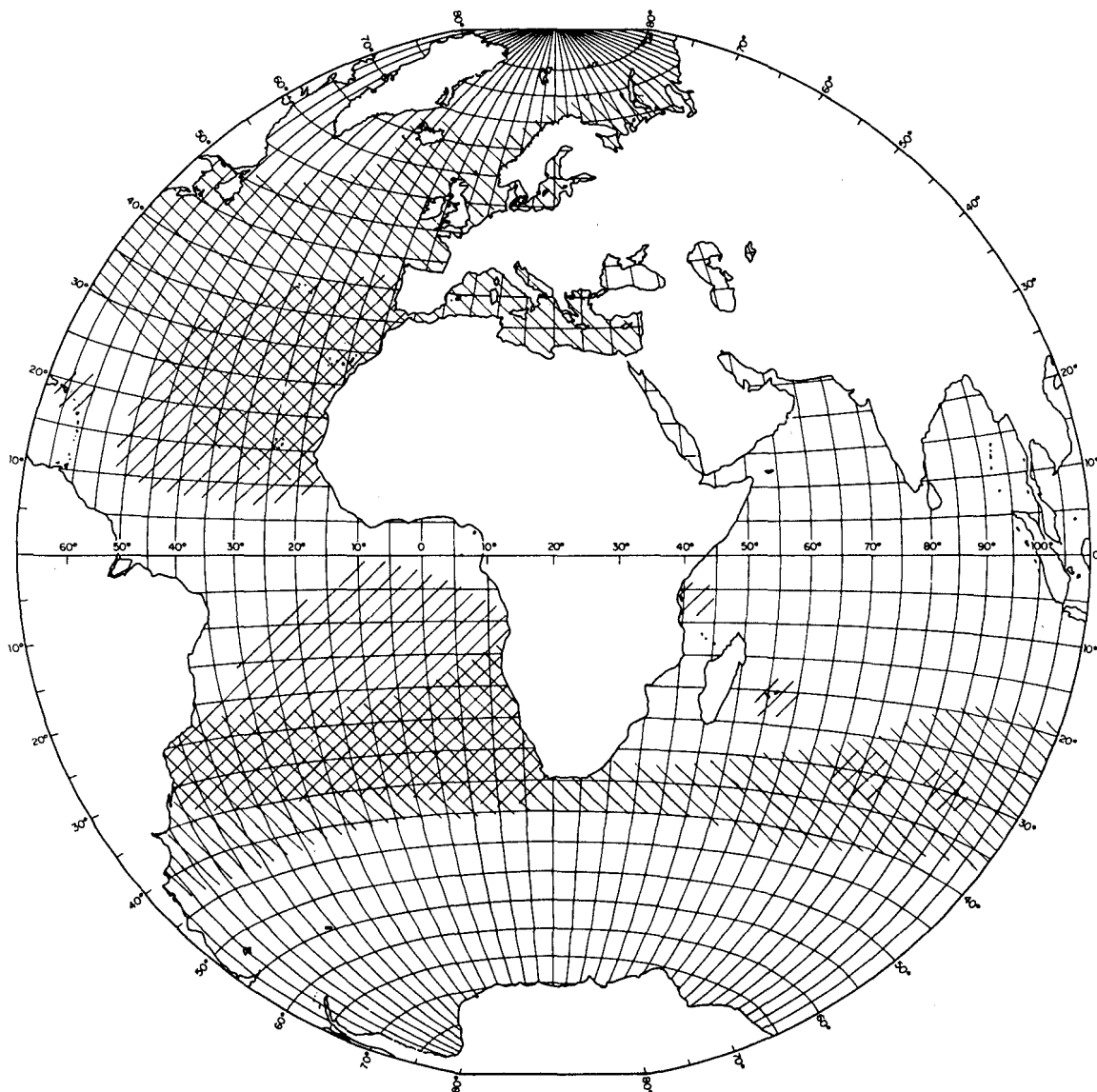


FIGURE 16.—Overlapping distributions of Scomberesocidae in the Eastern Hemisphere. Lines sloping downward to the left refer to *Nanichthys simulans*; lines sloping downward to the right refer to *Scomberesox saurus* in the Atlantic and Indian Oceans.

“young” specimens could have been confused. Mann (1954b, 1960) listed no scomberesocids or beloniforms from the Patagonian area. Also, there appears to be confusion as to the locality of the capture stated by Lönnberg: Smyth Channel and Eden Harbor appear to be about 240 mi apart. According to Defense Mapping Agency Chart 22ACO 22390, Eden Harbor (now Puerto Eden) lies on a narrow channel along the east side of Isla Wellington, about 49°09' S, 74°24' W. This is far inland from the open sea and is a seemingly im-

probable place to find a synentognath fish. Smyth Channel (Defense Mapping Agency Chart 22XHA 22404) opens to the Pacific Ocean at about 52°50' S, 73°50' W (about the center of its wide mouth) and extends northerly to about 52°23' S, where it merges with Mayne and Gray Channels. If scomberesocid fishes of any size occur in the area, the mouth of Smyth Channel is a more probable place than the inland Eden Harbor. The taking of seven young of *S. s. scombroides* at 47° S, 81° W, cited above, lends some credence to the possibility of the

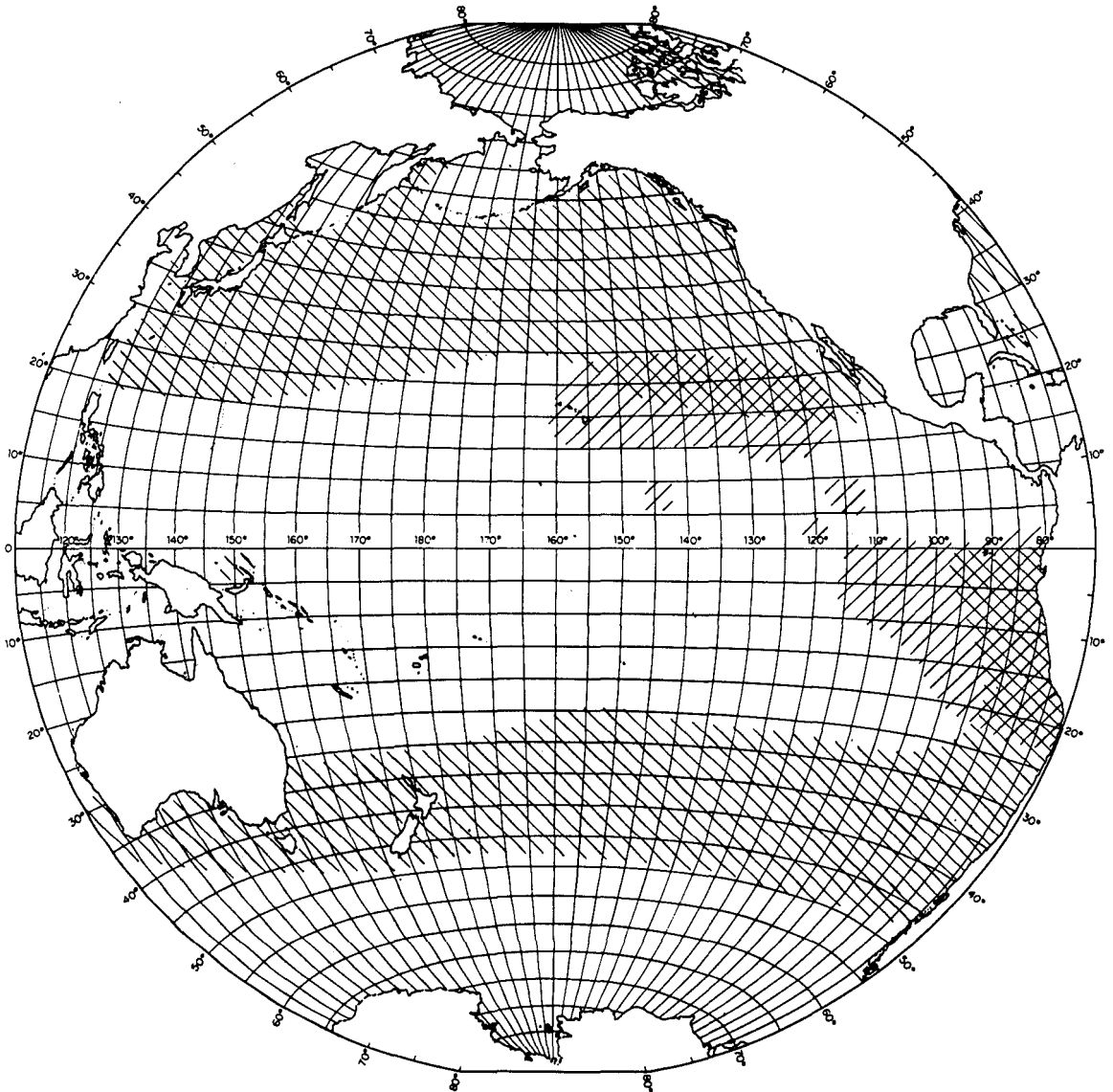


FIGURE 17.—Overlapping distributions of Scomberesocidae in the Western Hemisphere. Lines sloping downward to the right refer to *Cololabis saira* in the North Pacific and near New Guinea, and to *Scomberesox* spp. in the South Pacific and extreme northwestern Atlantic; lines sloping downward to the left refer to *Ellassichthys adocetus*.

species being taken in the wide oceanic mouth of Smyth Channel some 400 mi farther south.

Our findings on the distribution of *S. s. scombroides* westward across the South Pacific differ little from that shown by Parin (1968a).

The northern subspecies, *S. s. saurus*, occurs widely in the North Atlantic Ocean, north of about 30° N, but rather sparsely in the central area, where it is very largely replaced by *Nanichthys* (Figures 12, 14, 16). It ranges along North

America from Florida (rarely) to Newfoundland, and well into the Gulf of St. Lawrence (Vladykov and McAllister 1961) and to Iceland (Saemundsson 1949). The species occurs uncommonly along the eastern shores of the United States south of New Jersey. It occurs at the oceanic islands of the eastern North Atlantic, throughout the Mediterranean, Aegean, and Adriatic Seas, the British Isles, and along Norway to near Nordkapp. It has been reported from the Barents Sea, and from the

White Sea in Kandalaksha Bay, about 67° N, 32°45' E (Andriashev 1954, after Novikov). Berg (1939) reported it from the western entrance to the Strait of Matochkin Shar, Novaya Zemlya Island (about 73°16' N, 56°27' E); Andriashev (1954) gave the length of this specimen as 25 cm. Presumably the species is rare that far north and is a summer migrant. However, it has been reported (Anonymous 1970) that four Russian vessels captured 7 to 10 metric tons per vessel per day of "saury" in late September 1969 near Novaya Zemlya. W. L. Klawe¹⁶ feels that these large catches of *Scomberesox* so far north actually represented either "saida" (*Pollachius virens*, the Atlantic pollock) or "saika" (*Boreogadus saida*, the Arctic cod), and that the use of the Russian vernacular "saira" (= saury) was either a misprint or misinterpretation.

The southern extension of *S. s. saurus* into the central North Atlantic, to 15° N (Figure 14) is probably due to the southeasterly flowing currents of the huge gyre that extends across the ocean between about 40° and 20° N; the southern border of this gyre forms the northern boundary of the west-flowing North Equatorial Current; its southern boundary reaches to about 5° N.

Nanichthys is common in the more central parts of the North and South Atlantic Ocean but is not common in the Indian Ocean (Figure 12). We enter on the distributional chart (Figure 12) a question mark in the Red Sea on the dubious basis of Borodin's (1930) record of "*Scomberesox saurus*, young" from the "Red Sea" (accepted by Fowler 1956). The record is questioned because Borodin's identifications have proved to be commonly inaccurate, and we have not seen the specimen (which has been reported to us as no longer extant in the Vanderbilt Museum). If the record was not based on a juvenile hemiramphid or other nonscomberesocid synentognath, it may have been based on *Nanichthys*, which we have seen from Zanzibar. We also enter a question mark (Figure 12) in reference to the record of *S. saurus* reported by J. L. B. Smith (1955). Smith¹⁷ has stated: "With regard to the Aldabra record, I regret that we cannot find the specimen. In our field notes this species is entered as 'Juvs. in stomach of Tunny.' Neither my

wife nor I can remember whether that material was kept or not; it probably was in a bad state."

The records of capture of *Nanichthys* in the Indian Ocean are too few to warrant more than conjecture as to limits of distribution there; it is either uncommon or has been very infrequently taken. No specimens resulted from the broad station coverage of the International Indian Ocean Expedition, 1963-64. N. V. Parin¹⁸ did not encounter any specimens of *Nanichthys*, although he did report many captures of *S. s. scombroides* (Figure 14). Sauvage (1891) listed "*Scomberesox saurus*" from near Madagascar, within a rather broad area bounded by "3^E et 26^E parallèles et les 42^E et 65^E méridiens." Misidentification is possible as Sauvage included species of Belonidae, Hemiramphidae, and Exocoetidae in his "Scomberesocidae"; no size or number of specimens was given.

In most of the records of *Nanichthys* from the North Atlantic Ocean, the greatest number of captures lie within the large eddy system and easterly of about 40° W, extending to the African coast. The southern border of the range, ca. 10° N, is at about the middle of the North Equatorial Current, and the northern border, at ca. 35° N, at the northern margin of the eddy and the southern margin of the Gulf Stream and of its continuation—the North Atlantic Current. There is little difference in current structure between winter and summer in the southern portion of the North Atlantic (Anonymous 1965), and the currents are relatively slow during both periods. Oddly, *Nanichthys* is infrequently taken west of about 40° W, the most westerly occurrence being near St. Thomas Island, West Indies (Figure 12). *Nanichthys* appears to be more antitropical in distribution than does *Elasichthys*. Ueyanagi et al. (1972) mapped the occurrence of a juvenile at about 02° S, 10° W (Figure 12).

In the Atlantic, in both hemispheres, this dwarfed form has often been confused by authors with the young of *Scomberesox*. The material reported by Murray and Hjort (1912) ("M" in Figures 12 and 14), and by Lütken (1880) from the North Atlantic in part represent *Nanichthys*. Each author stated that the young of *Scomberesox* were taken in great numbers in collections from the open Atlantic; each figured (as young of *Scomberesox saurus*) the distinctive beak structure of

¹⁶W. L. Klawe, Inter-American Tropical Tuna Commission, La Jolla, Calif., pers. commun. 20 March 1970.

¹⁷J. L. B. Smith, Department of Ichthyology, Rhodes University, Grahamstown, South Africa, pers. commun. 20 November 1964.

¹⁸N. V. Parin, P. P. Shirshov Institute of Oceanology, Akademia 117218 Moscow, Krasikova 23, U.S.S.R., pers. commun. 14 September 1978.

adult or semiadult *Nanichthys*—the upper beak notably shorter than the lower. We have examined most, if not all, of these specimens and found them to be referable to *Nanichthys*. Also, most of the reports of *Scomberesox saurus* from the South Atlantic and Indian Oceans by Lampe (1914) ("L" in Figure 12) may, on the basis of geographical evidence, be referable to *Nanichthys*. We have, however, not seen the specimens, but many of Lampe's collections occurred in the area of overlap (Figure 16). Dudnik (1975a) reported on an extensive collection of "*Scomberesox saurus*" from the South Atlantic (about 3,000 specimens, from 8 to 460 cm). In general his data agree well with ours and with Parin's (1968a, b) but he shows (Dudnik 1975a, fig. 2) the species to extend northward to about 18° S along the coast of Africa. This is notably farther north of the expected range but is well within that of *Nanichthys*. He did not discuss the dwarf ("*Scomberesox* sp") in his study (Dudnik 1975a), submitted for publication on 20 January 1974, nor did he compare it with its larger relative, although presumably he was aware of the form and of Parin's (1968a) study for he submitted his own (Dudnik 1975b) concerning it on 20 November 1974. As no tabular or descriptive morphological data were offered in the first study (on *Scomberesox saurus*), it is not entirely clear whether or not Dudnik (1975a) dealt only with the larger form, for he indicated that only smaller specimens, larvae to juveniles up to 100 mm (a size range encompassing most adults of *Nanichthys*), occurred north of 20° S. Also, in his later work on *Scomberesox* sp. (= *Nanichthys simulans*), Dudnik (1975b) showed collections of the dwarfed form between about 10° and 15° S in this same area off Africa.

The dwarfed form, *Elassichthys adocetus*, of the eastern Pacific Ocean also has been confused with the young of *Cololabis saira*. Roedel (1953) and Chirichigno F. (1962) reported *C. saira* (as young) from off northern Perú. Schaefer and Reintjes (1950) reported (as young of *C. saira*) specimens of *E. adocetus* from between the Hawaiian Islands and the western coast of North America.

Elassichthys adocetus appears to be less antitropically distributed than is *Nanichthys simulans* in the Atlantic Ocean. A few specimens have been taken between the two principal areas of occurrence north and south of the Equator (Figure 13); perhaps these are strays from the main groups (presumably from the southern) and transported there by the complex current systems of the area

and/or associated with oceanic fronts, as reported by Knauss (1957) in the vicinity of 03° N, 120° W.

An interesting aspect of the distributions of the northern population of *E. adocetus* is its absence from the large area bounded by about 115° W and the Equator. Also, it has not been taken within hundreds of miles of the coast of Baja California, México. In contrast, the species is very common in the coastal waters of Ecuador and Perú. One reason for the avoidance (or absence) of the area westerly of Baja California may be the still cool water of the California Current, between 18° and 25° N. This broad current is evident out to about 120° W and flows southerly to about 22° N between January and June-July before turning westerly and mixing with the North Equatorial Current; from August to December these two currents merge at or north of 20° N. Temperatures within this large area range between 25° and 29° C (Wyrтки 1964) and are probably above the optimum tolerated by the species. Also, this area is one of very low oxygen content (0.05 ml/l), but this may not be a factor in the distribution of *E. adocetus* as it is an entirely surface form and probably remains well above the upper depth limit of the O₂ minimum layer, between 50 and 200 m (Wyrтки 1967).

The occurrence of *E. adocetus* (and *S. saurus scombroides*) near the coasts of Ecuador and Perú, and its westward extension of range to about 115° W near the Equator, are no doubt due to the still cool water of the Perú Current; the temperatures range to about 20°-26° C in summer and 16°-24° C in winter, between about 0° and 22° S (Wyrтки 1964).

In the northeastern Pacific Ocean the ranges of *C. saira* (again mostly juveniles and young) and the northern population of *E. adocetus* overlap in an extensive area roughly bounded by about 20° to 30° N, 115° to 155° W (Figure 17); perhaps the overlap is primarily seasonal but often the two have been taken together in the northern portion of the overlap area. King and Iversen (1962:320, app. table 8) reported one specimen (86 mm) of "*Scomberesocidae*" from the Equatorial Counter Current (ECC) in 1955-56. No coordinates were given but the collection was made between about 108° and 160° W within the ECC, the boundaries of which these authors indicated to be between about 5° and 10° N (p. 286, fig. 12). The stated size ("86 mm") is notably longer than the largest of hundreds examined by us (about 68 mm SL), but it can scarcely be other than *Elassichthys*, which is

common within the ECC. The southernmost known occurrence of *C. saira* is some hundreds of miles to the north.

Cololabis saira apparently does not occur south of about 20° N (Figure 15), based on our data and those of Parin (1960). North of this latitude it ranges throughout the North Pacific to the Aleutian chain, but apparently not into the eastern and central Bering Sea. In the far western area it occurs in the eastern portion of the Yellow Sea, the entire Sea of Japan to well along Sakhalin, into the southern Okhotsk Sea, and northerly along the Bering Sea coast of Kamchatka to Olyutorsky Bay, at about 60° N (Parin 1968a, b) (Figure 17). Along the North American coast *C. saira* is very common from Alaska to at least central California, but only sporadically so to about the Cedros Island region of Baja California, México; it is relatively uncommon south of that region, particularly adults, but young and juveniles have been taken at about 19° N in the eastern Pacific.

Cololabis saira juveniles (8-30 mm) were reported from 180 mi east of Port Macquarie (New South Wales, Australia) by Fourmanoir (1971); however, we have examined these small fishes and determined them to be *S. s. scombroides*. One apparently valid capture of *C. saira* near New Guinea (kindly communicated to us by N. V. Parin, 14 September 1978) was reported by Kailola (1974): "... one specimen. East of Kavieng [New Ireland] (2°34' S, 150°49' E) Dipnetted by night light, 1967.—205 mm SL." The count of dorsal and anal finlets (5 each) indicates the specimen is a scomberesocid, and certain proportions listed can pertain only to *Cololabis*: "Eye 5, 1.8 in snout. Snout 2.7 in head," falling far outside the range for *Scomberesox* of similar size. The stated size, 205 mm, is far too large for *Elassichthys*. This locality (Figure 15, large hexagon) is about 1,800 miles south of any other known occurrence of *C. saira* in the western Pacific. Parin believes, and we concur, that this specimen was very probably lost from a Japanese longline vessel; Fourmanoir and Laboute (1976) describe the use of frozen sauries (*C. saira*) as bait by longliners operating in the area.

Intriguing questions arise concerning this apparently valid capture in the Southern Hemisphere. We assume that the specimen was alive (at least it was not stated otherwise). Kailola (1974) postulated that "abnormal extensions of cold currents south of the Equator may thus account for the southern record of the species." An alternative

explanation is that the specimen was transported alive from northern waters in a bait tank aboard a vessel. However, *C. saira* does not keep well in live-bait tanks; they are "wild" and dash themselves to death against the walls, particularly of small tanks. And, to our knowledge, there are no recorded instances of a Japanese longline vessel carrying large live-bait tanks.

ACKNOWLEDGMENTS

Our efforts have been aided by many persons—so many that no doubt we will fail to list at least a few; in that event we hereby express our great appreciation for any effort made to further our work. We are deeply indebted to our Russian colleague Nikolai Parin for deferring to us the naming of his "*Scomberesox* sp" and for persuading his fellow workers also to refrain; also, we are indebted to him for providing many unpublished capture localities for all four species of the family. Our Japanese colleagues, Shoji Ueyanagi, Shigeru Odate, Keiichiro Mori, Hiroshi Hiyama, and Tokiharu Abe, have provided information on distribution of *Cololabis saira*; Ueyanagi, in addition, provided much information on *Scomberesox*, *Nanichthys*, and *Elassichthys*. We are very grateful to Philip Sloan, formerly a student at Scripps Institution of Oceanography, for his efforts on the Scripps expedition LUSIAD in gathering the nucleus of the material on which we base the new genus and species, *Nanichthys simulans*.

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Bruce B. Collette critically reviewed the manuscript and offered valuable suggestions. Elizabeth N. Shor typed the final manuscript and otherwise provided assistance. To all these persons (and those we have forgotten) we offer our very great appreciation and deep thanks.

ADDENDUM

Fossil Fishes from California
Referred to Scomberesocidae

We are uncertain of the synonymic status of the nominal genus *Scomberessus*, based on a fossil from the Miocene (Monterey) formations, introduced by Jordan (1920). By context, Jordan proposed *Scomberessus* as a new genus, as follows: "**Scomberessus** Jordan, 571 [referring to the same item in *The Genera of Fishes*], orthotype SCOMBERESOX ACUTILLUS J. & G. (fossil). Differs from the living genus SCOMBERESOX in the much larger dorsal, of 16 rays." But an examination of the text and figures of the two fossil specimens described by Jordan and Gilbert (1919: 37-38, pl. XIV, fig. 2, and XVIII—*Scomberesox acutillus* and *S. edwardsi*) indicate a serious confusion. The one item of diagnosis (dorsal fin) was obviously drawn not from the account and figure of *Scomberesox acutillus* Jordan and Gilbert (1919:37-38, pl. XIV, fig. 2 [the paratype]), but from the description and figure of *Forfex hypuralis* Jordan and Gilbert (1919:36-37, pl. XIV, fig. 3). The description of *S. acutillus* states only "dorsal obliterated," also, the paratype (a complete skeleton examined by us) shows no remaining trace of a dorsal fin. The description of *F. hypuralis* lists the dorsal rays as "apparently I, 16 in number" and the figure shows a long-based dorsal of approximately the stated number of rays and beginning before the middle of the body (without head). The juxtaposition of the two figures on the plate presumably led the aged master astray. Despite the nonapplicability of the one stated character, the generic name *Scomberessus* must, we assume, rest on the designated type-species, *Scomberesox acutillus*.

Regardless, we are more concerned with the reference of these fossils to the family Scomberesocidae. We have examined the paratype of *Scomberesox acutillus* (a complete skeleton but with crushed head), and five essentially complete skeletons referable (presumably) to *S. edwardsi* (the holotype is a head and anterior few vertebrae) and have failed to find any finlets—a key character of the family—this despite the listing by Jordan and Gilbert (1919) of "... traces of five finlets" for *S. acutillus* (the paratype); under high magnification these traces proved to be isolated scales.

David (1943) may have inferred the presence of finlets by listing counts for *S. edwardsi* of "Dorsal fin 14, V; anal fin 18, VI. . . ." As Roman numerals

have long been used to designate spiny or unsegmented rays, and as living scomberesocids and related fishes all have segmented rays, we assume that David was referring to finlets. However, on examination of David's and other material labelled *S. edwardsi*, we find nothing to substantiate a count including any "V" or "VI," particularly for finlets.

Each finlet of the Scomberesocidae and Scombridae (mackerels and tunas) arises from a single base (ray) that branches into a fanlike structure that is much more robust than a slender, single ray of the dorsal and anal fins proper. Since the individual rays of these fins are distinctly evident on some of these fossils, it is reasonable to expect the heavier finlets also to be preserved or that an imprint at least would have remained.

The lack of imprint of finlets is substantiated by the absence of any (or imprint) of the supporting bones associated with them. In present scomberesocids these supporting bones are robust, flattened laterally, and lie embedded somewhat parallel to the surfaces of the caudal peduncle rather than extending more or less vertically between the neural and haemal spines, as do those of the rays of the main portions of the fins. Thus, since the supporting rays of the main portions of the fins are often visible in the fossils, it is reasonable to expect such rays of the finlets also to be visible, if present.

In addition to the apparent lack of finlets on these fossils (labeled as of Clarendonian stage), there are notable differences in proportions in lengths of anal bases and caudal peduncle between them and present *Scomberesox*. In two fossils on which the anal fins appear to be entire (none have complete dorsal fins) the length of this fin is slightly shorter than the length of caudal peduncle (23.7 vs. 26.5 and 28.5 vs. 33.2 mm). In present *Scomberesox* the caudal peduncle is about 2.5 times the length of either the dorsal or anal fin base, exclusive of finlets. In this regard the fossils approach the condition found in the Belonidae, wherein the length of the caudal peduncle is one-half or less as long as the fin bases; in *Ablennes hians* the peduncle is scarcely more than one-fourth the length of these bases. Thus, among known marine fishes with both jaws greatly prolonged into beaks, these fossils are about midway between present belonids and *Scomberesox* in the ratio of lengths of caudal peduncle to the base of either dorsal or anal fins (exclusive of finlets in the latter group). An additional difference is a notable

reduction in numbers of vertebrae in those fossils with complete skeletons, 54-58 vs. 64-70 in present *Scomberesox*, and 62-69 in *Cololabis*.

Due to the apparent absence of finlets and the discrepancy in lengths of caudal peduncle and anal fin base, and the many fewer vertebrae, it seems justifiable to remove these fossils from the family Scomberesocidae. To retain them therein would require acceptance of development of finlets and drastic modification of the peduncular region since the Miocene period (7-26 million years BP [Before Present]) and a gain of at least six vertebrae; we hold these to be improbable occurrences. In any event, the name *Scomberessus* appears to have no bearing on the new generic names proposed herein.

Furthermore, we find no sound basis for even the doubtful reference of *Praescomberesox pacificus* David (1946:58-59, pl. 2, fig. 3, and pl. 3, fig. 2) to the Scomberesocidae on the basis of isolated scales found in a core from oil-well drilling at a depth between 3,895 and 3,907 feet (holotype).

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