Fishes of the Western North Atlantic

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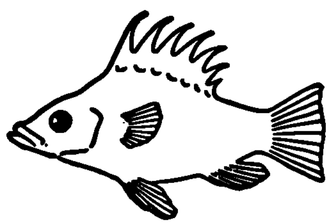
MEMOIR
SEARS FOUNDATION FOR MARINE RESEARCH

Number I

Fishes of the Western North Atlantic



PART SEVEN

Order Iniomi (Myctophiformes)

NEOSCOPELIDAE AND MYCTOPHIDAE
and
ATLANTIC MESOPELAGIC ZOOGEOGRAPHY

NEW HAVEN

SEARS FOUNDATION FOR MARINE RESEARCH, YALE UNIVERSITY

Yale

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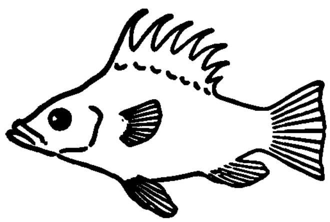

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NEW HAVEN

SEARS FOUNDATION FOR MARINE RESEARCH, YALE UNIVERSITY

Table of Contents

In memory of Rolf L. Bolin, who set the standards in lanternfish taxonomy.

Introduction

THIS seventh part of FISHES OF THE WESTERN NORTH ATLANTIC includes accounts of two iniomous (myctophiform) families for which short interim accounts have previously appeared in Part Five. These are the Neoscopelidae, which has few genera and species, and the Myctophidae, which has many genera and several hundred species in the world's oceans and is exceedingly important in the economy of the open sea. Also included is a special contribution on Atlantic Mesopelagic Zoogeography, based primarily on the species of Myctophidae. This section synthesizes a large amount of data to provide a scheme for relating fish distributions to characteristics of the Atlantic Ocean. These accounts were to have been written by Rolf Bolin, who was unquestionably the leading authority on lanternfishes. Rolf is no longer with us, and we miss him. This volume is dedicated to him.

Recent years have seen a great surge in the exploration of the open sea. As a result, the study of deep-sea fishes is receiving more attention than ever before. Lanternfishes are so abundant and speciose that they must be taken into account in any consideration of the dynamics and energetics of biological communities in oceanic midwaters. We have been fortunate, therefore, in enlisting the efforts of several leading scientists in preparing this volume, which we hope will be a guide and inspiration to others. There is still a great deal to be learned.

Users of this volume will notice that several names of species are spelled slightly differently than in much of the most recent literature. Some of the revised spellings are reversions to the *original spelling*, as used in the description of the species by the author who first named it. This follows a recent decision by the International Commission on Zoological Nomenclature, which had previously ruled that singular male patronyms should end in a single i, whether the original author used none, one, or two. The names so changed here, correctly spelled, are:

Electrona risso
Hygophum reinhardtii
Hygophum hygomii
Gonichthys cocco
Lobianchia gemellarii
Diaphus rafinesquii
Notoscopelus kroeyerii
Ceratoscopelus warmingii
Diaphus dumerilii

The use of diacritical marks in a scientific name is not accepted by the International Code of Zoological Nomenclature, and letters that originally employed an umlaut are to be transliterated (for example, ü becomes ue). This rule has been followed by some workers, but not by others. The names involved here are:

Diaphus luetkeni
Lepidophanes guentheri
Notoscopelus kroeyerii

One other name has been changed here from the spelling currently in use. *Myctophum obtusirostre* employs the correct neuter adjectival ending.

The Synonyms and References sections in this volume are limited to those names and references that were considered most important. For much fuller synonymies, readers should refer to the work by Krefft and Bekker (1973).

Two species names that have appeared in the literature recently, one of them having been in use for a long time, are herein newly relegated to the synonymy of an earlier-named species:

Myctophum selenoides Wisner is placed in the synonymy of
Myctophum selenops Tåning.

Diaphus elucens (Brauer) is placed in the synonymy of
Diaphus perspicillatus (Ogilby).

The following abbreviations have been used throughout in order to avoid repetition of the names of natural history collections housing the preserved specimens upon which the accounts have been based.

AMS	—	Australian Museum, Sydney
BMNH	—	British Museum (Natural History), London
BOC	—	Bingham Oceanographic Collection, Yale University, New Haven
CAS(SU)	—	Stanford University collections, now at California Academy of Sciences, San Francisco
ISH	—	Institut für Seefischerei, Hamburg
LACM	—	Los Angeles County Museum of Natural History
MCZ	—	Museum of Comparative Zoology, Harvard University
MMF	—	Museu Municipal do Funchal, Madeira
MOM	—	Musée Océanographique, Monaco
NMFS	—	National Marine Fisheries Service
NRMG	—	Naturhistoriska Riksmuseet, Göteborg
RMNH	—	Rijksmuseum van Natuurlijke Historie, Leiden
ROM	—	Royal Ontario Museum of Zoology, Toronto
SIO	—	Scripps Institution of Oceanography, La Jolla
USNM	—	National Museum of Natural History, Washington
WHOI	—	Woods Hole Oceanographic Institution
ZMHU	—	Zoologisches Museum der Humboldt Universität, Berlin
ZMO	—	Zoologisk Museum, Oslo
ZMUC	—	Zoological Museum, University of Copenhagen

Other often used abbreviations are:

TL	—	total length
SL	—	standard length
hl	—	head length
m.w. or m.w.o.	—	meters of wire out
f.w.o.	—	feet of wire out

The editors are grateful to the authors for their contributions and to the home institutions of the authors for supporting their work. We also thank the several agencies and foundations that have supported the authors in many ways, as the authors have noted in their acknowledgments. The museum community deserves special appreciation, for without their cooperation, good and comprehensive studies as exemplified by this series would be impossible. Finally, we renew our thanks to the Sears Foundation for the publication of this volume. The Editor-in-Chief points out the many services provided by the Smithsonian Institution during preparation of this volume and thanks Mrs. Jane Shaw for her diligence and hard work in preparing the manuscript for the printer and seeing it through to publication.

December, 1976
Washington, D. C.

ROBERT H. GIBBS, JR.
Editor-in-Chief

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Family Neoscopelidae

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University of Southern California, Los Angeles

Acknowledgments. I thank the following for providing me with specimens and information: Victor G. Springer, United States National Museum; John L. Butler and Elbert H. Ahlstrom, National Marine Fisheries Service, La Jolla, California; Elizabeth N. Shore and Robert L. Wisner, Scripps Institution of Oceanography, La Jolla, California. I also thank Mary Nafpaktitis for typing the manuscript and for editorial assistance.

This study received financial support through a grant (GB 13389) from the National Science Foundation.

General Characters. Deep-sea pelagic and benthopelagic fishes with compressed bodies and heads. Eyes lateral, small in *Scopelengys* and *Solivomer*, large in *Neoscopelus.* Mouth large, terminal; upper jaw extending to or beyond vertical through posterior margin of orbit; maxillary greatly expanded and truncate posteriorly, toothless and completely excluded from the gape by the premaxillary. Dorsal fin well in advance of anal fin. Adipose fin present. Lateral-line organs weakly developed. Scales large, deciduous and cycloid, except in *Solivomer arenidens,* which has ctenoid scales on body and cycloid ones on head (Miller, 1947). Luminous organs present in *Neoscopelus* only.

Dentition. In general, premaxillaries and dentaries with closely set villiform teeth; a band of small teeth on each palatine and similar ones on vomer and basibranchials.

Skeletal Characters. Six circumorbital bones. Subocular shelf absent. A long slender supramaxillary present along dorsal margin of posterior part of maxillary. Branchiostegals 8 in *Scopelengys,* 8–9 in *Neoscopelus,* and 10 (9–11) in *Solivomer.* Gill rakers well developed. Vertebrae 29–35. Three ventral and 4 dorsal hypurals; 3 epurals. Six to 8 dorsal and 5–7 ventral, soft procurrent caudal-fin rays; principal caudal-fin rays 10 (9) dorsal and 9 (8) ventral. Pelvic-fin rays 8. A small, spinelike splint at base of 1st dorsal-, 1st anal-, uppermost pectoral-, and outermost pelvic-fin ray in *Neoscopelus*; the same element is either very soft or absent altogether in *Scopelengys.*

Luminous Organs. The species of *Neoscopelus* have numerous photophores arranged linearly in horizontal series on the ventral part of the body and along the periphery of the tongue (Fig. 1). The photophores are superficial, oval in shape with a rim of black pigment along their dorsal and posterior margins. Their

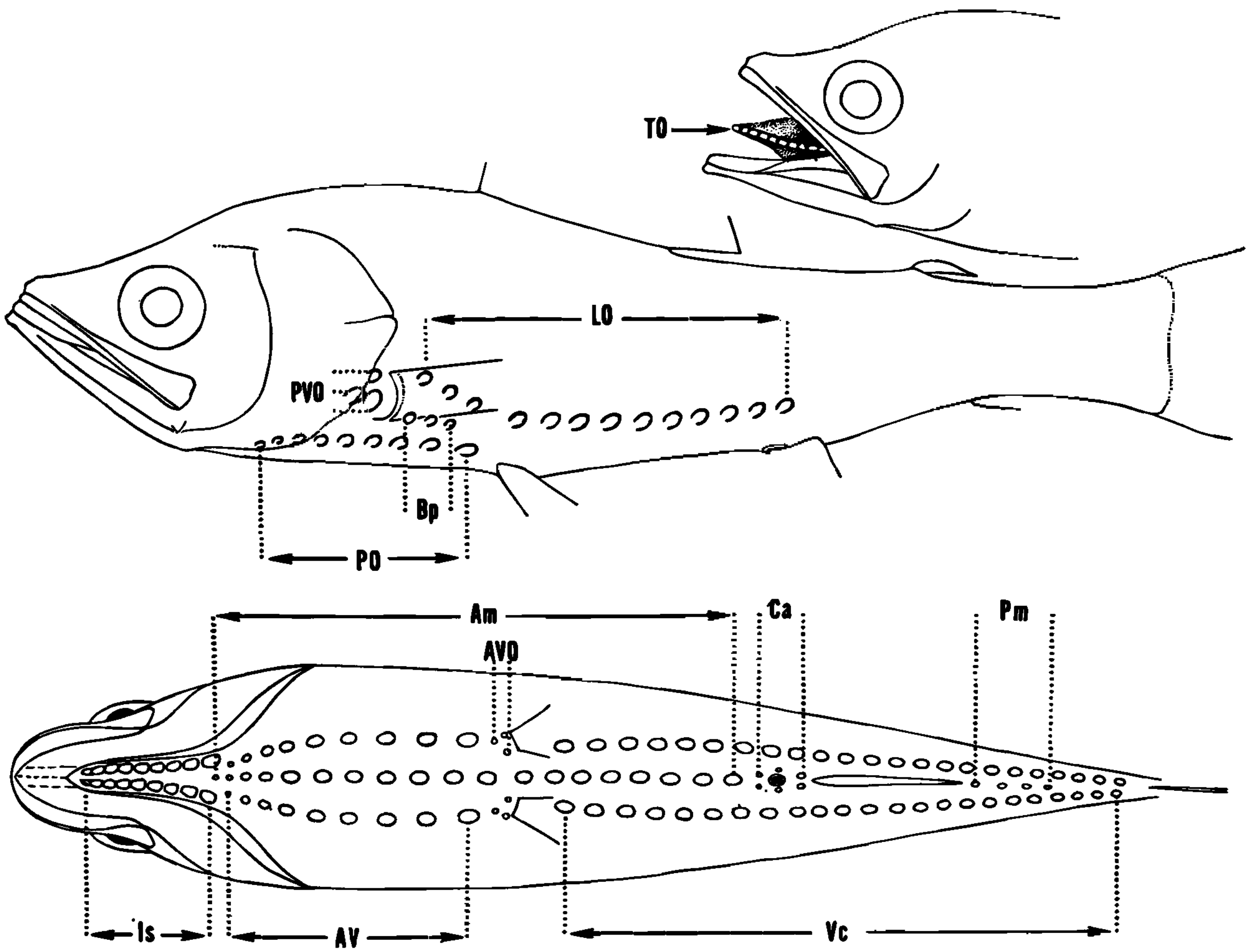

FIGURE 1. Arrangement of photophores in *Neoscopelus*. Terminology follows Matsubara (1943). Am, anteromedian; Av, anteroventral; AVO, accessory ventral; Bp, basipectoral; Ca, circumanal; Is, isthmus organs; LO, lateral; Pm, posteromedian; PO, thoracic; PVO, prepectoral; TO, tongue organs; Vc, ventrocaudal.

anteroventral margins are often indistinct, the reflective layer fading into the surrounding silver of the lower half of the body. The small mass of photogenic tissue is restricted to the posterodorsal or posterior part of each organ. The scales overlying the photophores are not modified into lenses. No other luminous organs or luminous tissue are evident on the bodies and heads of these fishes.

Swimbladder. A swimbladder is present in the monotypic *Solivomer* (Miller, 1947) and in *Neoscopelus*. The organ is absent in *Scopelengys*.

The swimbladder of *Neoscopelus macrolepidotus* was found by Marshall (1960: 42) to be capacious, with a gas gland that covers some two-thirds of its floor and supplied by 5 massive retia mirabilia. Marshall was able to find no trace of an oval or of any specialized region that might function in gas resorption.

Development. The larvae of *Scopelengys* have been studied by Moser and Ahlstrom (1970: 142) and found to bear a striking resemblance to certain myctophid larvae, especially those of the genus *Lampanyctus*. In their recent review of the genus *Scopelengys*, Butler and Ahlstrom (1976) described and illustrated a 13.9-mm larva of *Scopelengys tristis* and a 15.2-mm larva of a new species of this genus from the central North Pacific Ocean.

Diversity and Range. The Neoscopelidae are distributed in tropical and subtropical regions of all three major oceans. The family includes three genera: *Scopelengys*, with two species, inhabits deep, oceanic midwaters; the three species of *Neoscopelus* are benthopelagic and occur in the proximity of land masses; the third, monotypic genus *Solivomer* has been known in the past only from the holotype and 30 paratypes of *S. arenidens*, all collected in the vicinity of the Philippine Islands. Recently, Robert L. Wisner of SIO sent me seven additional specimens of *S. arenidens* which had been made available to him by Jørgen Nielsen of the ZMUC. The specimens (71–175 mm) were all taken off Mindanao (08°48'N, 124°09'E) during the GALATHEA Expedition, 1950–52.

Remarks. Originally, neoscopelids were included in the family Myctophidae. Their relationships with the lanternfishes were discussed by Regan (1911). Changes in the systematic picture began with Fowler's (1925) division of the family into the subfamilies Myctophinae and Neoscopelinae, the latter to include the genus *Neoscopelus* alone. Three years later, Parr (1928), on the basis of external characters, concluded that the forms included by Regan (1911) in the Myctophidae represented "three different types or stages of differentiation" each deserving a subfamilial status. He thus divided the family into the "Scopelengyni" with the single genus *Scopelengys*, the "Neoscopelini" with *Neoscopelus* and, "provisionally," *Scopelopsis*, and the "Myctophini" with most of the mytophids (*sensu stricto*). Following an examination of *Scopelengys* and *Neoscopelus*, Fraser-Brunner (1949: 1021) became convinced that the two had more in common with each other than with the Myctophinae, in spite of the presence of photophores only in *Neoscopelus*. He therefore placed the two genera, as well as *Solivomer* Miller, 1947, in the same subfamily, Neoscopelinae. He further showed that *Scopelopsis* belonged with the Myctophinae rather than with the Neoscopelinae, a relationship that obviously was not noticed by Smith (1949) who, without any explanation whatsoever, placed this genus along with *Neoscopelus* in a family of their own, the Neoscopelidae. Apart from the *Scopelopsis* question, Smith's action of according *Neoscopelus* full familial status proved to be correct and support for it came from Marshall (1955: 306 and, especially, 1960: 55) whose studies led him to suggest that it might be better to put *Neoscopelus* into a separate family (Neoscopelidae) together with the genera *Scopelengys* and *Solivomer*. Subsequent major systematic studies have all recognized the family Neoscopelidae.

Of the three neoscopelid genera, *Neoscopelus* with its large eyes, silvery, fusiform body, firm musculature, well-ossified skeleton, numerous photophores, and large swimbladder stands in sharp contrast to the small-eyed, dark brown *Scopelengys* with its flabby musculature, weakly ossified skeleton, lack of photophores and swimbladder. However, these striking differences are explainable if they are seen as reflecting adaptations to two different environments. *Scopelengys* inhabits the deep oceanic midwaters. In this food-poor environment the cost of maintaining highly complex organizations is prohibitive. On the other hand, the richer food resources available near and on the bottom over continental and island slopes provide the benthopelagic *Neoscopelus* with sufficient energy to maintain the features that make it so distinct from its midwater relative.

One is tempted to speculate that *Scopelengys* was derived from a *Neoscopelus*-like, benthopelagic ancestor which invaded the deep oceanic waters. In doing so, it had to evolve all the necessary adaptations (i.e., loss of certain organs and reduction of others) in response to the intense selective pressures of its new, midwater environment. Concerning the little-known, monotypic *Solivomer*, Fraser-Brunner (1949: 1021) noted, and I agree, that, in some morphological characters, it seems to be intermediate between the other two neoscopelid genera.

Key to the Genera of Neoscopelidae

1a. Photophores present; upper jaw extending to or slightly beyond vertical through posterior margin of orbit; pseudobranchia well developed. *Neoscopelus* Johnson 1863

1b. Photophores absent; upper jaw extending at least one eye diameter behind vertical through posterior margin of orbit; pseudobranchia rudimentary 2

2a. Vomerine teeth in one transverse patch; mesopterygoid teeth present; scales on trunk ctenoid. *Solivomer* Miller 1947
Known only from the Philippine Islands

2b. Vomerine teeth in two separate patches, one on each side of vomer; mesopterygoid teeth absent; scales on trunk cycloid. *Scopelengys* Alcock 1890

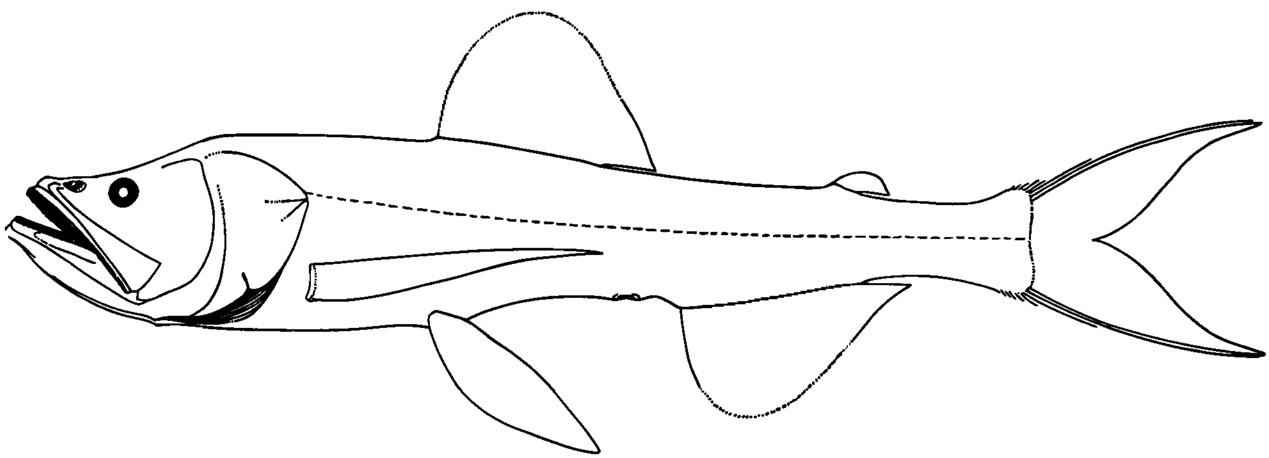

FIGURE 2. *Scopelengys tristis*, young, 129 mm, from the eastern North Pacific.

Genus *Scopelengys* Alcock 1890

Scopelengys Alcock, 1890: 302 (type-species *Scopelengys tristis* Alcock 1890, by monotypy).

Characters. Body moderately slender, elongate. Dorsal profile of head straight or somewhat concave. Eye small, its diameter more than 7 times in hl. Mouth large, terminal, oblique; upper jaw extending at least one eye diameter behind vertical through posterior margin of orbit; premaxillaries and dentaries with closely set villiform teeth on their outer surfaces and enlarged, sharp, posteriorly and medially depressible ones on their inner surfaces; small teeth in long narrow bands on palatines; similar teeth in two patches, one on each side of vomer, the two patches separated by a median, naked area; no teeth on mesopterygoids. Base of anal fin nearly equal in length to that of dorsal fin. Base of adipose fin over posterior half of base of anal fin. No luminous organs. Scales large, thin, cycloid and highly deciduous. Pseudobranchia rudimentary. Swimbladder absent.

Size. Members of this genus grow to a size of about 200 mm.

Range. Tropical and subtropical waters of all three major oceans. Absent or rare in the western parts of the Pacific and Atlantic Oceans.

Species. The genus contains two species: *S. tristis*, known from all three major oceans, and a second species recently described by Butler and Ahlstrom (1976) from the central North Pacific (see *Remarks* under *S. tristis*).

Scopelengys tristis Alcock 1890
Figure 2

Study Material. ATLANTIS II, 10′ IKMT stations: RHB 2051, 16°50′N, 18°50′W, 0–730 m, 1 (55); RHB 2059, 16°14′N, 20°44′W, 0–650 m, 1 (38); RHB 2075, 14°43′N, 25°27′W, 0–720 m, 1 (50), in LACM. Narragansett Marine Laboratory, U. Rhode Island, sta. MWT-5 TR-023, 10°N, 30°W, 0–1370 m, 10′ IKMT, 1 (153), in LACM. USNM 206789, 07° 32′N, 20°54′W, 0–1300 m, 1600-mesh Engel midwater trawl, 5 (152–164). VELERO IV, 10′ IKMT stations: 15521, 33°14′N, 118°36′W, 0–450 m, 2 (130–157); 18762, San Pedro Basin, 0–400 m, 1 (129), in LACM. ANTON BRUUN western Indian Ocean cruises 3 and 6, 91 (22.5–194), from 18 stations between 16°N and 20°S, in LACM.

Description.

Fin rays: dorsal 11–12 (13); anal 13 (12–14); pectoral 15–16 (14–17).

Gill rakers: 1 + 1 + 7 (6–8), total 9 (8–10) in North Atlantic and Indian Ocean material; 1 + 1 + 5–6, total 7–8 in eastern North Pacific specimens. These counts do not include the toothed tubercles of which there are 3 on the upper and, usually, 2 on the lower limb of the 1st gill arch.

Vertebrae: 30–31 (32).

The following measurements are in percent of SL and are based on 7 specimens 130–164 mm:

Eye diameter: 3.1–3.8.
Length of upper jaw: 15.0–16.2.
Length of head: 27.2–29.8.
Least depth of caudal peduncle: 6.7–7.6.

Tip of snout to: base of pectoral fin 28.5–30; base of pelvic fin 39.7–42.1; origin of dorsal fin 41.6–42.4; origin of anal fin 65.3–66.6; anterior end of base of adipose fin 79.0–81.5.

Head. Dorsal profile of head concave; hl 3.4–3.8 in SL. Mouth large, oblique, with lower jaw slightly projecting; maximum width of maxillary greater than diameter of eye; length of upper jaw about 1.8 in hl and 6.2–6.6 in SL; a long, narrow band of small but sharp, posteromedially depressible teeth on each palatine; an oval patch of similar, posteriorly depressible teeth on each side of vomer. Eye small, its diameter 4.2–5 in length of upper jaw, 7.6–9.2 in hl, and 28–31 in SL.

Fins. Origin of dorsal fin approximately over base of pelvic fin. Pectoral fins long, extending about to vertical through end of base of dorsal fin. Pelvic fins also long, extending to or somewhat beyond anus but not reaching origin of anal fin. Base of adipose fin over posterior ⅓ of base of anal fin.

Size. The largest specimen examined measured 194 mm. Ripe females ranging from 152 to 180 mm were found in both the North Atlantic and Indian Ocean material.

Development. Butler and Ahlstrom (1976) have described a 13.9-mm larva of this species. The larva is characterized by a horizontal bar of pigment that extends from the snout through the eye and on to the operculum. No pigment is apparent elsewhere on the body or head of the larva.

Range. *S. tristis* is found in tropical and subtropical waters of all three major oceans. The species is known mainly from the eastern North Atlantic, east of about 30°W, and between the equator and approximately 33°N. It is very rare in the western North Atlantic. In fact, the only two records reported so far are both from the Caribbean Sea off Venezuela (Mead, 1963; Devany, 1969). The species is known also from the eastern South Atlantic.

The distributional pattern of *S. tristis* in the Pacific Ocean is similar to that in the Atlantic Ocean. It is relatively common in the eastern Pacific off the Americas and between approximately 33°N and 20°S, with the latitudinal range and abundance tapering westward. No records are available from the waters west of about 170°W.

The species has repeatedly been taken in the western Indian Ocean between approximately 16°N and 20°S.

Features such as weakly ossified skeleton, flaccid musculature, small eyes, and absence of a swimbladder reflect a pelagic existence in deep oceanic waters. Indeed, available capture data indicate that young (less than 100 mm) *S. tristis* frequent depths between about 500 and 800 m, whereas adults tend to occur deeper than 1000 m. The species does not seem to migrate vertically.

Remarks. In their review of the genus *Sco-*

pelengys, Butler and Ahlstrom (1976) described a new species, *S. clarkei*, from the central North Pacific. The new form differs from *S. tristis* in having a lower number of pectoral-fin rays (12–13 vs. 14–17), a higher number of vertebrae (34–35 vs. 29–32), a deeper caudal peduncle (8.3–10.2% of SL vs. 5.6–8.3%), and a narrower maxilla (width 22.3–27.1% of its length vs. 29.9–36.7%). Further, a 15.2-mm larva belonging to the new species shows extensive pigment on the operculum and on the lower jaw. Pigment is also present on top of the head, in front of the pectoral-fin base, and on the nape immediately behind the head. The rest of the trunk and fins are devoid of pigment.

Synonyms and References:

Scopelengys tristis Alcock, 1890: 303 (Orig. descr., 11°12′47″N, 74°25′30″E, 1,000 fms; Zool. Surv. of India, Calcutta, F 12873); Bolin, 1939: 94, Fig. 2 (descr. from E N Pac.); Fraser-Brunner, 1949: 1040, Fig. (in key); Bussing, 1965: 200 (records from off Peru); Berry and Perkins, 1966: 655 (records from off southern Calif. and Baja Calif.); Kotthaus, 1967: 80 (record from Indian Ocean, 15°28′N, 69°26′E; char., photo of otol.); Nellen, 1973: 47 (records of larvae from W Ind. Ocean); Nielsen, 1973: 170 (synon., ref.; northernmost Atl. record 32°47′N, 16°24′W).

Scopelengys dispar Garman, 1899: 254, Pl. 54, Fig. 2 (Orig. descr., Gulf of Panama; holotype MCZ 28508).

Scopelengys whoi Mead, 1963: 255, Fig. 1 (Orig. descr., 12°01′N, 65°01′W, 400–600 m; holotype MCZ 41638); Devany, 1969: 127 (record from off Venezuela).

Genus *Neoscopelus* Johnson 1863

Neoscopelus Johnson, 1863: 44 (type-species *Neoscopelus macrolepidotus* Johnson 1863, by monotypy).

Characters. Body fusiform, compressed. Head conical, its dorsal profile straight or slightly concave. Eye large, its diameter 5 times or less in hl. Mouth large, terminal, oblique; upper jaw extending to or slightly behind vertical through posterior margin of orbit; premaxillaries and dentaries with closely set, blunt, villiform teeth on their outer surfaces and enlarged, conical, sharp, posteriorly and medially depressible ones on their inner surfaces; a band of small teeth on palatines and anterior limbs of ectopterygoids; similar teeth on entire ventral surface of vomer; a large, oval patch of densely set, minute teeth on each mesopterygoid. Upper limb of 1st gill arch with 2–4 well developed gill rakers restricted to its posterior ⅓ to ½; the rest of the limb covered with an anterior large and a posterior small dentigerous plate. Base of dorsal fin equal in length to or longer than that of anal fin. Base of adipose fin over middle or posterior half of base of anal fin. Scales large, cycloid, deciduous. Pseudobranchia well developed. Swimbladder present. Luminous organs present, arranged in a single series along the periphery of the tongue, and in a midventral and several bilateral series on trunk.

Size. Members of this genus grow to a size of about 300 mm.

Range. Close to land masses in tropical and subtropical waters of all three major oceans. Absent or rare in the eastern parts of the Pacific and Atlantic Oceans.

Species. The genus contains three species: *N. macrolepidotus*, *N. microchir*, and *N. porosus*. The first two occur in the North Atlantic, whereas the recently described *N. porosus* is, so far, known only from off central and southern Japan.

Neoscopelus macrolepidotus Johnson 1863
Figure 3

Study Material. USNM 159894, 07°46′N, 54°36′W, 400 fms, 40′ shrimp trawl, 5 (123–152); USNM 186285, 07°34′N, 54°49′W, 225 fms, 40′ shrimp trawl, 4 (64–75); USNM 188055, 14°18′N, 81°44′W, 2 (178–223); USNM 47736, 21°08′30″N, 157°49′W, 3 (140–149); USNM 125979, off Hawaii, 4 (112–166); USNM 148869, 35°06′N, 138°40′E, 197 fms, 2 (158–159); USNM 149555, 33°24′50″N, 135°38′40″E, 253 fms, 4 (101–138).

Distinctive Characters. In the Atlantic Ocean this species is distinguished from *N. microchir* by its shorter LO series, lower num-

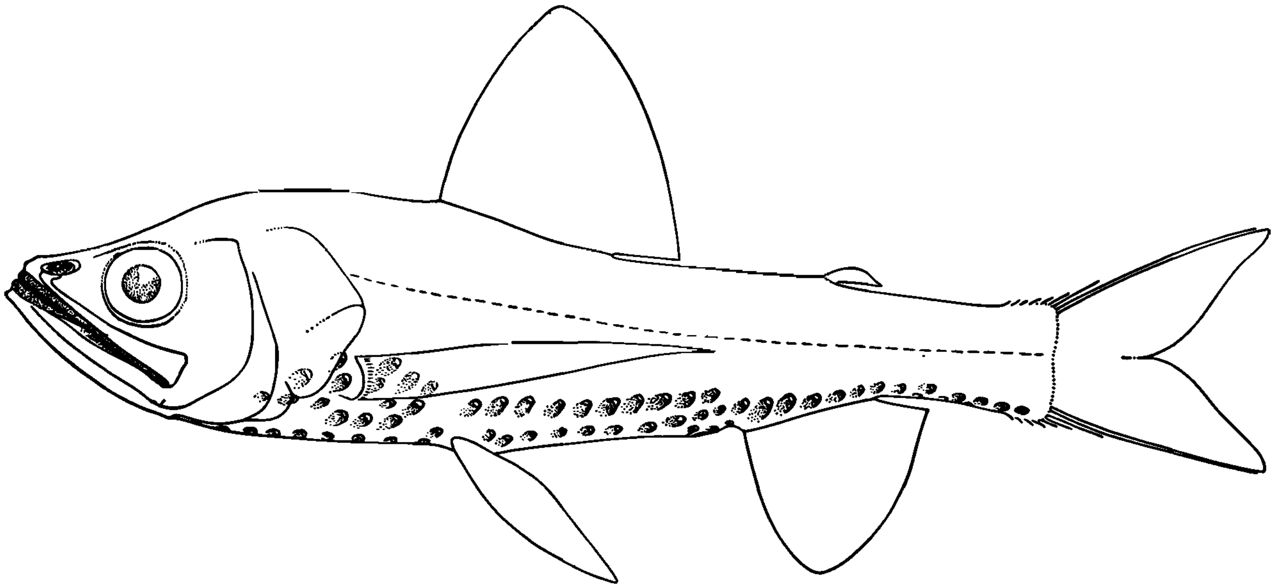

FIGURE 3. *Neoscopelus macrolepidotus*, young, 101 mm, from Japan.

ber of gill rakers, higher numbers of pectoral- and anal-fin rays, and longer base of the anal fin in relation to that of the dorsal fin. For characters differentiating Pacific populations of the two species see under *Geographic Variation.*

Description. The following description is based on 11 western North Atlantic and Caribbean specimens, 64–223 mm, and 7 specimens, 112–166 mm, from Hawaiian waters. Measurements are from 14 of the above individuals, ranging from 112 to 223 mm.

Fin rays: dorsal 12–13; anal 12 (11–13); pectoral 18–19.

Gill rakers: 2 (3 in a single specimen from Hawaii) + 1 + 8 (7 in two individuals from off Surinam, and 9 in a single specimen from Hawaii), total 11 (10–12).

Photophores: LO 12–14.

Vertebrae: 30–31, five X-rayed specimens.

Measurements in percent of SL. Mean values are followed by ranges in parentheses.

Length of head: 34.3 (33.0–36.0).

Depth of body: at origin of dorsal fin 24.0 (22.5–25.5).

Posterior end of base of dorsal fin to: anterior end of base of adipose fin 22.4 (21.0–24.2).

Tip of snout to: upper end of base of pectoral fin 35.3 (34.2–37.0); base of outermost ray of pelvic fin 46.7 (44.5–48.0); origin of dorsal fin 45.7 (44.2–48.0); origin of anal fin 73.2 (71.4–76.0); anterior end of base of adipose fin 79.4 (77.7–82.3).

Head. Dorsal profile of head straight or somewhat concave. Mouth large, oblique, with lower jaw slightly projecting beyond upper; upper jaw extending about to vertical through posterior margin of orbit, its length 1.8–2 in hl and 5.3–6 in SL. Eye large, its diameter 2.3–2.7 in length of upper jaw, 4.5–5 in hl, and 13–14.4 in SL.

Fins. Origin of dorsal fin usually a little in advance of base of pelvic fin. Length of base of anal fin 1–1.3 in that of base of dorsal fin. Pectoral fins long, extending to vertical through posterior margin of anus. Base of adipose fin directly over or a little behind middle of base of anal fin.

Luminous Organs. LO not reaching vertical through origin of anal fin. Vc series often turning upward and continuing posteriorly at level of preceding LO; in such cases caution should be exercised so as not to confuse the organs of the two series. 7 (8) Is.

Color. According to Matsubara (1943),

"color in life dark red on sides of head and body; belly silvery white with bluish reflection; pupil light green, translucent, sclerotic silvery white; fins uniformly pink." In alcohol, depending on original condition of animals and method as well as length of preservation, head, except operculum, and trunk light brown with operculum, back and ventral photophore regions dark brown; or head, including operculum, and ventral half of body silvery iridescent.

Size. The largest specimen in the collections studied was a 223-mm female from off Nicaragua with very large, thick-walled ovaries containing small, loosely packed eggs. The ovaries of a 152-mm long female from off Surinam were densely packed with eggs that appeared to be ripe or nearly so. A specimen reported by Maul (1951) from Madeira measured 250 mm.

Range. The great morphological similarity of the species in the genus and the very limited circulation of Matsubara's (1943) work on *N. microchir* have resulted in the assignment by previous workers of most of the Atlantic material to *N. macrolepidotus.* The confusion can be resolved only after a careful re-examination and correct identification of all the material reported so far. We know at present that both *N. macrolepidotus* and *N. microchir* occur in the North Atlantic, where their ranges seem to overlap, and that *N. microchir* is as common as (if not commoner than) its congener. Except for the holotype and the specimen reported by Maul (1951) from off Madeira, there are no confirmed records of *N. macrolepidotus* from the eastern North Atlantic. In the western part of the ocean, the species has been taken off Surinam, and in the western Caribbean Sea off Nicaragua. Specimens from the northern Gulf of Mexico and the Florida Straits (Bullis and Thompson, 1965) may prove to belong to *N. microchir.*

Captures in the South Atlantic include one specimen at 38°38′S, 50°48′W, and two at 30°03′S, 47°44′W, off southern Brazil. All three specimens were taken by bottom trawl at depths of 500 and 800 m (G. Krefft, personal communication).

Elsewhere, *N. macrolepidotus* is found in Hawaiian waters, off the coast of southern Japan, and in the waters of the Great Australian Bight.

Capture data indicate that *N. macrolepidotus* occurs over continental and island slopes, not far from the bottom and at depths between approximately 300 and 800 m. Morphological features, such as well-ossified skeleton, firm musculature, well-developed swimbladder, and countershaded coloration (silvery iridescent ventral parts, dark red or brown backs) attest to a benthopelagic existence in relatively shallow to moderately deep waters. There are no indications that the species migrates vertically.

Geographic Variation. Japanese specimens have a higher number of gill rakers [14 (13)] than specimens from Atlantic and Hawaiian waters [11 (10–12)]. Further, the distance between the posterior end of the base of the dorsal fin and the anterior end of the base of the adipose fin is somewhat shorter [20.9 (20.3–21.4) percent of SL] in Japanese than in Atlantic and Hawaiian specimens [22.4 (21.0–24.2) percent of SL].

Synonyms and References:

Neoscopelus macrolepidotus Johnson, 1863: 44, Pl. 7 (Orig. descr., off Madeira; holotype BMNH No. 1862.10.3.3); Gilbert, 1913: 69 (records from Suruga Bay, compar. with Atl. specim.); McCulloch, 1914: 90, Pl. 17 (record from Great Australian Bight, char.); Matsubara, 1943: 56, Fig. 12 (descr. of specim. from Japan; compar. with *N. microchir*); Maul, 1951: 56, Fig. 13 (records from off Madeira; compar. with *N. microchir*); Nielsen, 1973: 170 (synon., ref.).

Neoscopelus alcocki Jordan and Starks, 1904: 580, Pl. 2, Figs. 1, 2 (Orig. descr., Suruga Bay, 173–260 fms; holotype USNM 51477).

Neoscopelus bruuni Whitley 1931: 312 [proposed new name for *N. macrolepidotus* reported by McCulloch (1914) from Great Australian Bight, 129°28′E].

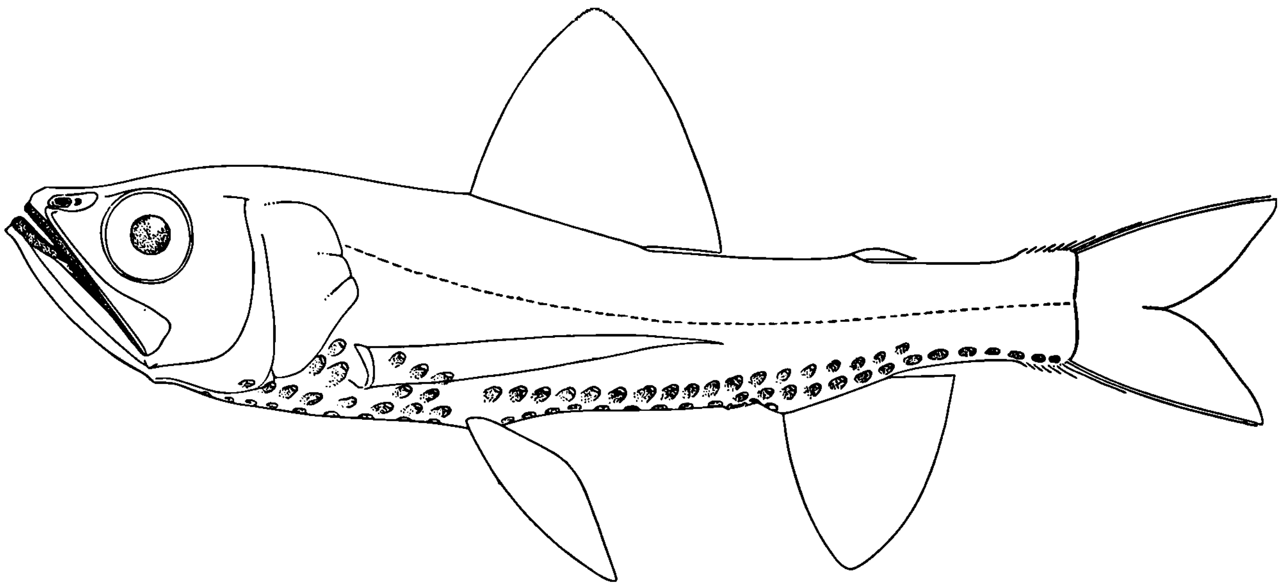

FIGURE 4. *Neoscopelus microchir*, young, 77 mm, from off Jamaica.

Neoscopelus microchir Matsubara 1943
Figure 4

Study Material. USNM: 108273, 18°39′N, 67°17′ W, 300 fms, 2 (147–159); 187897, 17°40′N, 77°55′ W, 4 (77–102); 188056, 16°58′N, 87°53′W, 14 (88–124); 188297, 23°59′N, 79°43′W, 350 fms, 10′ beam trawl, 30 (37–130); 135420, 13°46′45″N 121°35′08″ E, 190 fms, 25 (81–118); 135840, 09°20′30″N, 123° 23′45″E, 310 fms, 1 (128); 135841, 06°03′15″N, 120°35′30″E, 318 fms, 1 (131); 135843, 12°52′N, 121°48′30″E, 281 fms, 1 (105); 135844, 12°25′35″N, 121°31′35″E, 234 fms, 2 (139–141); 135845, 13°47′ 20″N, 120°43′30″E, 180 fms, 2 (107–119); 135846, 05°54′48″N, 120°44′24″E, 193 fms, 1 (89); 135847, 08°35′30″N, 124°36′E, 200 fms, 1 (124); 135848, 20°37′N, 115°43′E, 208 fms, 5 (70–126); 135849, 00°07′N, 127°28′E, 5 (110–146); 135850, 10°33′30″ N, 122°26′E, 137 fms, 1 (61); 135852, 10°09′15″N, 123°52′E, 162 fms, 1 (88); 135854, 16°38′N, 119° 57′18″E, 186 fms, one damaged specimen; 135855, 12° 54′40″N, 123°20′30″E, 209 fms, 10 (35–103); 135856, 12°51′30″N, 123°26′15″E, 226 fms, 1 (125); 135857, 13°49′40″N, 121°40′15″E, 83 (?) fms, 2 (149–152); 135858, 00°07′30″N, 127°29′E, 265 fms, 7 (113–145); 196650, Japan: Owashi, 1 (ca. 127).

Distinctive Characters. In the Atlantic Ocean, *N. microchir* is distinguished from *N. macrolepidotus* by its longer LO series that extends over the base of the anal fin, by its higher gill-raker counts, lower numbers of pectoral- and anal-fin rays, and shorter base of the anal fin in relation to that of the dorsal fin. For characters differentiating western North Pacific populations see under *Geographic Variation.*

Description. The following description is based on 16 western North Atlantic and Caribbean specimens, 59–159 mm.

Fin rays: dorsal 13 (12); anal 11 (10–12); pectoral 16–17.

Gill rakers: 3 (4 in one specimen) + 1 + 10 (11 in 3 specimens), total 14 (15 in two specimens, 16 in one).

Photophores: LO 20–22.

Vertebrae: 30–31, six X-rayed specimens.

Measurements in percent of SL. Mean values are followed by ranges in parentheses.

Length of head: 33.5 (32.5–35.0).

Depth of body: at origin of dorsal fin 23.6 (22.3–25.5).

Posterior end of base of dorsal fin to: anterior end of base of adipose fin 20.1 (18.2–21.5).

Tip of snout to: upper end of base of pectoral fin 34.5 (33.4–35.4); base of outermost ray of pelvic fin 45.5 (43.5–47.5); origin of dorsal fin 43.9 (42.2–45.6); origin of anal fin 74.7 (72.1–76.6); anterior end of base of adipose fin 80.2 (78.0–82.3).

Head. Dorsal profile of head straight or a little concave. Mouth large, oblique, with lower jaw slightly projecting beyond upper; upper jaw extending to or somewhat behind vertical through posterior margin of orbit, its length 1.8–2 in hl, and 5.2–6 in SL. Eye large, its diameter 2.1–2.6 in length of upper jaw, 3.9–4.3 in hl, and 11.6–13 in SL.

Fins. Origin of dorsal fin directly over or a little in advance of base of pelvic fin. Length of base of anal fin 1.5–1.7 in that of base of dorsal fin. Pectoral fins long, reaching anus in young individuals (smaller than about 120 mm), somewhat shorter in larger specimens. Base of adipose fin over posterior half of base of anal fin.

Luminous Organs. Posteriormost 1–2 LO behind vertical through end of base of anal fin. 9 (8) Is.

Color. According to Matsubara (1943), "color in life dark red or blood-red on sides of head and body, but paler below; belly silvery white, with bluish reflection. Pupil translucent light green; sclerotic silvery white. Fins uniformly pink." In alcohol, depending on original condition of animals and method as well as length of preservation, head, except operculum, and trunk light brown with operculum, back and ventral photophore regions dark brown; or head, including operculum, and ventral half of body silvery iridescent.

Size. The largest specimens in the collections examined measured 159 mm (western North Atlantic) and 175 mm (western North Pacific). Matsubara (1943) reported a 259-mm individual from "off Heta," and Maul (1951) a 305-mm specimen from off Madeira. A number of gravid females, ranging in size from 120 mm to 175 mm, were found among the material from the western tropical Pacific.

Range. N. microchir has been collected in waters around the Virgin Islands, in the western Caribbean off Jamaica and Honduras, and in the Straits of Florida. The species is most likely present in the Gulf of Mexico. Maul's (1951) specimen from Madeira is the only confirmed record from the eastern North Atlantic.

Neoscopelus microchir appears to be rather common in western tropical Pacific waters, the waters around the Philippine Islands, the northern China Sea, and off southern Japan. Collections reported from the Andaman and Arabian Seas (Alcock, 1899), east coast of Africa (Brauer, 1906), Indo-West Pacific, and off northeastern New Zealand (Brauer, 1906; Weber and DeBeaufort, 1913) under the name *N. macrolepidotus* should be reexamined, for although the figures in those reports are those of *N. microchir*, the accompanying data suggest that both species were represented in the collections.

Like its congener, *N. microchir* is a benthopelagic fish found over continental and island slopes at depths mainly between 250 and 700 m. Available data fail to reveal whether or not this species migrates vertically.

Geographic Variation. Listed below are differences in meristic and morphometric characters between the Atlantic and western North Pacific (in brackets) populations of *N. microchir.*

Anal-fin rays 11 (10–12), [12 (11)]; pectoral-fin rays 16–17, [15–16]; gill rakers 3 (4) + 1 + 10 (11), total 14 (15–16) [4 (3) + 1 + 12 (11–13), total 17 (16–18)]; LO 20–22 [23–25]; posterior end of base of dorsal fin to anterior end of base of adipose fin 20.1 (18.2–21.5) percent of SL, [22.8 (21.2–24.5)]; diameter of eye: in SL 12.1 (11.6–13.0), [13.4 (12.2–14.6)], in hl 4.0 (3.9–4.3), [4.5 (4.0–4.9)]; length of base of anal fin in that of base of dorsal fin 1.6 (1.5–1.7), [1.3 (1.2–1.5)]. Moreover, in western Pacific specimens the pectoral fins are 1–2 eye diameters shorter than those in Atlantic specimens.

Reference:

Neoscopelus microchir Matsubara, 1943: 59, Fig. 13 (Orig. descr., "off Heta"; holotype No. 6582, 146 mm SL, Repository ?); Maul, 1951: 56, Fig. 14 (records from off Madeira; compar. with *N. macrolepidotus*); Nielsen, 1973: 170 (ref.).

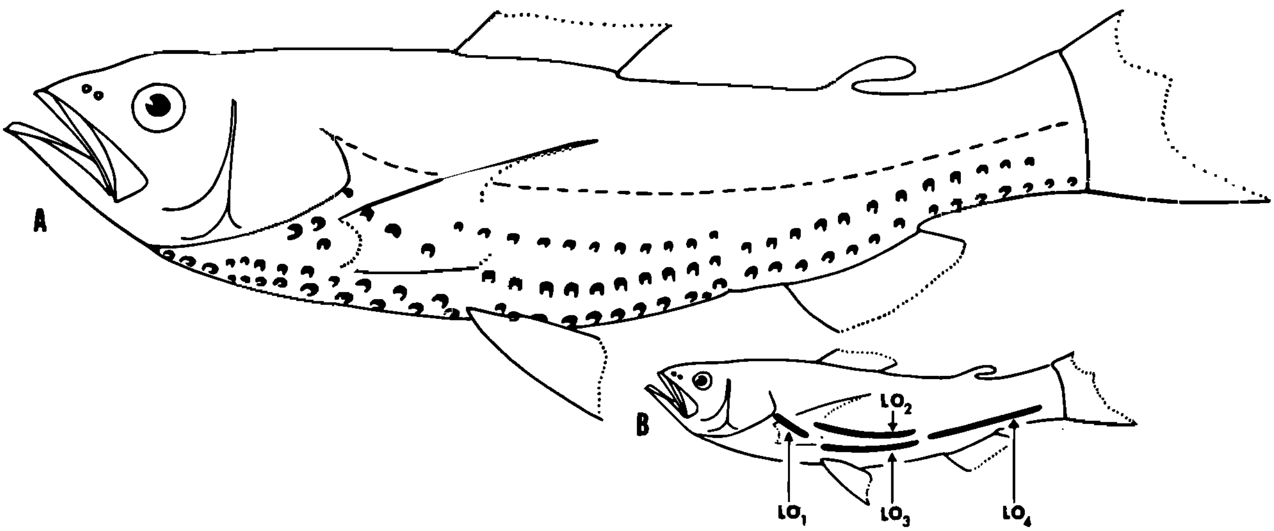

FIGURE 5. A, *Neoscopelus porosus*; B, lateral series of luminous organs (LO) in *N. porosus*. After Arai (1969).

Neoscopelus porosus Arai 1969
Figure 5

I have not seen representatives of this form. According to Arai (1969), it differs from its two congeners in having 36–40 photophores in its LO series which is subdivided into four subseries, LO_1 through LO_4.

Reference:

Neoscopelus porosus Arai, 1969: 465, Figs. 1–3, Pl. 1, Fig. 3 (Orig. descr., off Heta, Suruga Bay, central Japan; holotype: National Science Museum, Tokyo, P.7629).

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Family Myctophidae

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Authorship. Backus, Craddock, Haedrich, and Robison prepared the distribution maps. Backus and Craddock prepared the introductory account on North Atlantic Genera and Species, the accounts of the Atlantic Distribution of species, and some of the accounts of Extra-Atlantic Occurrence (the last identified by the letters BC in parentheses at the end of the account). Karnella and Craddock prepared the accounts of the Vertical Distribution of species. Nafpaktitis prepared all other parts, including most of the introductory sections, generic and species accounts, and some accounts of Extra-Atlantic Occurrence (the last identified by the letter N in parentheses at the end of the account).

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General Characters. Deep-sea pelagic fishes with compressed body and head. Eyes well developed, large, lateral (dorsolateral in *Hierops*). Mouth large, terminal (subterminal in *Loweina*, *Gonichthys*, and *Centrobranchus*); jaws extending to or far beyond vertical through posterior margin of orbit. Adipose fin present. Origin of anal fin under or close behind base of dorsal fin. Ventral fin rays 8, except in *Notolychnus* which has 6 and *Gonichthys* which may have 7. A rudimentary spine at base of first dorsal, first anal, uppermost pectoral, and outermost ventral fin ray. Principal caudal fin rays 10 dorsal and 9 ventral. Discrete, round or kidney-shaped photophores in distinct groups on trunk and head of all species but one (*Taaningichthys paurolychnus*). Much smaller, secondary photophores on trunk and head in some species, best developed in *Scopelopsis*. Luminous organs of various shapes and sizes present on head, caudal peduncle, or on both. Scales cycloid (ctenoid in four species of *Myctophum*), firm in forms found in relatively shallow depths, loose and easily lost in deeper-dwelling species.

Dentition. Premaxillaries and dentaries with bands of closely-set teeth, the inner ones of which may be enlarged. In some species of *Diaphus* the posterior premaxillary and dentary teeth are broad-based and strongly hooked forward. Similar teeth are found on either side of the premaxillary and dentary symphysis in species of *Taaningichthys.* The most specialized dentition is found in *Diogenichthys.* In addition to a number of forward-hooked teeth on the posterior parts of both jaws, there is a single series of flattened, lanceolate premaxillary teeth most of which bear a minute spine on each edge at the widest point. The teeth in the outer series on the dentary are closely set, flattened, and wider than high.

Palatines with a long, narrow band of closely-set small teeth or with one or two rows of distinctly enlarged, widely spaced ones. Each mesopterygoid with a patch of teeth. The size of the patch varies in different species and the teeth may be closely set and small or widely spaced and enlarged. In most species there is a cluster of minute teeth on each side of the vomer.

In most myctophids the 3rd pharyngobranchials are the largest of the four pairs in the series (Paxton, 1972: 26; Rosen, 1973: 454) and bear enlarged, strong teeth. In *Gonichthys* these teeth are modified into rounded protuberances and in *Centrobranchus* into rectangular, ridged plates arranged in closely-set rows. The modified pharyngeal dentition is apparently used for crushing the shells of pelagic gastropods on which these slender-tailed myctophids feed (Hartmann and Weikert, 1970 *in* Paxton, 1972: 26; also personal observations).

Skeletal Characters. Six circumorbital bones, the third, or jugal, being the largest. A subocular shelf extends medially from the third, fourth and usually the fifth circumorbital (Rosen and Patterson, 1969: 379; Paxton, 1972: 10). The maxillary, which is toothless and completely excluded from the gape by the premaxillary, is greatly expanded posteriorly in *Protomyctophum, Electrona, Benthosema, Diogenichthys,* and *Hygophum,* less so or not at all in the other genera. A small, L-shaped supramaxillary is present in *Lampanyctodes, Gymnoscopelus, Lampichthys, Notoscopelus,* and *Scopelopsis* (Paxton, 1972: 14). Branchiostegal rays 7–11, but there may be as few as 6 (Moser and Ahlstrom, 1970: 9, Table 5) and as many as 12 (McAllister, 1968: 93). The posterodorsal opercular margin is markedly serrate in species of *Myctophum,* weakly so or smooth in the rest of the genera. Well-developed gill rakers are present in all genera except *Centrobranchus.* There are 4 proximal radials in the pectoral fins, but sometimes there may be only 3 due to fusion (Paxton, 1972: 30). Vertebrae range in number from 28 in *Notolychnus* to 45 in *Gymnoscopelus* (Moser and Ahlstrom, 1970: 9, Table 5; Paxton, 1972: 33, Table 8). Three (2) epurals, 7 (1–7) hypurals, the numbers depending on the degree of fusion. Five to 14 dorsal and 5–15 ventral procurrent caudal fin rays; these may be flexible or stiff. The stiff elements are considered to be rays by Paxton (1972: 36) and spines by Rosen and Patterson (1969: 454) and Rosen (1973: 452).

Luminous Organs and Sexual Dimorphism. Myctophids have a variety of luminous organs, hence their common name "lanternfishes." However, the most characteristic type of luminous organ found in all but one (*Taaningichthys paurolychnus*) of the numerous species of the family is the photophore. Lanternfishes may have anywhere between 50 and 80 of these photophores studding the ventral halves of their trunks and heads.

Photophores are highly specialized, complex organs, richly vascularized, those on the head receiving nerve supply from branches of the nervus facialis, those on the body from branches of the spinal nerves (Ray, 1950). Each body photophore consists of a scale embedded in the dermis and modified into a shallow cup that provides mechanical support to the delicate tissues in it (Fig. 1). Lining the

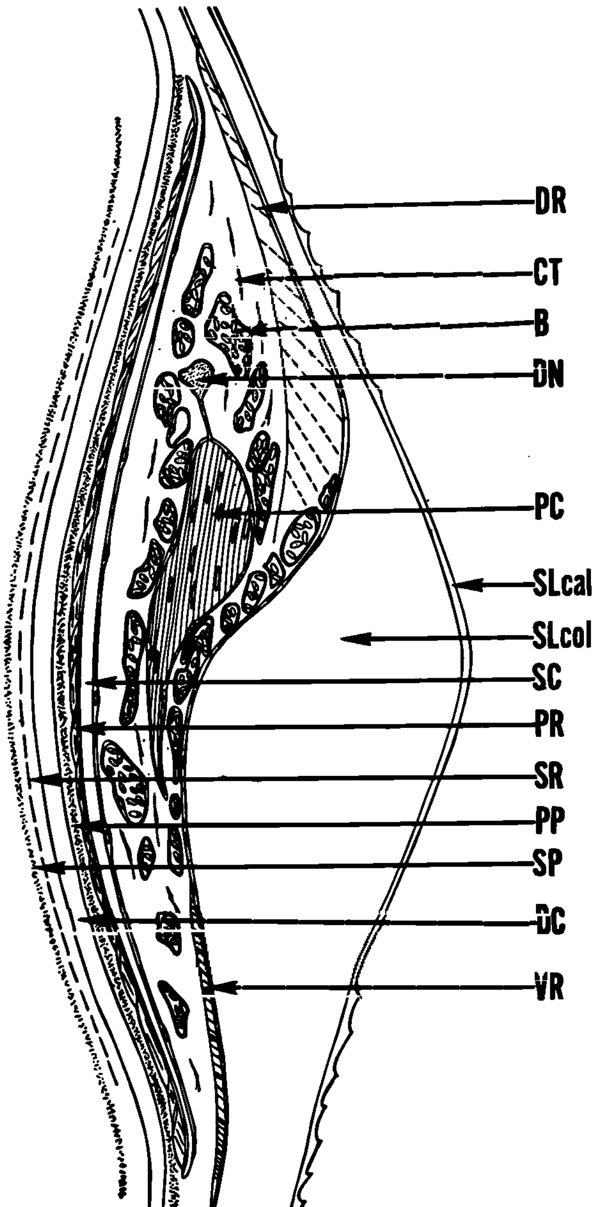

FIGURE 1. Schematic diagram of a median transverse section of a body photophore of *Stenobrachius leucopsarus*. Abbreviations: B, blood; CT, connective tissue; DC, dense connective tissue; DN, dorsal nerve; DR, dorsal reflector; PC, photocytes; PP, primary pigment backing; PR, primary reflector backing; SC, scale cup; SLcal, scale lens (calcified layer); SLcol, scale lens (collagenous layer); SP, secondary pigment backing; SR, secondary reflector backing; VR, ventral reflector. From O'Day (1972).

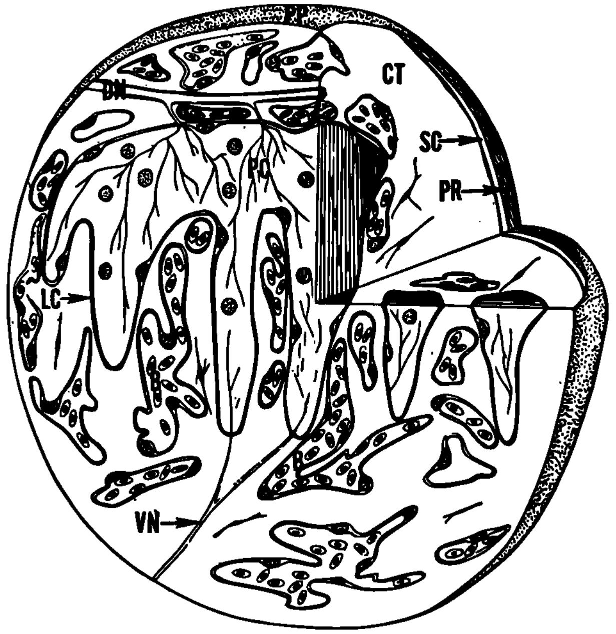

FIGURE 2. Schematic stereo-diagram of a body photophore of *Stenobrachius leucopsarus*. The overlying scale lens, the reflector layers associated with the scale lens, and some vascular tissue have been omitted to reveal the interior of the photophore. Abbreviations: B, blood; CT, connective tissue; DN, dorsal nerve; LC, lining cell; PC, photocyte; PP, primary pigment backing; PR, primary reflector backing; SC, scale cup; VN, ventral nerve. From O'Day (1972).

convex surface of the scale cup is a reflector layer which is in turn backed by a layer of dark pigment. Inside the scale cup, connective tissue provides support for the blood vessels, nerves, and the extremely delicate photogenic tissue. O'Day (1972) described the photogenic tissue in the body photophores of *Stenobrachius leucopsarus* as consisting of "a stack of very thin cells, flattened in a plane parallel with the overlying scale lens" (Fig. 2). The scale that overlies the scale cup and its contents is modified into a lens. Its central portion is very thick, generally biconvex, without growth rings and transparent (O'Day, 1972).

Work so far has shown that the bluish light emitted by myctophid photophores is the result of a chemical reaction which involves the oxidation of a substrate (luciferin) by molecular oxygen in the presence of an enzyme