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PRELIMINARY GUIDE TO THE IDENTIFICATION OF THE EARLY LIFE
HISTORY STAGES OF MOLID FISHES OF THE WESTERN CENTRAL NORTH
ATLANTIC

BY

Joanne Lyczkowski-Shultz

U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary

National Oceanic and Atmospheric Administration
Conrad C. Lautenbacher, Jr., Under Secretary for Oceans and Atmosphere

National Marine Fisheries Service
William T. Hogarth, Assistant Administrator for Fisheries

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It will be a chapter entitled Molidae in the "Guide to the early life history stages of fishes of the western central North Atlantic".

Author's address:

Dr. Joanne Lyczkowski-Shultz
NOAA Fisheries
Mississippi Laboratories
3209 Frederic Street
Pascagoula, MS 39567
E-mail: joanne.lyczkowski-shultz@noaa.gov

Copies may be obtained by writing:

The author

or

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All three cosmopolitan species in three monotypic genera are found in the western central North Atlantic (WCNA). These highly specialized, tropical to temperate, epipelagic fishes attain enormous sizes and were once thought to feed exclusively on gelatinous plankton. It is now known that molids can dive to depths >700 m and feed on small fishes, squid and benthic invertebrates. The most prominent morphological characteristic of molids is the absence of a caudal peduncle and true caudal fin, having instead a 'clavus' or pseudocaudal fin composed of rays derived from elements of the dorsal and anal fins (Raven 1939; Fraser-Brunner 1951). These latter fins are the primary means of propulsion which can be rapid and powerful in healthy individuals. Other prominent morphological features include pelvic fins absent; beaklike jaws with teeth fused; no spines in dorsal or anal fins; lateral line and swim bladder absent; single ovary; body highly compressed and, in two species, as wide as long; small, closely spaced plate-like scales forming a tough, continuous covering over the body; and low vertebral count (16 to 18).

Molids, considered to be the most fecund among bony fishes, spawn large, spherical, pelagic eggs that measure 1.42 to 1.8 mm in diameter and contain 20 to 40 oil globules. Incubation in at least one species is relatively long, 7 to 8 days. Newly hatched larvae measure 1.80 mm NL; possess pigmented eyes, functional mouth, pore-like gill opening, ossified cleithrum, large pectoral fins with some ossified rays, dorsal fin anlage, a normal tail with a caudal lobe; and are heavily pigmented over head and trunk (Leis 1977). Pigment in the youngest larvae is present over head, trunk and gut, and extends across the abdomen to the isthmus. After dermal spine formation pigment develops over the entire body including the dermal sac. Molid larvae never pass through the typical stages of notochord flexion, instead, the tail section atrophies distally and a true caudal fin never forms. Molid larvae are extremely rotund with the head and trunk appearing as a ball-like unit. The head and trunk are contained in a vesicular, dermal sac until at ca. 2 mm when large pyramidal-shaped spines develop that become massive and/or

elongated, variously ridged and serrated, and eventually obliterate the dermal sac. After clavus formation these spines begin to diminish in size and eventually disappear in *Ranzania laevis* larvae. They persist in *Mola mola* and *Masturus lanceolatus* larvae during a distinct ontogenetic, prejuvenile phase termed the 'molacanthus' stage when the body is deep and compressed, possesses a ventral keel and is unlike the adult in shape (Leis 1984). Prior to development of their unique spines molid larvae may be confused with the larvae of some lophiiforms, and, among tetraodontiforms, the tetraodontids, ostraciids and diodontids. Resemblance among these taxa in early larvae is due to rotund body shape, presence of a dermal sac (or inflated epidermis) over head and trunk and low myomere count. Larvae of lophiiform families in general differ from molids in having paddle-like pectoral fin bases that are narrow at their origin and broaden distally. Pectoral element formation begins at sizes >2.5 mm in lophiiforms whereas, molids hatch with pectoral rays present. In ceratioid anglerfishes the dermal sac encases not only head and trunk but also the tail, and in antennariid larvae the small gill opening is located below the pectoral fin base not ahead of it as in molids. In contrast to molid larvae, tetraodontid larvae are more oblong than rotund in shape and the dermal sac when present is low in profile. Larvae of ostraciids are uniformly pigmented early in development even on the dermal sac while in diodontid larvae pigment remains concentrated dorsally until late in development. The broader body of diodontids further serves to distinguish them from molid larvae. Leis (1977) states that vesicles in the dermal sac of *R. laevis* are more numerous than in other tetraodontoids.

There are numerous illustrations, many made from old photographs, of young *Mola* and *Masturus* in the literature that originate from two obscure sources, Steenstrup and Lütken (1898) and Schmidt (1921). But only the larval development of *R. laevis* has been definitively described (Leis 1977). Direct comparisons of published accounts of molid larvae are further complicated by the diverse metrics used to measure body length; these include total length, notochord length, snout to

anus length and preclaval length. Martin and Drewry (1978) interpreted much of the previous literature on molid larvae and described the diagnostic value of spine morphology using the numbering system of Steenstrup and Lütken (1898). The four sets of spines found in molid larvae and referred to in the following key are based on Leis (1977). A single, 1.95 mm NL *Mo. mola* larva was taken in a neuston sample in

December during a SEAMAP plankton survey in the open Gulf of Mexico. An additional 43 specimens of young molids collected in midwater trawls from the western Atlantic Ocean (Gulf Coast Research Laboratory Museum, University of Southern Mississippi, Ocean Springs, Mississippi) were also examined. Among these specimens ranging in size from 2 to 10 mm TL were: three, *Mo. mola*; two, *Ma. lanceolatus*; and 38, *Ranzania laevis*.

Nominal Key to Molid Larvae > 2 mm NL from the western central North Atlantic after formation of characteristic dermal spine patterns (modified from Martin and Drewry, 1978 and using the spine terminology of Leis, 1977):

- 1a. Spine bases with both longitudinal and transverse ribs.....2
- 1b. Spine bases without transverse ribs. Certain spines becoming more elongate than others in their respective set: anteriormost and posteriormost spines in the dorso-medial set; the second and posteriormost spines in the dorso-lateral set; and the posteriormost spine in the ventro-lateral set..... *Ranzania laevis*
- 2a. All spines similar in size and shape..... *Mola mola*
- 2b. Certain spines becoming exceedingly more elongate than others and lanceolate in shape..... *Masturus lanceolatus*

Table Molidae 1. Meristic characters for species of Molidae known to occur in the western central North Atlantic. Number in () is the range for the count. Sources of data: Leis (1977); Martin and Drewry (1978); Tyler (1980).

Species	Dorsal	Anal	Pectoral	Clavus	Vertebrae
<i>Ranzania laevis</i>	18-19	18-19	13	21-22	8+10
<i>Masturus lanceolatus</i>	18-20	16-18	7-10	17-26	8+8
<i>Mola mola</i>	18 or 19(15-20)	16-18(14-18)	11-13	12-15	8+9

MERISTICS

	Range
Vertebrae:	
Precaudal	8
Caudal	10
Total	18
Number of Fin Spines and Rays:	
First Dorsal	0
Second Dorsal	18-19
Anal	18-19
Pectoral	13
Pelvic	0
Pseudocaudal ¹	21-22
Branchiostegals	5

LIFE HISTORY

Range: cosmopolitan in tropical & subtropical waters; in western Atlantic from Florida to Brazil
 Habitat: epipelagic
 ELH Pattern: oviparous
 Spawning: oceanodromous; in central parts of subtropical circulations

LITERATURE

Schmidt (1921a, b, 1932); Tortonese (1956); Sololovskaya & Sololovskiy (1975); Leis (1977); Sherman (1961); Watson (1996bv)

ILLUSTRATIONS

A – H from Leis (1977)

EARLY LIFE HISTORY DESCRIPTION**EGGS:**

Diameter: 1.42-1.65 mm
 No. of Oil Globules: 20-30
 Oil Globule Diameter: 0.05-0.16 mm
 Yolk: unsegmented
 Shell: clear and unsculptured
 Perivitelline Space: narrow
 Hatch Size: 1.8 mm NL

LARVAE:

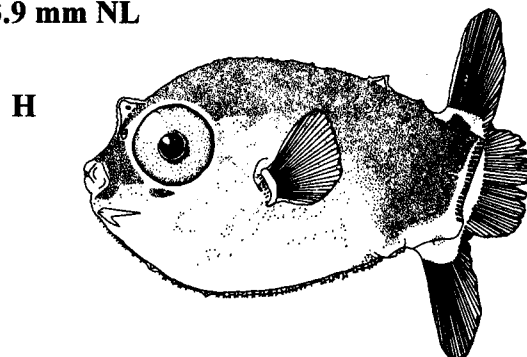
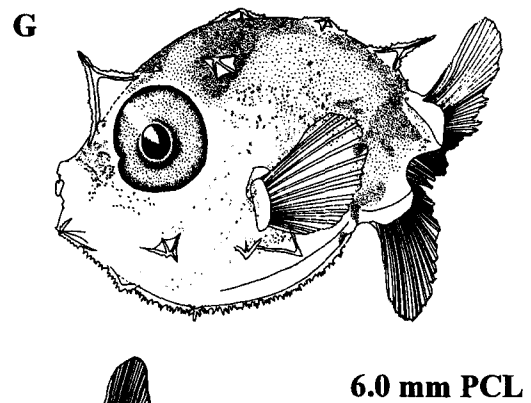
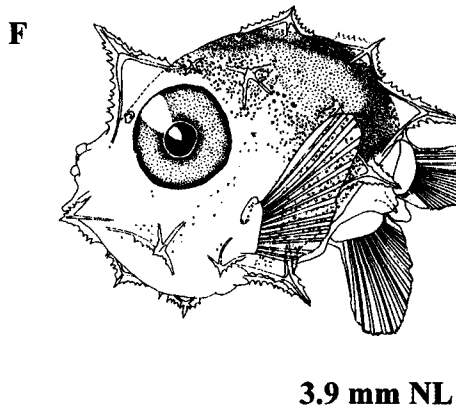
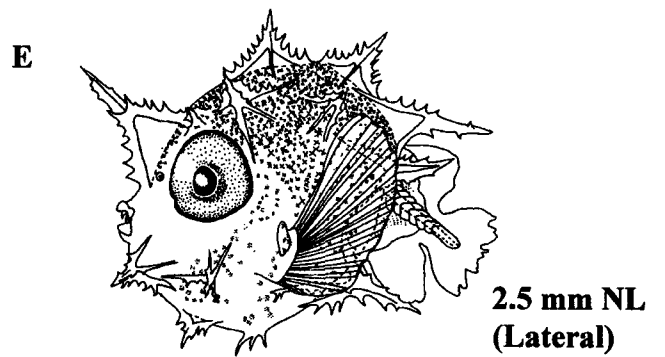
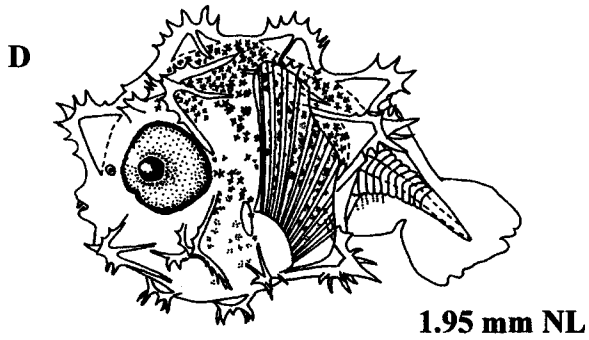
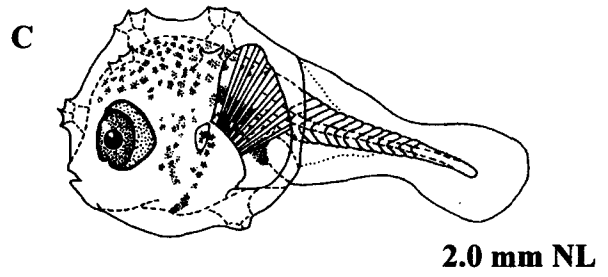
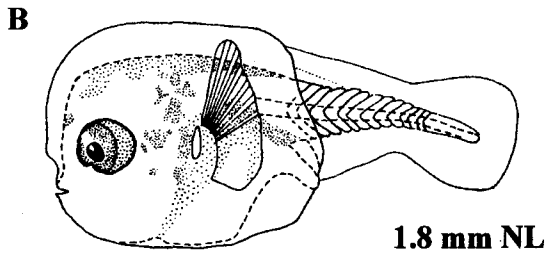
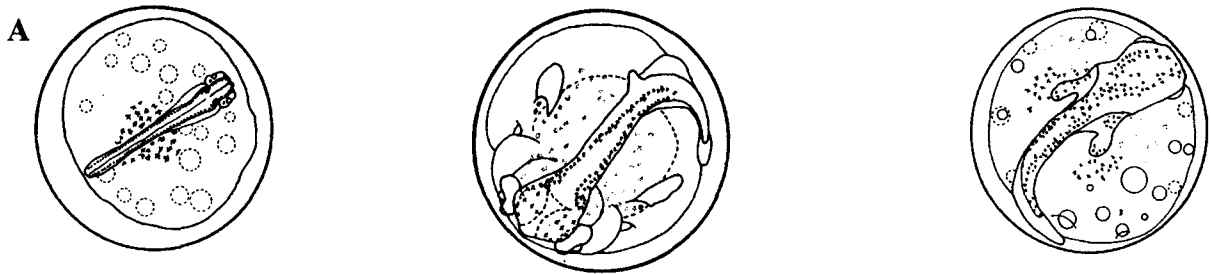
Length at Flexion: (flexion does not occur, notochord tip atrophies)
 Length at Transformation: ca. 15 mm PCL².
 Sequence of Fin Development: P₁, D&A, C¹
 Pigmentation: Subdermal & dorsally from brow to posterior of dermal sac except over hindbrain; dorsally over gut; laterally across abdomen & on isthmus, otherwise, none ventrally on trunk, & none on tail until ca. 4 mm NL; spreading over entire body, on snout & jaws by 3 to 5 mm NL, on median fin bases by 6 mm PCL; more dorsally than laterally and ventrally; live larvae dark blue or black dorsally, silver laterally & light ventrally.
 Diagnostic Characters: Distinguish from *Masturus* & *Mola* after 2 mm NL by bases of dermal spines without transverse ribs; by elongation of specific spines: anteriormost & posteriormost in the dorso-medial set, second & posteriormost in the dorso-lateral set; & posteriormost in the ventro-lateral set; postanal region characteristically bent downward from the longitudinal axis of the body between ca. 2 mm NL to 4.5 mm PCL; normal orientation of body axis regained by 6 mm PCL.

JUVENILES:

No prejuvenile or 'molacanthus' stage present; by ca. 15 mm PCL body elongated, relatively compressed with ventral keel evident, dermal spines absent or reduced to pyramidal bases; body distinctly countershaded by 15 mm PCL.

¹ Clavus or pseudocaudal fin

² preclaval length, i.e. snout to base of claval elements



MOLIDAE***Masturus lanceolatus* (Liénard, 1840)****MERISTICS**

	Range
Vertebrae:	
Precaudal	8
Caudal	8
Total	16
Number of Fin Spines and Rays:	
First Dorsal	0
Second Dorsal	18-20
Anal	16-18
Pectoral	7-10
Pelvic	0
Pseudocaudal ²	17-26
Branchiostegals	6

LIFE HISTORY

Range: cosmopolitan in tropical to temperate waters; in western Atlantic from North Carolina to southeastern Brazil
 Habitat: epipelagic; depth range to >700 m
 ELH Pattern: oviparous; pelagic eggs
 Spawning: oceanodromus; in central parts of subtropical circulations

LITERATURE

Martin & Drewry (1978); Yabe (1953); Sololovskaya & Sololovskiy (1975); Watson (1996bv)

ILLUSTRATIONS

A, from Martin & Drewry (1978); B, C, specimens captured in midwater trawl collections in the western Atlantic Ocean (Gulf Coast Research Lab Museum #34656 & #21447, respectively); D, from Sololovskaya & Sololovskiy (1975); E, from Yabe (1953).

EARLY LIFE HISTORY DESCRIPTION**EGGS:**

Diameter: 1.8 mm
 No. of Oil Globules: ca. 40
 Hatch Size: unknown

LARVAE:

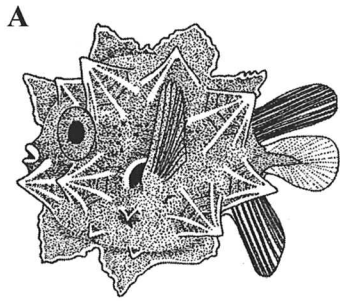
Length at Flexion: (flexion does not occur, notochord tip atrophies)
 Length at Transformation: ca. 5 mm TL
 Sequence of Fin Development: unknown but likely as in *Ranzania laevis*; P1, D&A, C 1
 Pigmentation: uniformly over entire body but not on P1, D or A bases or rays at 3.65 mm NL (still prior to atrophy of notochord tip); concentrated in spots of varying diameter all over body in 7 mm specimen.
 Diagnostic Characters: None to distinguish from *Mola* prior to elongation of dermal spines at ca. 3.5 mm NL when five spines in the dorso-medial, ventro-lateral and ventro-medial sets become 2 to 3 times the length of the other spines. Distinguished from *Ranzania laevis* by presence of both longitudinal and transverse ribs on base of dermal spines; & after ca. 3.5 mm, by the specific spines that become elongated (see illustrations). Additionally, the horizontal axis of the body remains straight & does not bend downward as in *Ranzania*.

JUVENILES:

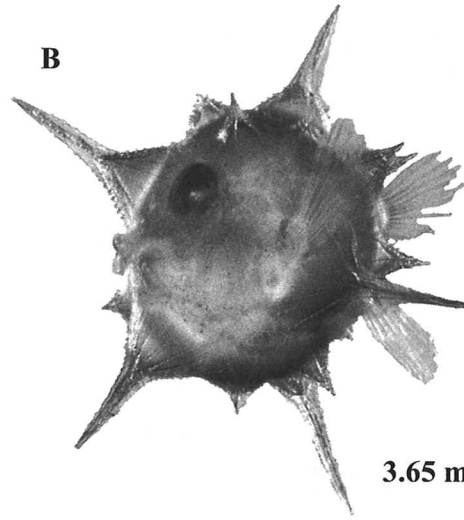
Diagnostic Characters: A prejuvenile or 'molacanthus' stage persists from ca. 5 mm TL to ca. 55 to 60 mm PCL². During this period the body is deeper than long; the five elongated spines become longer than the body & over half as long as the body is wide; the bases of the non-elongated spines become reduced in size; & the body becomes compressed with the lower half, anterior to the anus becoming even more compressed, protruding down & forward as a keel. A claval filament or elongated claval elements are shown in illustrated specimens as small as 12 mm (PCL ?). The inconsistent appearance of this feature in published accounts & illustrations of young *Masturus* may indicate that this structure is easily lost during capture. Claval elements in the largest specimen (7 mm) that I examined were equal in length.

¹ Clavus or pseudocaudal fin

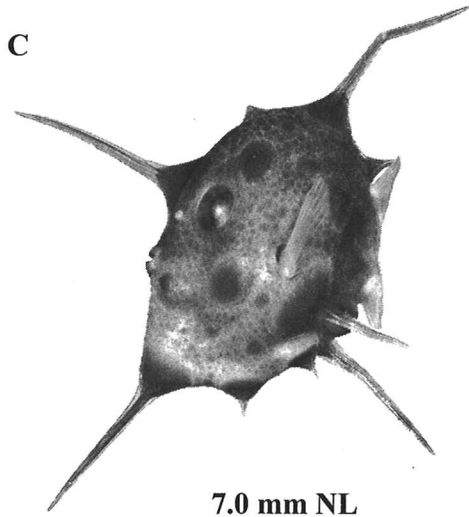
² preclaval length, i.e. snout to base of claval elements



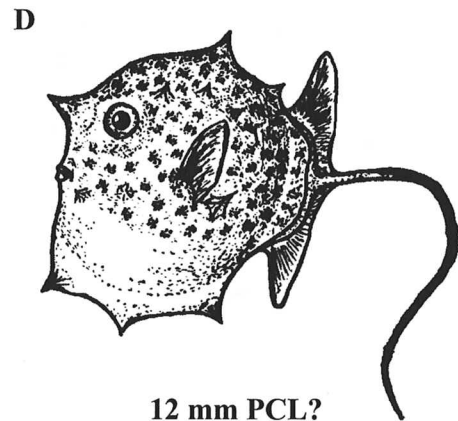
2.8 mm TL



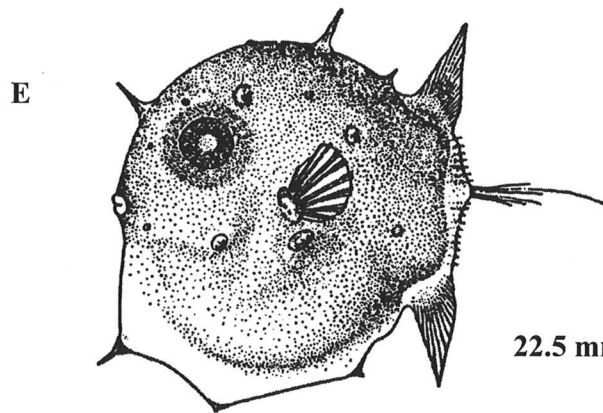
3.65 mm NL



7.0 mm NL



12 mm PCL?



22.5 mm PCL

MOLIDAE

Mola mola (Linnaeus, 1758)

MERISTICS

	Range
Vertebrae:	
Precaudal	8
Caudal	9
Total	17
Number of Fin Spines and Rays:	
First Dorsal	0
Second Dorsal	18-19(15-20)
Anal	16-18(14-18)
Pectoral	11-13
Pelvic	0
Pseudocaudal ³	12-15
Branchiostegals	6

LIFE HISTORY

Range: cosmopolitan in tropical to temperate waters; in western Atlantic from Newfoundland, Canada to Argentina

Habitat: epipelagic; depth range to 300 m

ELH Pattern: oviparous

Spawning: oceanodromus; in central parts of subtropical circulations

LITERATURE

Martin and Drewry (1978); Tortonese (1956); Sololovskaya & Sololovskiy (1975); Watson 1996

ILLUSTRATIONS

A, from Tortonese (1956); B, larva from a neuston collection in the Gulf of Mexico; C, D, specimens captured in midwater trawl collections from the western Atlantic Ocean (Gulf Coast Research Lab Museum #21448); E, from Sololovskaya & Sololovskiy (1975).

EARLY LIFE HISTORY DESCRIPTION

EGGS: Unknown

LARVAE

Length at Flexion: (flexion does not occur, notochord tip atrophies)

Length at Transformation: ca. 4 mm TL

Sequence of Fin Development: unknown but likely as in *Ranzania laevis*; P₁, D&A, C¹

Pigmentation: uniformly over body but not on lips, P₁, D or A bases or rays at 1.95 mm NL (still prior to atrophy of notochord tip); concentrated in spots of varying diameter all over body in 3.0, 4.2 and 5.5 mm specimens; belly of 5.5 mm specimen unpigmented.

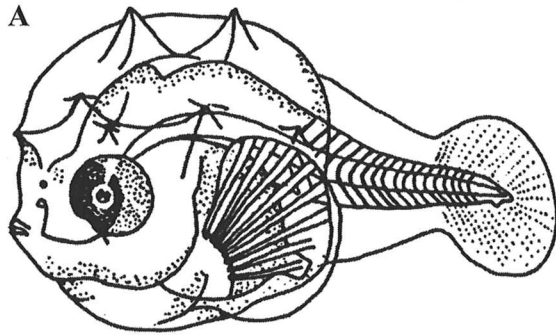
Diagnostic Characters: None to distinguish from *Masturus* prior to elongation of dermal spines at ca. 3.5 mm NL in that species; dermal spines in *Mola* remain the same size; at 2 to 3 mm the spine bases form a complete 'shell' around the larva. Distinguished from *Ranzania* by presence of both longitudinal & transverse ribs on base of dermal spines; and after 2.5 mm when certain spines in *Ranzania* become elongated (see illustrations). Additionally, the horizontal axis of the body remains straight and does not bend downward as in *Ranzania*.

JUVENILES:

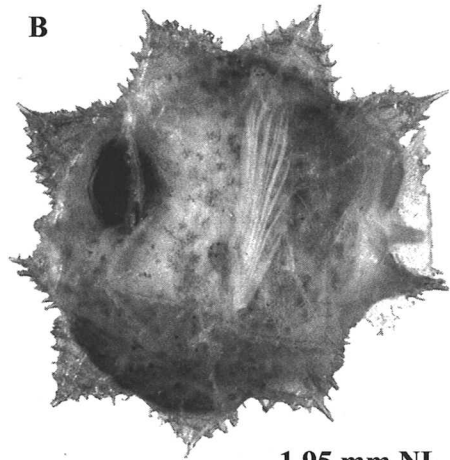
Diagnostic Characters: A prejuvenile or 'molacanthus' stage persists from ca. 4 mm TL to ca. 59 mm PCL². During this period the body is deeper than long; with growth the spacing between spine bases increases & the larva is no longer completely encased; the body becomes compressed with the lower half, anterior to the anus becoming even more compressed, protruding down & forward as a keel.

¹ Clavus or pseudocaudal fin

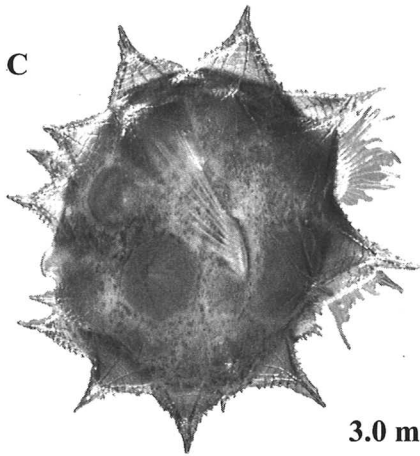
² preclaval length, i.e. snout to base of claval elements



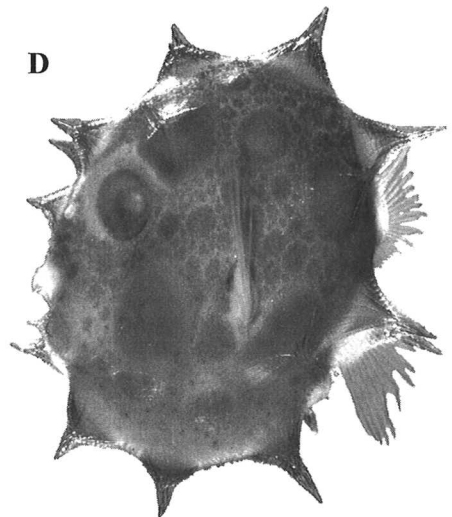
1.8 mm TL



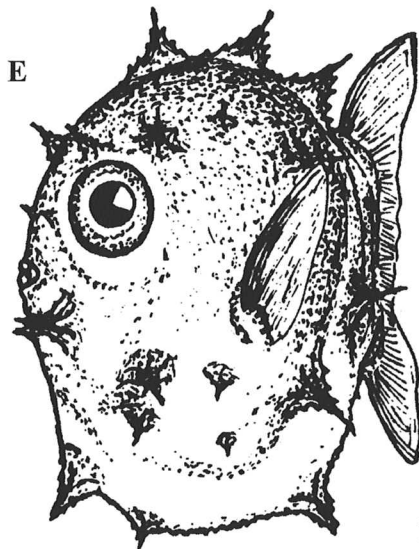
1.95 mm NL



3.0 mm NL



5.5 mm PCL



11.0 mm TL

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Contrib. Nankai Reg. Fish Res. Lab.
(1) Contrib. 4: 40-42.