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INSTRUCTIONS FOR AUTHORS

GENERAL INFORMATION

The Bulletin of the Sea Fisheries Institute is a scientific journal which accepts papers from all over the world. Foreign authors are requested to submit their papers in English, the research staff of the SFI in Polish and authors not associated with the SFI in Polish and English.

Papers submitted to the Bulletin are classified according to the following three categories: 1) scientific papers, 2) short communications, 3) varia.

The Editorial Staff will accept a paper and assign it to one the above categories. Papers accepted for publication in the *Bulletin* may not be published elsewhere. Publication in the *Bulletin* is free of charge.

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Papers should be submitted in two copies of single-sided, double-spaced typescript on A4 paper and a diskette containing all the material in the article must be included. Words to be set in italic type, i.e. Latin names of species and genera, as well as symbols for the values of variables, should be underlined with a wavy line (~~~~~). No other underlineation should be used.

In the papers from categories 1 and 2, the following order is required:

1. **Title**: brief (up to 100 characters).
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8. **Footnotes** should be marked with Arabic numerals in superscript (...[1]), and numbered in succession throughout the text, except for tables; footnote content should be on separate sheets of paper.
9. **Tables** should supplement, not duplicate, data contained in the text or figures. Tables should be numbered and each one should be on a separate sheet of paper. All tables must have titles; all references to them should be placed within the text. Each column in a table is supplied with a heading, explaining the content of the column. Footnotes in tables should be marked with letters in italics, in superscript (e. g. Years[a]), and their explanation should be placed under the table.
10. **Figures**. Successive numeration with a reference to each number in the text should be used. Captions must be on a separate sheet of paper. Abbreviations, terms and symbols used in figures must correspond to those used in the text. After scaling, each figure, placed on a separate sheet of paper and marked with a successive number and the author's name, must fit into a column of the *Bulletin*; this should be taken into account by using the appropriate thickness of lines and size of legends in the figures. Only computer generated figures are acceptable. Both a printout and a diskette are required. Papers can be illustrated with photographs in black and white or color. The total content of drawings and photographs must not exceed 30% of the paper.

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Prace złożone klasyfikowane są według trzech kategorii: 1) artykuły naukowe, 2) noty, 3) varia.

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Occurrence of the Larvae of Beryciform Fishes in the Gulf of Mexico

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Abstract. Since 1982 Polish and American scientists have cooperatively amassed a great body of knowledge on the early life stages of marine fishes from the Gulf of Mexico and adjacent waters. Identification of larvae remains a difficult task because the larvae of less than 30% of fishes in this region have been described. Our recent examination of young beryciform fishes, taken in over 8000 ichthyoplankton samples collected during Southeast Area Monitoring and Assessment Program (SEAMAP) surveys in 1982 to 1995, yielded new insights into the early life history of these unusual, rarely collected fishes. Six families of beryciform fishes were represented among the specimens we examined. The squirrelfishes and soldierfishes, family Holocentridae, were the most numerous group with 549 specimens, including 65 rhynchichthys-stage juveniles. Nearly as numerous were the young of the bigscales, family Melamphaidae, comprising 511 specimens among which all four known genera of the family were represented. Only a few specimens were observed in each of the remaining four families: Polymixiidae, Diretmidae, Trachichthyidae, and Gibberichthyidae.

Keywords: fish larvae, ontogeny, Beryciformes, Gulf of Mexico

INTRODUCTION

The productive and rewarding association between the Plankton Sorting and Identification Center (PSIC) and SEAMAP has resulted in numerous contributions to fisheries science and marine fish ontogeny in the Gulf of Mexico. Many significant developments in fish stock assessment have been based on the long-term and stable database for which the 25-year relationship between PSIC and SEAMAP serves as a paradigm. Examples of these developments include: 1) an annual Atlantic bluefin tuna (*Thunnus thynnus*) larval index that is used by the International Commission for the Conservation of Atlantic Tunas to assess the status of Atlantic bluefin tuna in the Gulf of Mexico (Scott *et al.* 1993); 2) indices of larval king mackerel (*Scomberomorus cavalla)* occurrence and abundance that are highly correlated with spawning

stock size and provide useful variables for calibrating king mackerel population assessments (Gledhill and Lyczkowski-Shultz 2000); and 3) descriptions of larval development of economically important fishes, a prerequisite for the use of larvae in population assessments (Ditty and Shaw 1992; Ditty and Shaw 1993; Ditty *et al.* 1994; Drass *et al.* 2000 press).

Our cooperative taxonomic work usually focuses on species that are economically important to U. S. fisheries (e.g. Drass *et al.* 2000). Yet the early life stages of a wide variety of fishes are collected by SEAMAP, thereby yielding material for taxonomic study. Here we present results from a longstanding interest in the larvae of an eclectic group of fishes, the Beryciformes. Few ichthyologists agree on either the taxonomic composition or phylogeny of beryciform fishes (Nelson, 1984; Nelson 1994; Baldwin and Johnson 1995). Most, but not all, beryciform species reside in deep demersal and pelagic habitats while their larvae occur in the upper portion of the world's oceans. The immature stages of some beryciform fishes have been described as distinct taxa due in part to their rarity in collections and their bizarre morphology (Keene and Tighe 1984). Such was the case with the pelagic prejuveniles or rhynchichthys-stage of the holocentrids (Figure1A) that were first described as the genus *Rhynchichthys* by Valenciennes 1831 (McKenney 1959).

METHODS

Ichthyoplankton samples are taken during SEAMAP surveys in the Gulf of Mexico with a 61 cm mouth diameter bongo net fitted with two 335 micron mesh nets, and with a 1 by 2 m or 1 by 4 m mouth diameter neuston net fitted with one or two 947 micron mesh nets. All bongo net tows follow an oblique path to the surface from a maximum depth of 200 m or to 2 m off the bottom where station depth is less than 200 m. Water volume filtered during bongo net tows is measured with a mechanical flowmeter that is hung in the mouth of each bongo net. The neuston net is towed at a depth of 0.5 to 1 m alongside the ship away from vessel prop wash for 10 minutes. SEAMAP ichthyoplankton samples are initially preserved in 5-10 % formalin and are transferred within 48 hours to 95% ethanol for long term storage. They are sorted for fish eggs and larvae and the larvae are identified at the Plankton Sorting and Identification Center in Szczecin. Identified specimens and data are returned to the SEAMAP Archiving Center in St. Petersburg, Florida, USA for archival storage. Images of larvae presented in this paper were acquired with imaging software and a color video camera mounted on a stereo microscope using both reflected and transmitted light.

RESULTS

Forty-five species in ten families of beryciform fishes (Kotlyar 1996) can be found in the western central Atlantic Ocean, FAO (Food and Agricultural Organization of the United Nations) Fishing Area 31, which includes the Gulf of Mexico and Caribbean Sea (Table 1). Representatives of nine of those families and 36 species occur in the Gulf of Mexico (McEachran and Fechhelm, 1998). Our examination of larvae from over 8000 samples taken during SEAMAP surveys in the U.S. Gulf of Mexico during the period 1982 to 1995 yielded just over 1050 specimens of young beryciform fishes:

Table 1. Beryciform taxa found in the western central Atlantic Ocean, FAO Fishing Area 31, including the Gulf of Mexico and Caribbean Sea. Species in bold letters are listed as occurring in the Gulf of Mexico by McEachran and Fechhelm (1998).

Polymixiidae	*Ostichthys*
Polymixia	***trachypoma***
nobilis	*Corniger*
lowei	***spinosus***
Berycidae	*Plectrypops*
Beryx	***retrospinis***
decadactylus	Anoplogasteridae
splendens	*Anoplogaster*
Diretmidae	***cornuta***
Diretmus	***brachycera***
argenteus	Gibberichthyidae
Diretmoides	*Gibberichthys*
pauciradiatus	***pumilis***
Diretmichthys	Stephanoberycidae
parini	*Stephonoberyx*
Trachichthyidae	***monae***
Gephyroberyx	*Acanthochaenus*
darwini	*luetkenii*
Hoplostethus	Melamphaidae
atlanticus	*Scopelogadus*
mediterraneus	***mizolepis***
occidentalis	***beanii***
Paratrachichthys	*Poromitra*
argyrophanus	***megalops***
Anomalopidae	***capito***
Kryptophanaron	***crassiceps***
alfredi	*Scopeloberyx*
Holocentridae	***robustus***
Holocentrus	***opisthopterus***
adscensionis	*Melamphaes*
rufus	*microps*
Neoniphon	*ebelingi*
marianus	*polylepis*
Sargocentron	*suborbitalis*
vexillarium	***eulepis***
coruscum	*longivelis*
bullisi	***typhlops***
poco	***simus***
Myripristis	***pumilus***
jacobus	

Polymixiidae (beardfishes) – 11 specimens,
Diretmidae (spinyfins) – 5 specimens,
Trachichthyidae (roughies) – 1 specimen,
Gibberichthyidae (gibberfishes) – 1 specimen,
Melamphaidae (bigscales) – 511 specimens,
Holocentridae (squirrelfishes and soldierfishes) – 549 specimens.

In this paper we present digitized images of young beryciform fishes taken in SEAMAP samples, and give distinguishing characteristics for larvae in each of the six families collected. Distribution maps depicting the occurrence and distribution of melamphaid and holocentrid larvae in the Gulf of Mexico are presented from selected survey data.

Polymixiidae

Eleven young *Polymixia lowei,* ranging in length from 4 to 31 mm SL (standard length) were collected in nine bongo net samples from the deep, central Gulf of Mexico east of 90°W longitude between 27°and 25°N latitude. The two smallest SEAMAP specimens, 4.1 and 5.3 mm SL, already closely resemble the juvenile specimen in Figure 2A in both pigmentation and squamation. Scales present on the trunk and tail each bear two posteriorly directed spines giving these postflexion larvae an overall 'fuzzy' appearance, and developing hyoid barbels are present as unpigmented, fleshy thickenings. Larval development of the Polymixiidae has not been described but postflexion larvae and early juveniles can be distinguished by: blunt snout and heavily pigmented, robust body; transformation beginning at small size, 4 mm; lack of prominent head spines; 4 to 6 dorsal spines and over 25 dorsal rays; 3 to 4 anal spines and 13 to 18 anal rays; presence of hyoid barbels (indicated with arrows in Figure 2A).

Trachichthyidae

The only representative of this family in SEAMAP collections was captured in the northern Gulf of Mexico on 6 January 1993 in a bongo tow at 28.2°N latitude 87.8°W longitude where water depth was over 2000 m. Positive identification beyond the family level could not be made because fin development was incomplete in this 5.3 mm specimen (Figure 2B). Although less than half the size, our specimen shares characteristics with the young of both *Hoplostethus* and *Gephyroberx* illustrated in Okiyama (1988) and Baldwin and Johnson (1995). Distinguishing features of larvae in this family are 26 to 30 myomeres; weak to strong head spination, including prominent cranial ridges; heavily pigmented, stocky body with long gut (preanal length > 50%); large head and mouth; and precocious pelvic fin development (Jordan and Bruce 1993). The presence of a preanal fin (indicated by the arrow in Figure 2B) may be an additional distinguishing characteristic of *Hoplostethus* and *Gephyroberx* larvae.

Gibberichthyidae

Probably the most exciting discovery among our SEAMAP collections is what appears to be the larva of *Gibberichthys pumilis*, the only member of the family occurring in the Gulf of Mexico and the smallest specimen, 6 mm SL, yet reported (Figure 2C). Our specimen was captured on 3 September 1992 in the neuston net at 28°N latitude and 93.5°W longitude where water depth was 95 m. The specimen is in fair condition but its lower jaw is turned in on itself, and although fin element formation and differentiation are incomplete the dorsal, anal and pelvic counts support our identification.

The juveniles of this species were previously assigned to a separate family, Kasidoroidae, but they are now known to be the prejuvenile or kasidoron-stage of the Gibberichthyidae. The unique characteristic of *Gibberichthys* young (37.5 mm) is the modified 3rd pelvic ray or pelvic appendage that resembles Sargassum weed or the tentacles of a siphonophore and is lost during

metamorphosis to the adult stage (de Sylva and Eschmeyer 1977). The tip of the 3rd pelvic ray in the 6 mm SEAMAP specimen is beginning to elongate (indicated by the arrow in Figure 2C). It is difficult, with so few known specimens, to give characters that can be used to identify *G. pumilis* larvae prior to development of the modified 3rd pelvic ray. Our specimen resembles the illustrations of *G. pumilis* in De Sylva and Eschmeyer (1977) in having large eyes; dorsal and anal fins directly opposite each other with 13 dorsal fin elements and 11 anal fin elements; elongated caudal peduncle; and 29 or 30 myomeres. It differs from those specimens most notably in having a much less developed pelvic appendage and more anteriorly positioned pelvic fin base.

Diretmidae

All five spinyfin larvae were taken in SEAMAP collections (4 in neuston and 1 in bongo samples) during January and February, 1993 in open Gulf waters between 26 and 28°N latitude and 96 and 88°W longitude where station depths ranged from 700 to 2600 m. Diretmid larvae are distinguished by a large head, deep body, absence of dorsal and anal spines, and greatly enlarged parietal and preopercular spines. Although the larvae of *Diretmus argenteus* have been described (Post 1976), the specimen in Figure 3A exhibits a banding pattern on the body that has not been previously illustrated. Larvae of *Diretmichthys parini* (Figure 3B) exhibit a different body pigmentation pattern and smaller parietal and preopercular spines than the larvae of *Diretmus argenteus* (Post and Quero 1981).

Melamphaidae

Larvae of this family were the most diverse and second most abundant beryciform group in the SEAMAP collections with larvae of *Melamphaes simus* accounting for over 90% of all melamphaid larvae captured (Figure 4A). The larvae of *Poromitra* spp., *Scopeloberyx* spp., and *Scopelogadus* spp. were also present but in lower numbers (Figure 4B,C,D). Features that distinguish bigscale larvae include: moderately large head and eyes; precocious pelvic fin development (most species); dorsal fin with 2 to 3 weak spines preceding soft rays; anal fin with one spine and 7 to 11 rays; and genus- or species-specific body pigmentation (Ebeling and Weed 1973; Sandknop and Watson 1996).

SEAMAP ichthyoplankton surveys are conducted in offshore waters of the U.S. Gulf of Mexico during April and May (spring) and in continental shelf waters from late August to early October (early fall). The occurrence of young melamphaids in the offshore and nearshore waters of the Gulf during two years are depicted in Figure 5. During the spring of 1991, melamphaid larvae occurred primarily in the central and eastern Gulf of Mexico, i.e. the region most influenced by Caribbean Sea water that enters the Gulf via the Loop Current. In early fall of 1993, melamphaid larvae were, in all but one instance, collected at the outermost survey stations on the continental shelf.

Holocentridae

Among beryciform fishes, the holocentrids are unique in that the adults reside in shallow waters, most typically on reefs. Their larvae are unique among marine fish larvae in developing greatly

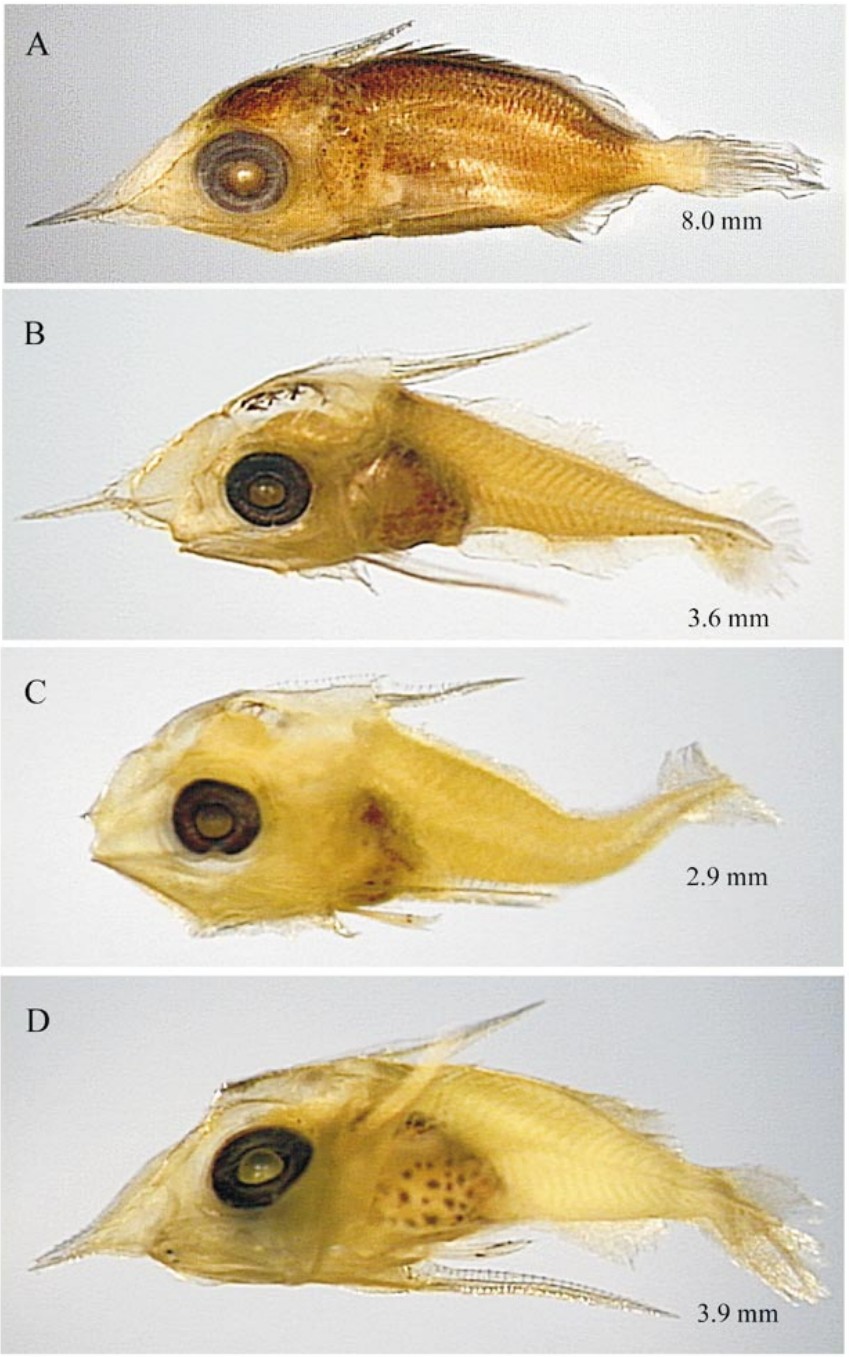

Fig. 1. Young of the beryciform family, Holocentridae from the Gulf of Mexico: (A) prejuvenile or rhynchichthys-stage of the subfamily holocentrinae, 8 mm SL (SEAMAP Catalogue No. SML126901-000); (B) preflexion larva of the subfamily holocentrinae, 3.6 mm (SEAMAP Catalogue No. SML 71490-000); (C) preflexion larva of the subfamily myripristinae, 2.9 mm (SEAMAP Catalogue No. SML124952-000); (D) flexion larva of the subfamily myripristinae, 3.9 mm (SEAMAP Catalogue No. SML 81690-001).

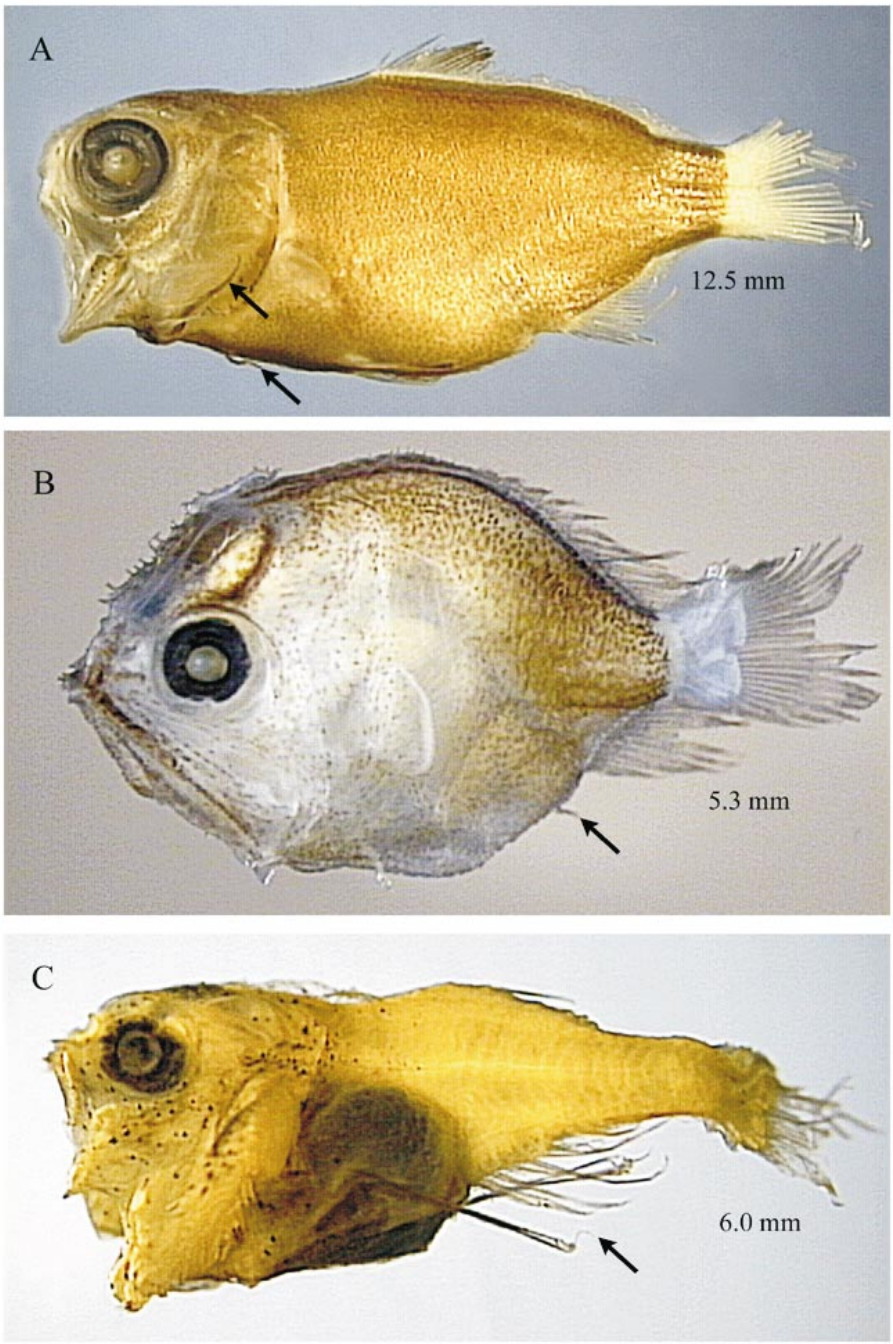

Fig. 2. (A) Polymixiidae – juvenile *Polymixia lowei*, 12.3 mm SL (arrows point to hyoid barbels, SEAMAP Catalogue No. SML 80579-000); (B) Trachichthyidae – unidentified postflexion larva, 5.3 mm SL (arrow points to preanal fin, SEAMAP Catalogue No. SML108474-000); (C) Gibberichthyidae – prejuvenile or kasidoron-stage *Gibberichthys pumilis*, 6.0 mm SL (arrow points to elongating 3rd pelvic ray, SEAMAP Catalogue No. SML 98110-000).

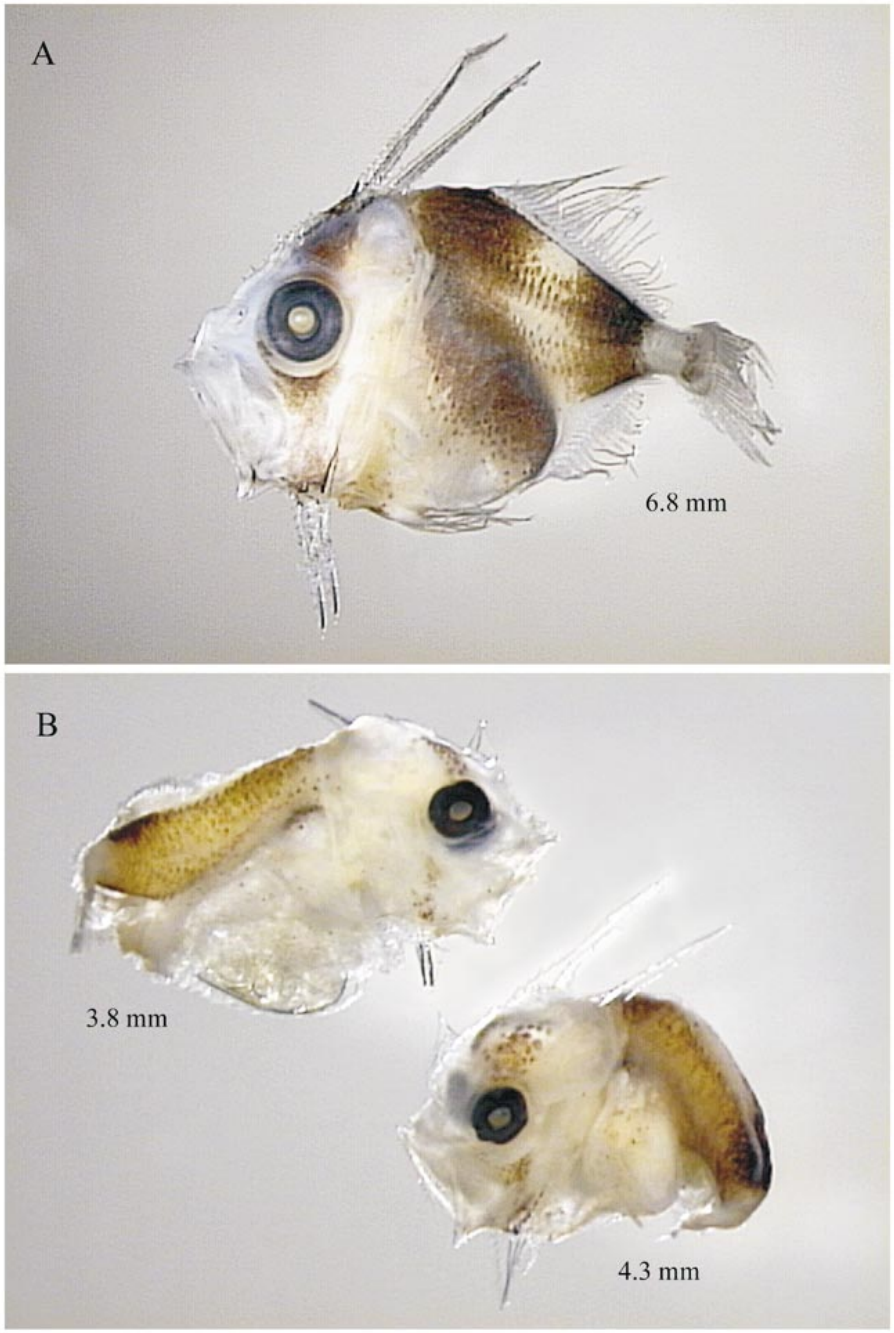

Fig. 3**.** Young of the beryciform family, Diretmidae from the Gulf of Mexico: (A) postflexion larva of *Diretmus argenteus*, 6.8 mm SL (SEAMAP Catalogue No. SML109645-000); (B) flexion larvae of *Diretmichthys parini*, upper specimen 3.8 mm SL (SEAMAP Catalogue No. SML122978-000) and lower specimen 4.3 mm SL (SEAMAP Catalogue No. SML124005-000).

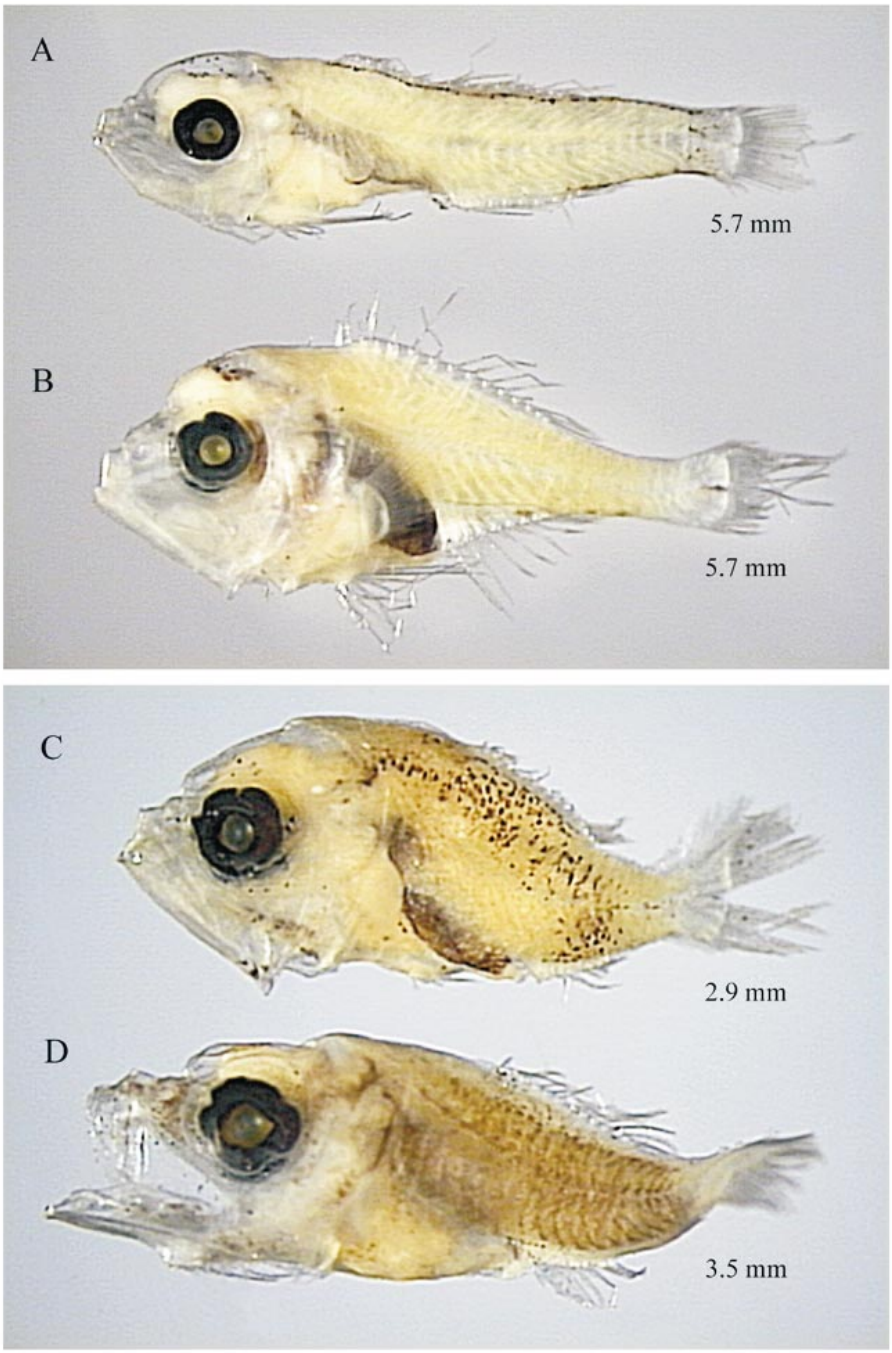

Fig. 4. Young of the beryciform family, Melamphaidae from the Gulf of Mexico: (A) postflexion larva of *Melamphaes simus*, 5.7 mm (SEAMAP Catalogue No. SML109717-000); (B) postflexion larva of *Poromitra sp.*, 5.7 mm (SEAMAP Catalogue No. SML109130-000); (C) postflexion larva of *Scopeloberyx sp.*, 2.9 mm (SEAMAP Catalogue No. SML136611-000); (D) flexion larva of *Scopelogadus sp.*, 3.5 mm (SEAMAP Catalogue No. SML 26717-000).

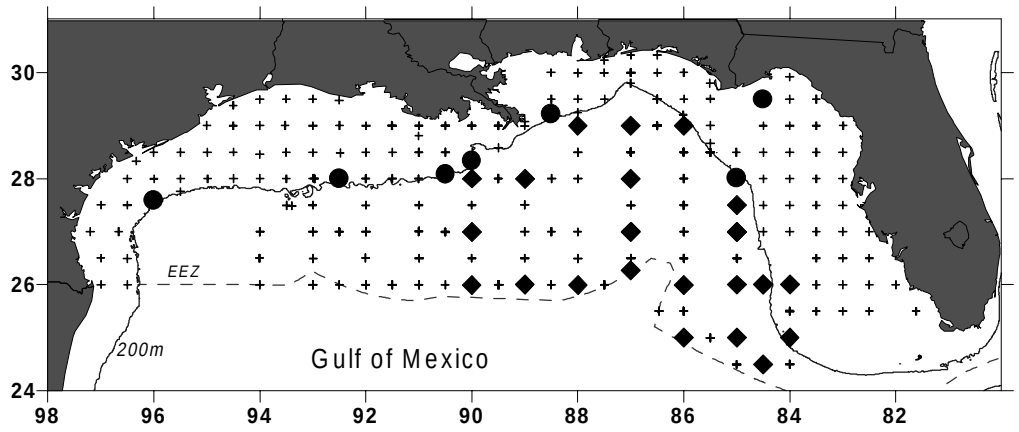

Fig. 5. Distribution of Melamphaidae larvae captured in the U.S. Gulf of Mexico during SEAMAP ichthyoplankton surveys of continental shelf waters in the fall of 1993 (●) and offshore waters in the spring of 1991 (◆). +'s indicate stations where melamphaid larvae were not captured. The dashed line labeled '*EEZ*' denotes the Exclusive Economic Zone or 200 mile limit of U.S. jurisdictional waters. The solid contour line is the 200 m isobath.

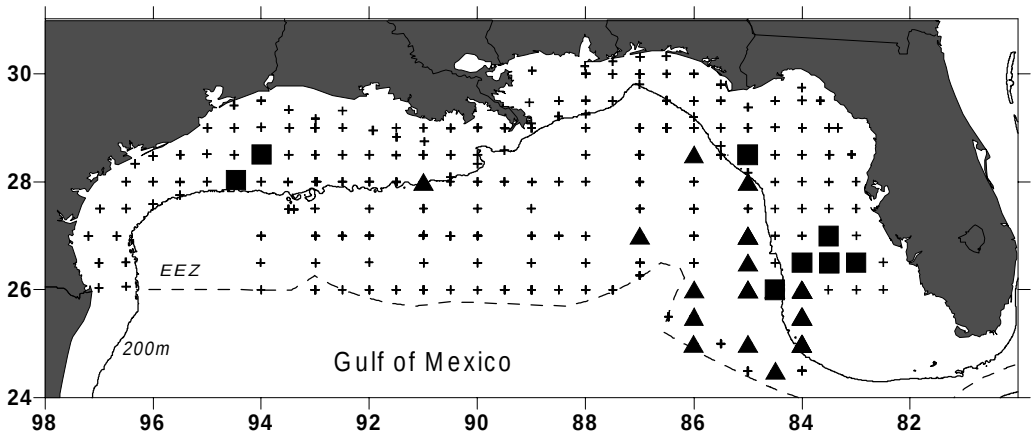

Fig. 6. Occurrence of Holocentridae larvae captured in the U.S. Gulf of Mexico during 1991 SEAMAP ichthyoplankton surveys of continental shelf waters in the fall (■) and of offshore waters in the spring (▲). +'s indicate stations where holocentrid larvae were not captured. The dashed line labeled '*EEZ*' denotes the Exclusive Economic Zone or 200 mile limit of U.S. jurisdictional waters. The solid contour line is the 200 m isobath.

enlarged rostral, supraoccipital, preopercular and opercular spines (Figure 1). Distinction between the two subfamilies of holocentrids is straightforward (Jones and Kumaran 1962). The larvae of the holocentrinae (squirrelfishes) exhibit late forming pelvics and have a very long, single rostal spine (Figure 1B). Larvae of the subfamily myripristinae (soldierfishes), however, form pelvic fins early in development and have a short bifurcate rostral spine (Figure 1C and D). Identification of holocentrid larvae below the family level remains problematic since the larval development of only one taxon in the central western Atlantic, *Holocentrus vexillarius* (now *Sargocentron vexillarium*) has been described (McKenney 1959). Many of

the 11 species in 7 genera in the SEAMAP survey area exhibit subtle yet consistent differences in the number of fin elements and lateral line scales (Woods and Sonoda 1973). These differences will be explored by examination of the 65 rhynchichthys-stage juveniles (Figure 1A) in the SEAMAP collections using 'clearing and staining' techniques to obtain accurate fin element and scale row counts (Potthoff 1984).

Occurrences of holocentrid larvae in the U.S. Gulf of Mexico during the SEAMAP ichthyoplankton surveys in the spring (offshore waters) and fall (continental shelf waters) for one year (1991) are depicted in Figure 6. Most specimens were taken in the southeastern region of the Gulf close to the coral reefs of the Florida Keys and 'downstream' of the Caribbean Sea. Holocentrid larvae in the western Gulf occurred between 90° and 95°W longitude and in the vicinity of the 'Flower Gardens', the northernmost coral reefs of the continental U.S.

SUMMARY

Our examination of the extensive SEAMAP collections has yielded new insights into the ontogeny of beryciform fishes that will be incorporated into an upcoming book, "Guide to the early life history stages of fishes from the western central North Atlantic", W. J. Richards, editor. With our initial examination concluded, we can begin more detailed analysis of the holocentrids including the 'clearing and staining' of juvenile specimens in order to obtain accurate meristic data. Positive identification of juveniles using adult meristic characters may allow us to assemble developmental series of holocentrid larvae through linkage of successively smaller specimens.

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