LARVAE AND YOUNG OF WESTERN NORTH ATLANTIC BOTHID FLATFISHES *ETROPUS MICROSTOMUS* AND *CITHARICHTHYS ARCTIFRONS* IN THE CHESAPEAKE BIGHT[1, 2]

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ABSTRACT

Development of smallmouth flounder, *Etropus microstomus*, and Gulf Stream flounder, *Citharichthys arctifrons*, is illustrated and described from larval to adult stages. Adults occur along the Atlantic coast, mainly from Cape Cod, Mass., to Cape Hatteras, N.C. Larvae of these two species were the most numerous of all flatfishes collected from 1959 to 1963 in the Chesapeake Bight by the Virginia Institute of Marine Science.

Changes in pigmentation, changes in morphology, sequences of ossification, and developmental osteology are described and compared. Occurrence of both species as larvae and adults in the Chesapeake Bight, their spawning times, abundance, and economic importance are noted. Taxonomic problems involving the validity of the generic separation of *Etropus* and *Citharichthys* are mentioned.

This paper presents the first descriptions of larvae of smallmouth flounder, *Etropus microstomus* (Gill), and Gulf Stream flounder, *Citharichthys arctifrons* Goode. The larvae of these two species were the most numerous of all flatfishes collected in the Chesapeake Bight plankton by the Virginia Institute of Marine Science (VIMS) from 1959 to 1963.

Adult *E. microstomus* and *C. arctifrons* are found principally from Cape Cod, Mass., to Cape Hatteras, N.C. The reported northern limit for *E. microstomus* is New England (Parr, 1931; Norman, 1934). The southern limit may extend to the Gulf coast of Florida and Mississippi (Springer and Bullis, 1956; Gutherz, 1967). *C. arctifrons* is found from the southwest part of Georges Bank (Bigelow and Schroeder, 1953) to the Gulf coast of Florida and Yucatan, Mexico (Gutherz, 1967). *E. microstomus* is most common at depths of 4-27 m (2-15 fm) and is generally not in the tidal zone or greater than 46 m (25 fm) (Parr, 1931). *C. arctifrons* occurs mainly at depths of 46-366 m (25-200 fm) (Goode and Bean, 1895; Gutherz, 1967) and infrequently in waters as shallow as 22 m (12 fm) (Bigelow and Schroeder, 1953). Little additional information is available on the life history of either species.

MATERIALS AND METHODS

Specimens

Several thousand larvae of each species, fixed and stored in 3-5% Formalin,[5] were examined. Juveniles and adults had been fixed in 10% Formalin and transferred to 40% isopropyl alcohol for storage.

Larvae used in this study came mainly from VIMS collections made with the RV *Pathfinder* during three series of Atlantic plankton cruises: monthly from December 1959 through December 1960 (October excluded) and from March 1961 through March 1962, and seasonally from July 1962 to April 1963 (winter excluded). The pattern of stations at which col-

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[2] Part of a dissertation submitted by the senior author to the Faculty of the College of William and Mary in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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[5] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Manuscript accepted November 1972.
FISHERY BULLETIN: VOL. 71, NO. 3, 1973.

lections were made (Figure 1) changed for each of the three series of cruises (Joseph, Massmann, and Norcross, 1960; Massmann, Norcross, and Joseph, 1961; Massmann, Joseph, and Norcross, 1962). All collections were made in the Chesapeake Bight between lat. 36° and 38°N and from near shore to 80 nautical miles offshore. Gear, depths of sampling, and tow times were modified throughout the cruises (Joseph et al., 1960; Norcross, Massmann, and Joseph, 1961; Wilson, 1962). Meter and half-meter nets and the Gulf III high speed plankton sampler (Gehringer, 1952, 1962; Bridger, 1958) were the main types of gear used.

Larvae collected in the Chesapeake Bight by the Sandy Hook Sport Fisheries Marine Laboratory in New Jersey were examined also. The specimens were taken with Gulf V high speed plankton samplers (Arnold, 1959) during an offshore survey ranging from Martha's Vineyard, Mass., to Cape Lookout, N.C. The survey consisted of eight cruises made from December 1965 to December 1966. Clark et al. (1969) give details of the survey area and sampling procedures.

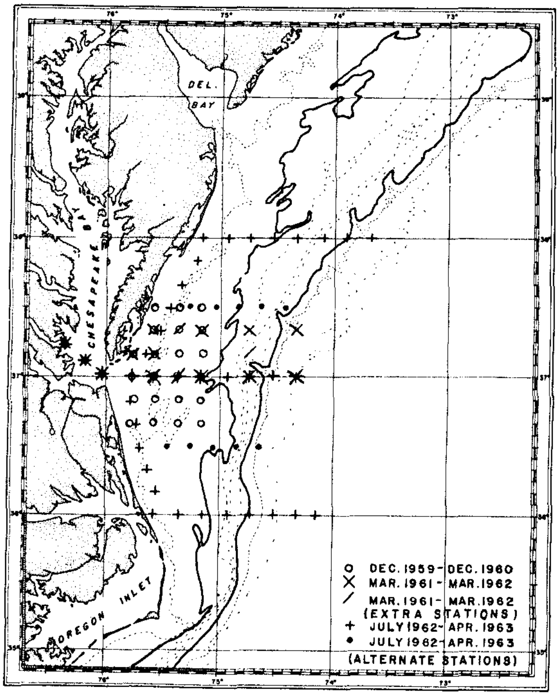

FIGURE 1.—Stations sampled by the RV *Pathfinder* of the Virginia Institute of Marine Science during three series of Atlantic plankton cruises from 1959 to 1963. The 37-m (20-fm) and 183-m (100-fm) depth contours are emphasized.

Additional larvae were collected in Norfolk Canyon (approximately lat. 37°04'N, long. 74°40'W), 13-14 August 1969, by VIMS personnel on board the National Marine Fisheries Service RV *Albatross IV*. Four plankton tows, each 1 h long, were made at 6-h intervals. Each tow consisted of four Miller plankton samplers (Miller, 1961), a pair of 0.2-m bongos (McGowan and Brown, 1966), all without closing mechanisms, and a 2-foot Braincon depressor. Estimated fishing depths for the Miller samplers were 2, 50, 100 and 275 m for each tow. The bongos fished at nearly the same depth as the deepest Miller sampler.

Juvenile and adult specimens were examined from various trawl collections taken between Cape Cod and Cape Hatteras by VIMS or by the National Marine Fisheries Service Laboratory at Woods Hole, Mass.

Measurements

Measurements were made on 100 unstained larvae of each species with an ocular micrometer and on 100 unstained adults of each species with dividers and a wooden millimeter scale. The larvae were selected from the VIMS 1962 plankton collections to represent the available size range. The adults were taken from trawl collections made from 1954 to 1967 (mostly 1965-67) between lat. 35°58'N and 40°09'N. Lengths reported in this study refer to standard length (SL). Fish were measured with the left side uppermost. The following body measurements, some of which were modified from Hubbs and Lagler (1958), were made:

- Standard length - snout tip to notochord tip preceding development of caudal fin, then to end of hypural plate.
- Head length - snout tip to anterior edge of cleithrum where it meets posterior opercular edge (larvae) or to posteromost margin of opercular membrane (juveniles and adults).

Snout length - snout tip to anterior margin of orbit of left eye.

Snout to anus length - distance along body midline from snout tip to vertical through center of anus.

Eye diameter - greatest diameter of left eyeball.

Upper jaw length - snout tip to posterior margin of maxillary.

Depth at anus - vertical distance from base of dorsal finfold or fin to anus.

Depth behind anus - vertical distance from base of dorsal finfold or fin to base of ventral finfold or fin immediately behind anus at the angle where body depth decreases greatly (larvae) or where body depth is greatest (juveniles and adults).

Peduncle depth - least depth of caudal peduncle (in larvae, body depth at posteromost myomere before formation of caudal fin).

Meristics

Meristic counts were made on 192 selected larvae of both species taken from the VIMS 1962 plankton collections. The larvae had been stained with Alizarin Red S by a method modified slightly from that described by Hollister (1934). Faded larvae were restained using Taylor's (1967) enzyme method. Counts were made of dorsal fin rays, anal fin rays, caudal fin rays, left and right pectoral fin rays, branchiostegal rays, vertebral centra, neural spines, and hemal spines. Fin rays and vertebrae were counted even if they were tinted only slightly with alizarin.

Meristic data on fin rays of adults of both species were obtained from specimens in VIMS collections. Fifty specimens of *E. microstomus* came from lower Chesapeake Bay in 1955, and 27 had been collected offshore from Wachapreague, Va., in 1965. Fifty-two specimens of *C. arctifrons* had been trawled near lat. 40°N in 1967, and 33 had been taken from approximately lat. 36°N in 1966. Fifty adults of each species were x-rayed for vertebral counts. Half of these specimens came from lat. 36°N and half from lat. 38°N, an area encompassing that of the VIMS larval collections. For comparison, additional meristic data were gathered from the literature (Gutherz, 1967).

Illustrations

Illustrations were made with the aid of a camera lucida. Penciled halftones (Figures 2-8) show the external morphology of larval to adult stages. Line drawings of osteological features (Figures 9-11) were made from alizarin stained specimens.

The illustrations were made from specimens representative of general trends, as considerable variation may be found.

EGGS AND LARVAE OF OTHER SPECIES OF *ETROPUS* AND *CITHARICHTHYS*

Norman (1934) listed 6 species of *Etropus* and 14 species of *Citharichthys;* all but one are found along the Atlantic and Pacific coasts of North, Central, and South Americas. Very little has been published about early stages of any of these species.

Goode and Bean (1895) illustrated (Plate CIV, Figure 361) a larval stage (size not given) of what they thought to be *E. rimosus.* Hsiao (1940) illustrated a 6.5-mm larva and described larvae from 6.5 mm to 15 mm which he called *E. crossotus.* None of these larvae resemble those of *E. microstomus.* They more closely resemble those of *Bothus* sp. figured and described by Kyle (1913), Padoa (1956), Colton (1961), and Jutare (1962).

Kyle (1913) illustrated two larvae labelled *?Citharichthys* sp. A and *?Citharichthys* sp. B. Pigmentation on Kyle's *Citharichthys* A is similar to that of *Paralichthys dentatus* (Smith and Fahay, 1970; Plates 9, 10); fin ray and vertebral counts of *Citharichthys* A are within the range for this species and agree with no other North Atlantic species of *Paralichthys* (Gutherz, 1967). Kyle's *Citharichthys* B were collected in the northwestern part of the Gulf Stream (lat. 42°12'N, long. 62°15'W). Vertebral counts (plus urostyle) and fin ray counts of Kyle's *Citharichthys* B lie within the range for *C. arctifrons* (Gutherz, 1967); however, Kyle's illustrated specimen closely resembles the 10.6-mm SL larva of *E. microstomus* figured here (see Figure 4A) in pigmentation, stage of development, and mouth size. Kyle's specimens are probably *Citharichthys* or *Etropus* as Gutherz (1970) suggests, but lack of knowledge of larval bothids prevents identification.

Ahlstrom (1965) figured several stages of *C. stigmaeus*, *C. sordidus*, and *C. xanthostigma*. However, he provided only a small amount of descriptive information on the larvae of these species together with larvae of *C. fragilis* and *C. gilberti*.

VERIFICATION OF IDENTIFICATION OF LARVAL *E. MICROSTOMUS* AND *C. ARCTIFRONS*

The larvae of *E. microstomus* and *C. arctifrons* were identified using the series method of Schmidt (1905). Developmental series of larvae of each of two distinguishable but similar flatfishes were taken from VIMS collections made in the Chesapeake Bight. Larvae in each series were linked together primarily by pigment patterns and meristics. Migration of the right rather than the left eye in the largest specimens indicated they were members of the Scophthalmidae or Bothidae rather than the Pleuronectidae. VIMS records of adult sinestral flatfishes other than cynoglossids taken in the Chesapeake Bight (Table 1) listed one scophthalmid and seven bothids. Descriptions of larvae of *Scophthalmus aquosus* (Moore, 1947), *Bothus ocellatus* (Colton, 1961; Jutare, 1962), *Hippoglossina oblonga* (Agassiz and Whitman, 1885; Miller and Marak, 1962; Leonard, 1971b), *Paralichthys dentatus* (Deubler, 1958; Smith and Fahay, 1970) revealed differences from the larvae in question.

The unknown larvae were the most numerous flatfishes collected by VIMS in the Chesapeake Bight from 1959 to 1963. The great numbers of larvae in each series comprised large size ranges which indicated they were progeny of adults of two species which also should be fairly abundant in the same area. *E. microstomus* and *C. arctifrons*, constituting well over half of the total number of bothid and scophthalmid flatfishes taken in spring and summer of 1966 (Table 2), were prime candidates; other possible candidates, *C. macrops* or *E. crossotus*, occur only rarely in the bight.

Most of the unknown larvae were collected between July and October and were assumed to be products of summer spawnings. We have obtained gravid *E. microstomus* in July and August and *C. arctifrons* in August and September from the Chesapeake Bight.

Dorsal and anal fin ray and vertebral counts (Table 1) of the largest larvae in each series correspond to those of adult *E. microstomus* and *C. arctifrons*.

TABLE 1.—Abundance, spawning season, and meristics of adult bothid and scophthalmid flatfishes which occur in the Chesapeake Bight.[1]

Species	Relative abundance	Spawming season	Dorsal fin rays	Anal fin rays	Vertebrae	
					Abdominal	Caudal
Etropus microstomus	Numerous	Summer	67-82 [2](72-$\overline{76}$-84)	50-63 [2](54-$\overline{57}$-62)	[2]10	[2]24-35
Citharichthys arctifrons	Numerous	Summer	75-86 [2](75-$\overline{81}$-87)	58-67 [2](60-$\overline{65}$-71)	[2]10-11	[2]26-28
Bothus ocellatus	Rare	Summer	76-91	58-68	10	25-27
Citharichthys macrops	Very rare	Unknown	·80-85	56-64	10	24-25
Etropus crossotus	Rare	Summer	75-87	58-68	10	25
Hippoglossina oblonga	Numerous	Summer	71-86	58-72	11	30-31
Paralichthys dentatus	Numerous	Fall and winter	80-96	61-74	11	30-31
Scophthalmus aquosus	Numerous	Summer	63-71	46-55	11	23-25

[1] Compiled from Jordan and Evermann, 1898; Parr, 1931; Norman, 1934; Moore, 1947; Ginsburg, 1952; Bigelow and Schroeder, 1953; Deubler, 1958; Colton, 1961; Jutare, 1962; Gutherz, 1967.
[2] *Data from studies conducted at the Virginia Institute of Marine Science.*

TABLE 2.—Total numbers of adult *Etropus microstomus* and *Citharichthys arctifrons* (and percentage of these two species combined in parentheses) compared with total numbers of bothids and scophthalmids and all flatfishes collected in the Chesapeake Bight during 1966.[1]

Species	February and March		May		August and September		November	
Bothidae and Scophthalmidae:								
Etropus microstomus	52		29		36		141	
Citharichthys arctifrons	103		1,146		230		100	
Subtotal	155		1,175		266		241	
Hippoglossina oblonga	286		148		71		191	
Paralichthys dentatus	145		46		41		111	
Scophthalmus aquosus	38		119		41		90	
Total Bothidae and Scophthalmidae		624 (24.8%)		1,488 (79.0%)		419 (63.5%)		633 (38.1%)
Pleuronectidae:								
Glyptocephalus cynoglossus	7		3		2		0	
Limanda ferruginea	17		17		33		35	
Pseudopleuronectes americanus	29		440		98		272	
Soleidae:								
Trinectes maculatus	0		0		11		2	
Cynoglossidae:								
Symphurus plagiusa	0		0		2		0	
Total Pleuronectidae, Soleidae, and Cynoglossidae		53		460		146		309
Grand total flatfishes		677 (22.9%)		1,948 (60.3%)		565 (47.1%)		942 (25.6%)

[1] From Virginia Institute of Marine Science trawl data.

DISTINGUISHING FEATURES OF *E. MICROSTOMUS* AND *C. ARCTIFRONS* LARVAE

Characters useful in distinguishing and separating larvae of *E. microstomus* and *C. arctifrons* taken in the Chesapeake Bight are listed in Table 3. Larvae <4 mm are most easily separated by the presence of preopercular spines in *E. microstomus*. Larvae >4 mm are best separated by pigment patterns (*C. arctifrons* has less pigment in general than *E. microstomus*) and the presence of three elongated anterior dorsal fin rays in *C. arctifrons*.

The number of myomeres, which usually corresponds to the number of vertebrae, is frequently a valuable character for identification of larvae. In this study, myomeres were usually impossible to count on specimens <4 mm because the segments, especially those on the most anterior and posterior parts of the body, were indistinct. The same was true of many larger specimens. When accurate counts were possible, the number was always less than vertebral numbers, i.e., *E. microstomus*—31-33 myomeres (34-35 vertebrae) and *C. arctifrons*—34-35 myomeres (36-39 vertebrae). Specimens selected for illustration were the best representatives and all had rather well-defined myomeres. Myomeres are still visible in juveniles of 40 mm (see Figure 7) mainly because of the deciduous nature of the scales. However, scales or scale pockets, particularly in the anterior abdominal region, tend to obscure them.

EGGS AND YOLK SAC LARVAE OF *E. MICROSTOMUS* AND *C. ARCTIFRONS*

Eggs of *E. microstomus* and *C. arctifrons* have not yet been identified in plankton samples. Attempts to strip, fertilize, and rear eggs of both species have been unsuccessful.

None of the ovaries examined of several hundred mature specimens of *E. microstomus* was running ripe. Eggs taken from the ripest ovaries were still hard, opaque, and quite small. They were approximately spherical with no apparent oil globule. Eggs stripped from *C. arctifrons* which were approaching spawning condition were pliable and almost transparent. They were spherical to slightly ovoid, with a

TABLE 3.—Distinguishing features of larvae of *Etropus microstomus* and *Citharichthys arctifrons* from the Chesapeake Bight.[1]

Character	*Etropus microstomus*	*Citharichthys arctifrons*
Pigmentation:		
Head	Internal spot below hindbrain (8 mm).	No.
	Stellate melanophore on operculum (10-11 mm).	No.
Abdomen	1-2 stellate melanophores on pectoral fin.	No.
	Internal spots along notochord (4 mm).	No.
Tail	3 postanal horizontal bars (3-4 mm).	Similar (4-5 mm).
	Internal spots along length of notochord (4 mm).	Internal spots along notochord only in region of postanal bar (5 mm).
	2 prominent ventral clusters between anus and postanal bars (4 mm).	No.
Morphology:		
Size at metamorphosis	10-12 mm.	13-15 mm.
Preopercular spines	Prominent from 2.5-8 mm, disappear by 10 mm.	None.
Elongated fin rays	None.	3 elongated anterior dorsal rays (4-5 mm to 11-12 mm).
Body depth	Depth at anus/SL and depth behind anus/SL usually greater for *E. microstomus* than *C. arctifrons* of equal size. Depth behind anus/depth at anus related to SL greater for *E. microstomus* than *C. arctifrons* of equal size (8 mm).	
Meristics:		
Anal fin rays	Usually <60 (8 mm)	Usually >60 (10 mm).
Vertebrae	10 abdominal	10-11 abdominal.
	24-25 caudal (9 mm) including urostyle	26-28 caudal (10 mm) including urostyle.

[1] Sizes in parentheses indicate size at which the character is attained.

deviation of ± 0.04 mm between major and minor axes. The eggs had a smooth surface; no oil globule was apparent although most bothid eggs have a small one. Diameters of these *C. arctifrons* eggs ranged from 0.70 to 0.82 mm ($\bar{X}$ = 0.74 mm). Diameters of fertilized eggs may differ.

The smallest larvae examined of both species were 2.3 mm. At that size, a small amount of yolk material is still present. These larvae are similar in appearance to the 2.5-mm larvae (Figure 2) described in the next section. No additional information is available on earlier stages. Because larvae of the two species are comparable in size (under 5 mm) and developmental stage, they probably hatch at about the same size, estimated to be about 2 mm.

DEVELOPMENT OF *E. MICROSTOMUS* AND *C. ARCTIFRONS* - LARVAE TO ADULTS

Descriptions of the development of *E. microstomus* and *C. arctifrons* are patterned after workers who followed the dynamic approach, e.g., Ahlstrom and Ball (1954), Ahlstrom and Counts (1955, 1958), Kramer (1960), Moser and Ahlstrom (1970), and others. Three major aspects of development are discussed: pigmentation changes, morphological changes, and osteological changes. Descriptions are based primarily on the left (eyed) side. A length designation of 4 mm implies a range of values from 4.0 to 4.9 mm. The term metamorphosis is used to describe the period of eye migration until the right eye rests in its final position on the left side of the head. The term larva is used to define all stages from yolk sac absorption until all fins are formed after completion of metamorphosis. The term juvenile refers to all stages from completion of fin formation to adult. Comparative development is followed through to the adult stage.

Pigmentation Changes

Changes in pigmentation of *E. microstomus* and *C. arctifrons* are described as they occur throughout development in three body regions: head, abdominal, and tail.

E. microstomus - Head Region

The eyes of the smallest specimens examined (2.3 mm) are pigmented. The head of early stage larvae, 2-3 mm, is marked by a few melanophores scattered along the lower jaw and on the ventral body margin from the angle of the lower jaw to the cleithrum (Figure 2A). The concentration of ventral pigment increases with age to about 8-9 mm (Figure 3) and then decreases (Figure 4), although it may vary considerably among individuals. A group of melanophores is usually noticeable on the posteroventral angle of the lower jaw and sometimes at the tip of the cleithrum in larvae over 3 mm (Figures 3, 4). Melanophores occur over the hindbrain and midbrain singly or in groups in larvae from 3.5 mm up to metamorphosis (Figures 3, 4). Larvae over 8 mm have additional scattered melanophores around the snout and upper jaw and on the operculum. An internal pigment spot may be seen beneath the lobe of the hindbrain by about 8 mm (Figure 3D). A single stellate melanophore appears on the operculum anterior to the base of the pectoral fin at about 10-11 mm (Figure 4A, B).

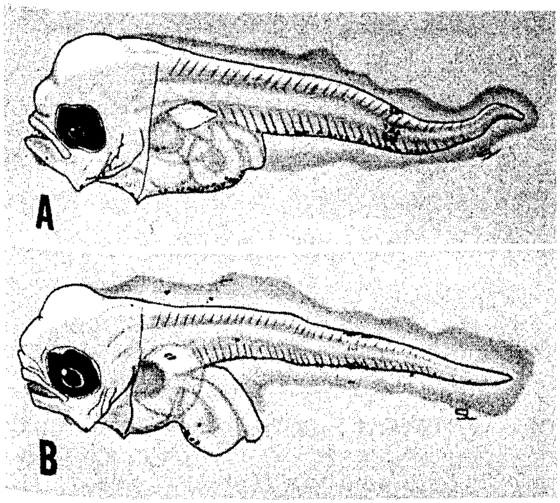

FIGURE 2.—Early stage larvae of A) *Etropus microstomus* (2.5 mm SL) and B) *Citharichthys arctifrons* (2.5 mm SL).

After metamorphosis and with scale formation, head pigmentation becomes less pronounced. A general darkening occurs on the lips and over the brain (see Figure 7A). Later the snout darkens and pigmentation increases on the operculum.

E. microstomus - Abdominal Region

Most conspicuous is the pigmentation, which persists until metamorphosis, on the gas bladder (Figures 2A, 3). This pigment area spreads out onto the hindgut with the disappearance of the gas bladder (Figure 4B, C). Melanophores line the ventral body margin from the cleithrum to the hindgut in early stage larvae (Figure 2A). After the pelvic fin begins to form (5-7 mm), melanophores no longer line the ventral body margin at the base of the fin but increase in concentration under the gut (Figures 3D, 4A). Several diffuse melanophores, the number increasing with age, appear over the end of the hindgut at about 3 mm (Figure 3A). One or two stellate melanophores are visible on the pectoral fin near its ventral origin throughout the larval period. Scattered melanophores appear on the distal margin of the pelvic fin after it forms. Two or three characteristic internal pigment spots appear along the dorsal surface of the notochord above the gut cavity at about 4 mm and remain until metamorphosis. A pigment spot appears on the dorsal body margin above the gut cavity at about 3 mm (Figure 3A). It persists until metamorphosis, although later it is located on the proximal margin of the interneural musculature (Figure 4A, B). As the larva approaches metamorphosis, pigmentation appears and increases along the myosepta of the body (Figure 4B, C).

After metamorphosis, the gut cavity becomes darkened on the eyed side. Pigmentation increases on the pectoral and pelvic fins (Figures 7A, 8A). Pigmentation along myosepta disappears on the body but increases on the interneural and interhemal regions in juveniles.

E. microstomus - Tail Region

Larvae of 2.3 mm have a band of pigment about two-thirds the distance from the anus to

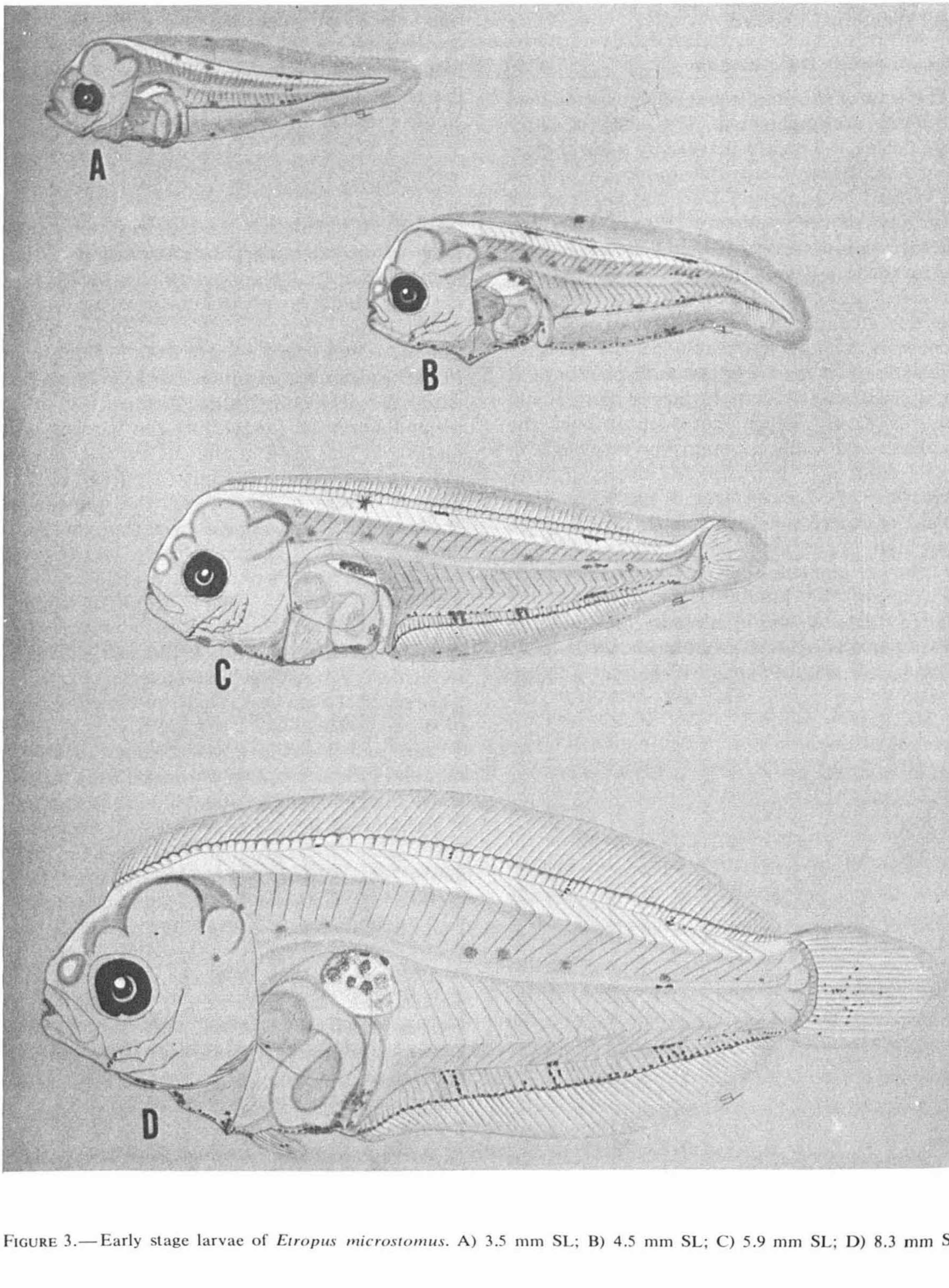

FIGURE 3.—Early stage larvae of *Etropus microstomus*. A) 3.5 mm SL; B) 4.5 mm SL; C) 5.9 mm SL; D) 8.3 mm SL.

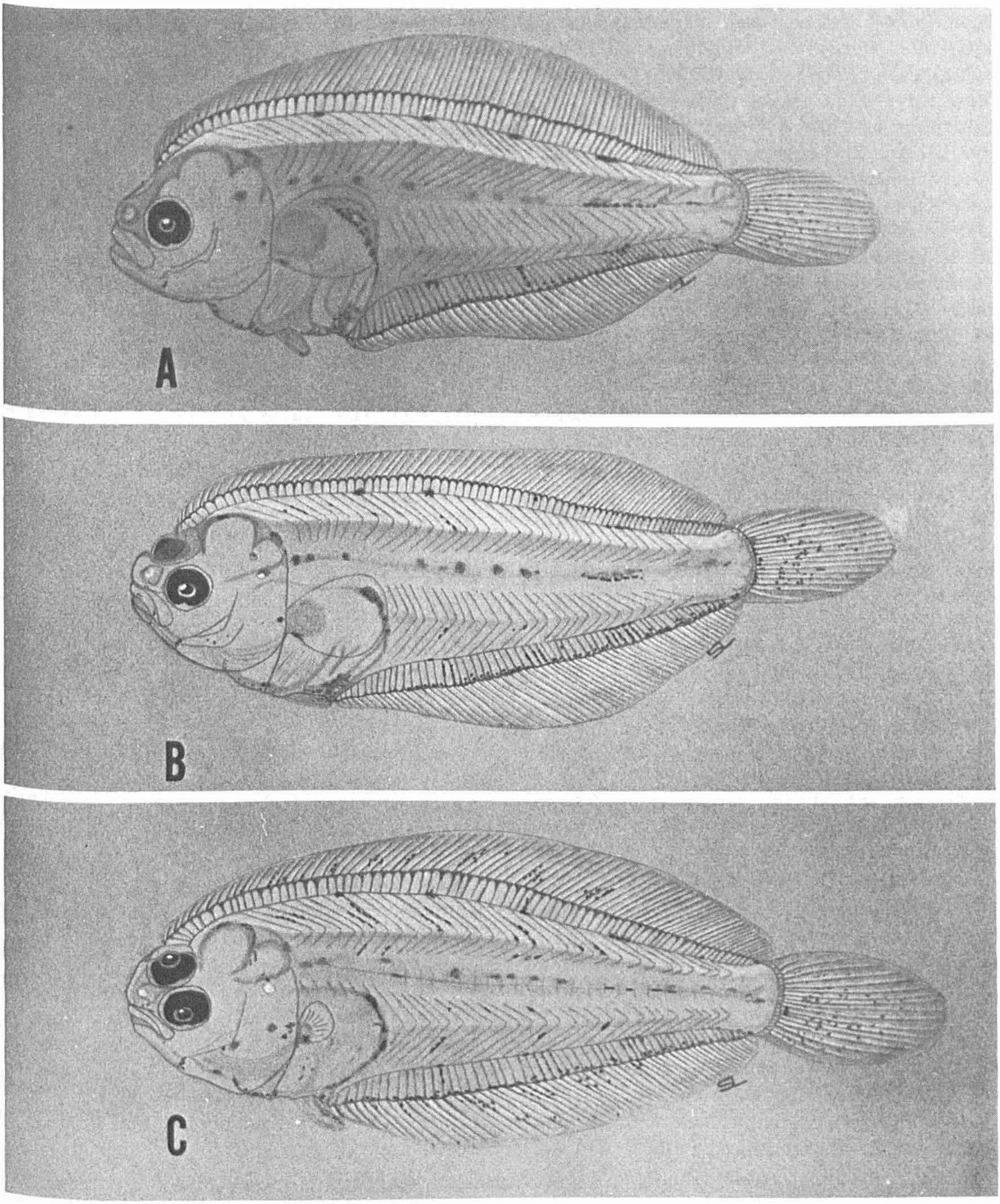

FIGURE 4.—Late stage larvae of *Etropus microstomus*. A) 10.6 mm SL; B) 10.9 mm SL (early transformation); C) 11.4 mm SL (late transformation).

the notochord tip (Figure 2A). By about 3 mm, sometimes before, this band differentiates to become two horizontal lines of pigment on the dorsal and ventral body margin, and a third line appears along the notochord (Figure 3A). These three lines persist until metamorphosis. Melanophores line the ventral body margin from the gut to the notochord tip on the smallest specimens (Figure 2A). As development proceeds, this ventral pigmentation shifts from its original position to the distal margin of the interhemal musculature (Figure 3C, D). One prominent ventral pigment spot appears in larvae of about 3 mm (Figure 3A), one-third the distance from the hindgut to the postanal pigment bars. A second prominent ventral spot appears by about 4 mm (Figure 3B), halfway between the first spot and the postanal bars. At the location of these two ventral pigment spots and the ventral postanal pigment bar, melanophores form several vertical lines along the septa of the interhemal musculature from proximal to distal margin (Figure 3C, D), beginning at about 5 mm. These vertical pigment lines persist until metamorphosis (Figure 4).

By about 4 mm, characteristic internal pigment spots begin to appear along the dorsal margin of the notochord from the abdominal region to the tail. These spots number 3 to 5 at first and may increase to about 8 to 10 by metamorphosis (Figure 4C).

Along the dorsal body margin one prominent pigment spot appears at about 3 mm (Figure 3A), and another by about 6-7 mm (Figure 3D) between the gut cavity and the tail tip, opposite those on the ventral margin. Up to metamorphosis these spots may appear as a cluster of melanophores (Figure 3A), a horizontal line (Figure 3C), or vertical line (Figure 3D), extending onto the interneural musculature. An increase in pigmentation occurs along the myosepta on the eyed side as the larva begins to metamorphose (Figure 4B, C).

One to three prominent melanophores may be seen on the distal edges of the finfold dorsally and ventrally (Figure 3A, B), on larvae up to about 5 mm. Scattered melanophores of less prominence may be seen in some specimens, depending on state of preservation, along the ventral finfold from the anus to the three postanal pigment bars (Figure 3B). These melanophores disappear with fin formation at about 6-8 mm. When the urostyle turns upward and the caudal fin begins to form at about 5-6 mm, scattered melanophores appear along its base (Figure 3C). Later, melanophores become scattered throughout the caudal fin and sometimes delineate its base (Figure 4B). Melanophores begin to dot both dorsal and anal fins at about metamorphosis (11-12 mm), first appearing in groups (Figure 4C) and later scattered throughout.

After metamorphosis, concentrated blotches of pigment become prominent along the proximal portions of the dorsal and anal fins (Figures 7A, 8A). The caudal fin base is delineated by pigment. An increase in pigmentation occurs along interneural and interhemal myosepta and along the lateral line. In adults, this pigment is partially obscured by scales. Pigment along body myomeres tends to disappear, but scale pockets are outlined with pigment which accounts for the general darkening of the eyed side. In females, an increase in pigmentation occurs over the ovarian cavity.

C. arctifrons - Head Region

The eyes are heavily pigmented by 2.3 mm. Early stage larvae of 2-5 mm (Figures 2B; 5A, B, C) have melanophores scattered along the ventral body margin from the angle of the lower jaw to the cleithrum. This pigment becomes less conspicuous with age (Figure 6). Clusters of melanophores are usually noticeable on the posteroventral angle of the lower jaw and at the tip of the cleithrum from about 5 mm throughout larval development. Pigment begins to appear over the brain at about 6-7 mm. At metamorphosis, the amount of pigment increases on the head (Figure 6C). Concentrations of melanophores develop on the tips of the three elongated anterior dorsal fin rays at about 8 mm (Figures 5D, 6A).

After metamorphosis, a general darkening occurs over the brain, on the lips (Figure 7B) and later over the operculum (Figure 8B).

C. arctifrons - Abdominal Region

A heavy concentration of pigment occurs over the gas bladder in larvae of 2.5 mm (Figure 2B) and persist until metamorphosis. Additional melanophores appear over the dorsal surface of the hindgut beginning at about 4 mm (Figure 5B). Scattered melanophores occur along the ventral body margin from the cleithrum to the hindgut. When the pelvic fin forms (5-7 mm), this pigment becomes less concentrated at its base. The concentration of pigment over the ventral part of the gut cavity increases with age (Figure 5C, D), and several diffuse melanophores appear near the end of the hindgut by 8-10 mm (Figures 5D; 6A, B). Pigment becomes noticeable on the tip of the pelvic fin by about 5-6 mm (Figure 5C, D). As the larva approaches metamorphosis, one to three prominent pigment spots appear along the proximal margin of the interneural musculature (Figure 6B, C). After these spots appear, a general increase in pigmentation occurs along the myosepta of the body (Figure 6B, C) on the eyed side.

Pigmentation over the gut cavity increases greatly after metamorphosis (Figure 7B) and the pectoral and pelvic fins become dotted with melanophores. The amount of pigment lining myosepta tends to decrease on the body and increase in the interneural and interhemal regions.

C. arctifrons - Tail Region

Larvae of 2-3 mm may have a postanal band of pigment, which becomes a dorsal and anal bar of pigment (Figures 2B, 5A), on the body margins about two-thirds the distance from the anus to the notochord tip. A distinct horizontal pigment bar appears intermediate to the dorsal and anal bars by 4-5 mm (Figure 5C). The three postanal pigment bars remain until metamorphosis (Figure 6C).

Melanophores appear scattered along the ventral body margin from the hindgut to the tail tip at 2-3 mm (Figures 2B, 5A). This pigmentation shifts to the distal margin of the interhemal musculature as development proceeds (Figure 5D). By about 10-11 mm, two clusters of melanophores develop along the proximal margin of the interhemal musculature between the hindgut and the ventral horizontal pigment bar (Figure 6A, B). These clusters increase in prominence until metamorphosis (Figure 6C).

Internal pigment spots appear along the dorsal surface of the notochord immediately above the intermediate postanal pigment bar by about 5 mm (Figure 5C). These internal spots remain apparent until metamorphosis.

Along the proximal margin of the interneural musculature, several (usually three) clusters of pigment become prominent by 12-13 mm, two between the abdominal region and the dorsal postanal pigment bar and one posterior to the dorsal bar (Figure 6B, C). After the appearance of the dorsal and anal pigment clusters, as metamorphosis proceeds, pigmentation increases along the myosepta of the body on the eyed side (Figure 6C).

Scattered pigment may occur on the finfold from 2 to 4 mm, but in no set pattern (Figures 2B; 5A, B). Melanophores begin to delineate the base of the caudal fin by about 10 mm (Figure 6A) and later appear scattered over the fin (Figure 6C). Pigmentation appears on the dorsal and anal fins, first in clusters (Figure 6C) and then scattered throughout, as the larva nears the completion of metamorphosis at around 14 mm.

After metamorphosis, pigmentation becomes less pronounced along the body myomeres but increases along the septa of the interneural and interhemal musculature (Figure 7B). Pigmentation appears along the lateral line on both eyed and blind sides. In females, pigmentation increases over the ovarian cavity. In adults, the most prominent pigmentation is that of the scale pockets which results in a general darkening of the eyed side (Figure 8B).

Comparative Morphological Changes

Nonmorphometric changes are described for both species together as they are quite similar. Differences are noted.

Body shape of the earliest stage larvae of both species is characteristic of flatfishes. The head and abdominal region are deep and later-

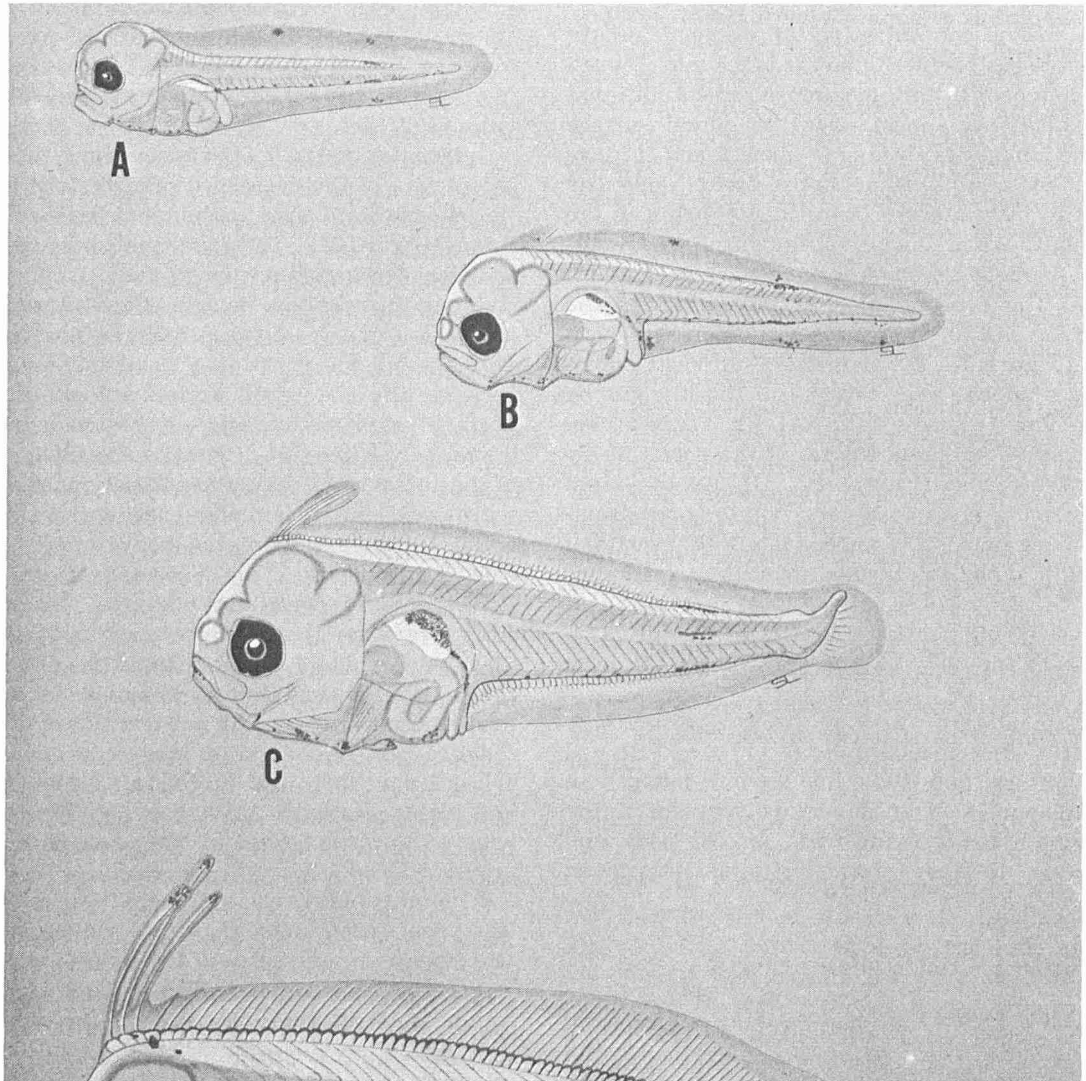

FIGURE 5.—Early stage larvae of *Citharichthys arctifrons*. A) 3.5 mm SL; B) 4.5 mm SL; C) 5.9 mm SL; D) 8.3 mm SL.

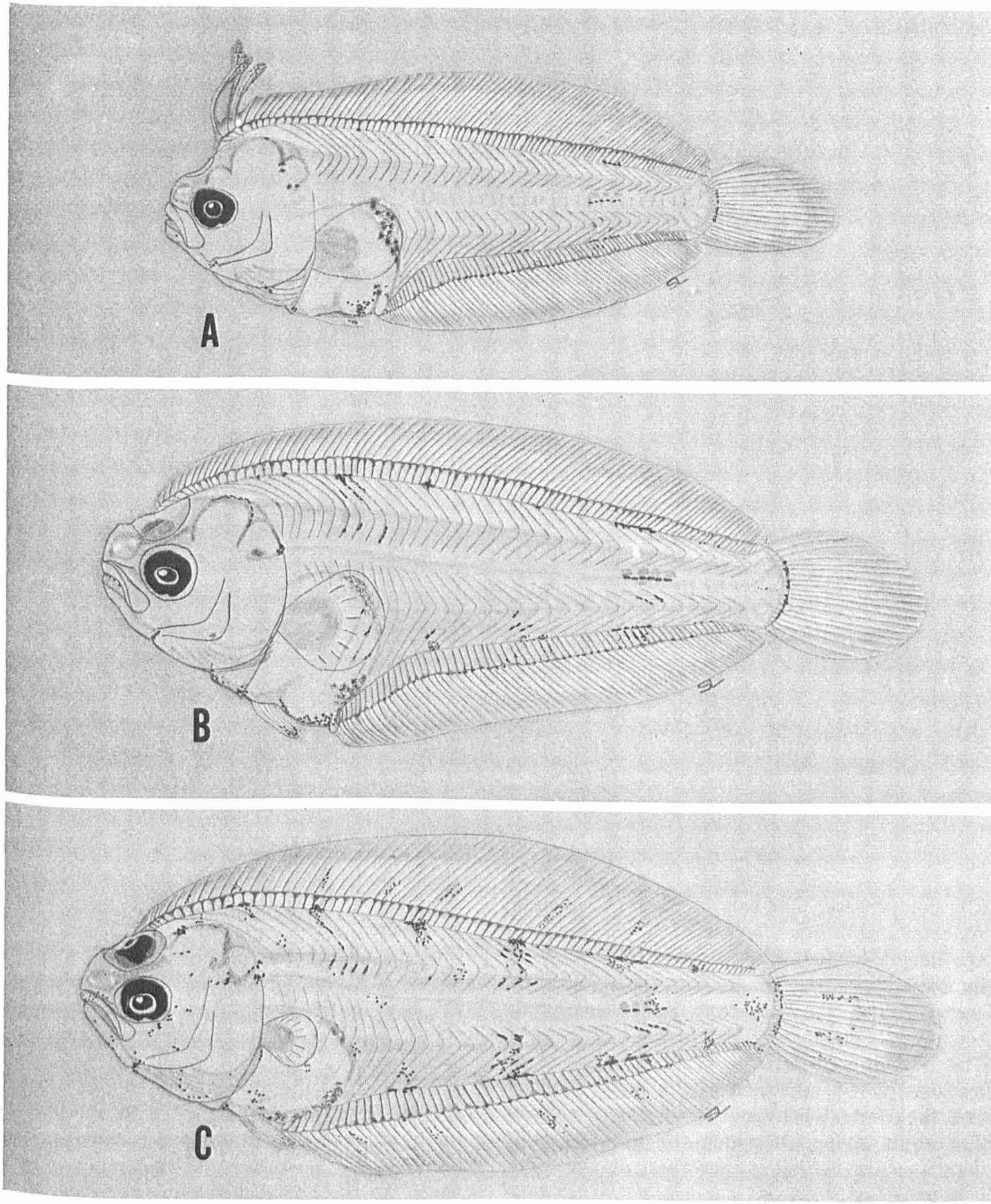

FIGURE 6.—Late stage larvae of *Citharichthys arctifrons*. A) 11.2 mm SL; B) 13.8 mm SL (soon before transformation); C) 14.4 mm SL (transformation).

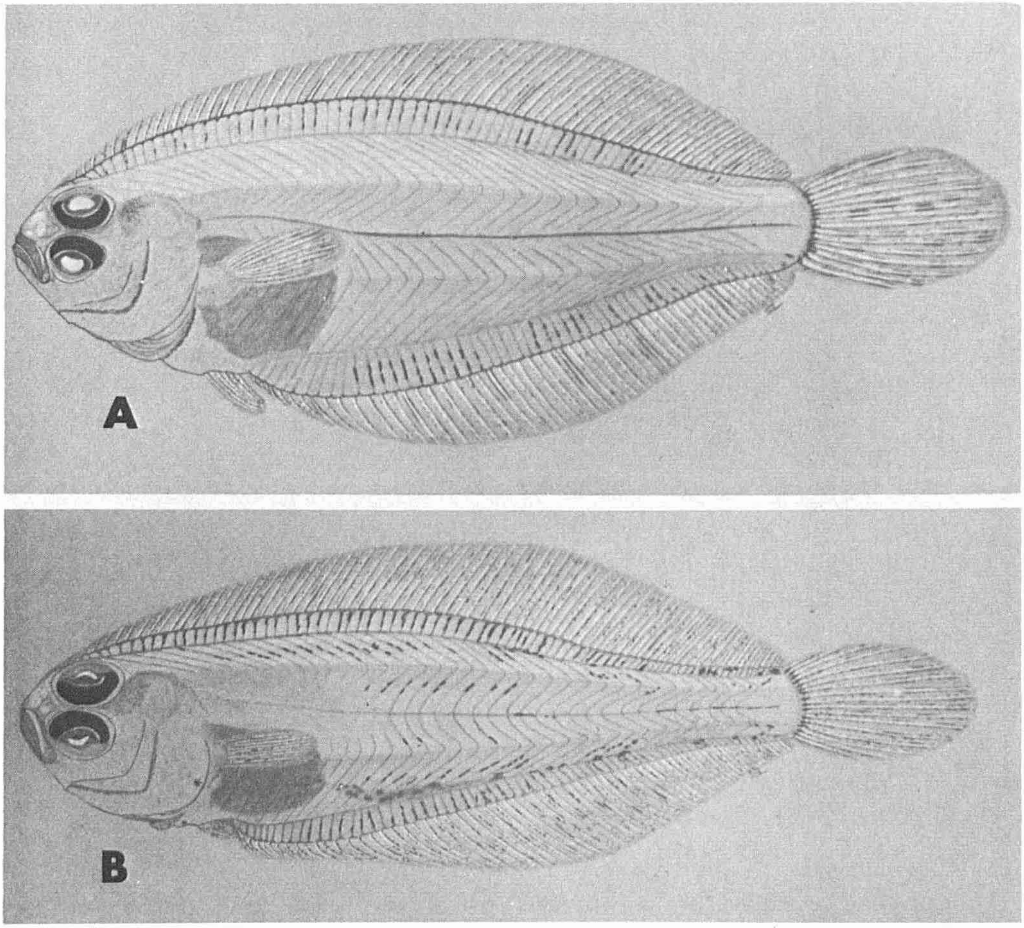

FIGURE 7.—Juvenile stages of A) *Etropus microstomus* (41 mm SL) and B) *Citharichthys arctifrons* (40 mm SL).

ally compressed. The caudal region is slender. At comparable sizes, larvae of *E. microstomus* are deeper-bodied than those of *C. arctifrons* immediately posterior to the anus. With increasing age, the head and peritoneal cavity occupy proportionately less of the body length. The dorsal body outline becomes convex. As metamorphosis approaches, the body deepens, and the ventral body outline becomes convex. The adult shape, in which the greatest body depth occurs behind rather than at the anus, is approached.

The fore-, mid-, and hindbrain are distinctly outlined in 2.5-mm larvae of both species and remain so until metamorphosis. A nasal capsule is evident on the snout at about 3 mm in both species and remains prominent until metamorphosis. The left otolith becomes noticeable in the head on the eyed side of *E. microstomus* at about 10-11 mm. It is not observable in *C. arctifrons.*

The coils of the alimentary tract can be seen clearly in 2.5-mm larvae of both species with the hindgut ending in a nearly vertical position immediately posterior to the main visceral mass. As the larval development proceeds, the position of the anus shifts anteriorly until it rests adjacent to the base of the left pelvic fin

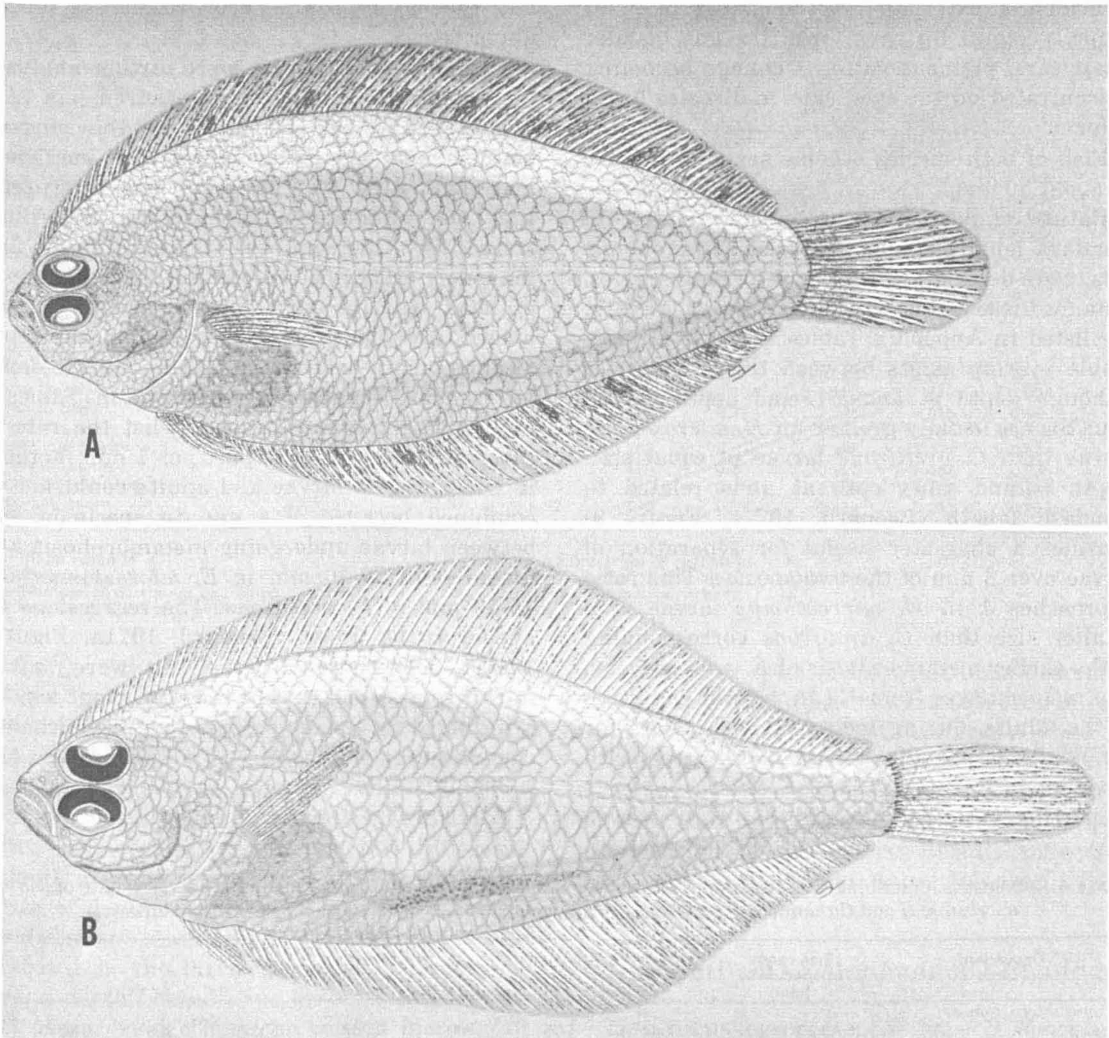

FIGURE 8.—Adult stages of A) *Etropus microstomus* (64 mm SL) and B) *Citharichthys arctifrons* (69 mm SL).

and lies beneath the center of the gut cavity. As metamorphosis approaches, the coils of the gut become obscured by overlying musculature.

Eye shape tends to be roughly spherical becoming more smoothly rounded with increasing age. A ventral cleft of the eye is apparent in larvae of both species from 3.0 mm up to metamorphosis.

The gas bladder is developed dorsal to the gut region in the smallest specimens of both species. It becomes increasingly prominent during larval development, but disappears during metamorphosis.

Metamorphosis occurs at 10-12 mm in *E. microstomus* and at 13-15 mm in *C. arctifrons*. Some variation was found in that a few specimens of *E. microstomus* were not transformed by 12 mm and some specimens of *C. arctifrons* had begun to do so at 12 mm. During metamorphosis, the right eye moves over the dorsal ridge of the head in front of the dorsal fin, the body deepens, the facial bones become distorted as evidenced externally by the change in snout shape, pectoral fin rays form, the gas bladder disappears, pigment patterns change becoming concentrated on the eyed side, and scales begin to form.

Fish of both species become sexually mature by about 50 mm.

Ratios of body measurements related to standard length, frequently used as taxonomic aids, were determined for larvae of both species. Data for these ratios, which change with growth, are listed in Appendix Tables 1 and 2. Considerable overlap exists between the two species although depth at anus/SL and depth behind anus/SL are usually greater for *E. microstomus* larvae than *C. arctifrons* larvae of equal size. Depth behind anus/depth at anus related to standard length (Leonard, 1971a, Figure 9) provides a character useful for separation of larvae over 8 mm of the two species. This ratio approaches 1 in *E. microstomus* larvae of a smaller size than *C. arctifrons* corresponding to the earlier metamorphosis of *E. microstomus*. The ratio changes from <1 to >1, the condition in the adults, during metamorphosis. Data for the adults (Appendix Tables 3, 4) agree with those given by Parr (1931). *E. microstomus* is proportionately deeper bodied than *C. arctifrons* but the latter has a proportionately longer upper jaw.

Changes in body form were further analyzed for growth patterns. Body measurements (Appendix Tables 1-4) were used for this purpose because methods using ratios "are inefficient and may often lead to erroneous interpretation" as explained by Marr (1955) and illustrated by Ahlstrom and Counts (1955) and Mansueti (1958). Statistics for the regressions of head length, snout length, snout to anus length, eye diameter, upper jaw length, depth at anus, depth behind anus, and peduncle depth on standard length are presented in Tables 4 and 5. The columns headed b list the rate of increase in size of body part per 1 mm increase in SL. Data on larvae and adults could not be combined because of a gap in specimen size between larvae undergoing metamorphosis and juveniles of 30-40 mm in *E. microstomus* and 40-50 mm in *C. arctifrons*. The regressions all appear to be linear (Leonard, 1971a, Figures 10-17). Correlation coefficients were >0.93 for all regressions except those of snout length, eye diameter, and upper jaw length which had correlation coefficients >0.87 in larvae and >0.80 in adults.

All body parts measured increase more in

TABLE 4.—Statistics describing the regressions of body measurements on standard length for larval stages of *Etropus microstomus* and *Citharichthys arctifrons*. The independent variable X is standard length in all cases.

Dependent variable Y	Size range of specimens (mm)	$\bar{X}$	$\bar{Y}$	N	b	a	S_y	r
Etropus microstomus:								
Head length	3.53-12.60	7.44	1.95	100	0.267	-0.039	0.208	0.987
Snout length	3.53-12.60	7.44	0.47	100	0.068	-0.040	0.155	0.895
Snout to anus	3.53-12.60	7.44	2.93	100	0.321	0.538	0.428	0.960
Eye diameter	3.53-12.60	7.44	0.49	100	0.048	0.127	0.127	0.875
Upper jaw length	3.53-12.60	7.44	0.66	100	0.076	0.096	0.178	0.890
Depth at anus	3.53-12.60	7.44	2.57	100	0.482	-1.017	0.450	0.980
Depth behind anus	3.53-12.60	7.44	2.08	100	0.481	-1.498	0.418	0.982
Peduncle depth	3.53-12.60	7.44	0.76	100	0.162	-0.441	0.244	0.950
Citharichthys arctifrons:								
Head length	4.54-14.36	7.55	2.06	100	0.304	-0.236	0.275	0.984
Snout length	4.54-14.36	7.55	0.51	100	0.080	-0.098	0.155	0.931
Snout to anus	4.54-14.36	7.55	3.10	100	0.378	0.248	0.605	0.974
Eye diameter	4.54-14.36	7.55	0.55	100	0.063	0.072	0.084	0.954
Upper jaw length	4.54-14.36	7.55	0.77	100	0.099	0.028	0.095	0.933
Depth at anus	4.54-14.36	7.55	2.31	100	0.462	-1.177	0.152	0.991
Depth behind anus	4.54-14.36	7.55	1.69	100	0.403	-1.352	0.260	0.991
Peduncle depth	4.54-14.36	7.55	0.68	100	0.168	-0.591	0.236	0.962

$\bar{X}$ - Mean value of X
$\bar{Y}$ - Mean value of Y
N - Number of specimens examined
b - Rate of increase of Y with respect to X
a - Y-intercept of regression line
S_y - Standard deviation of the regression
r - Correlation coefficient

TABLE 5.—Statistics describing the regressions of body measurements on standard length for juvenile and adult stages of *Etropus microstomus* and *Citharichthys arctifrons*. The independent variable X is standard length in all cases.

Dependent variable Y	Size range of specimens (mm)	$\overline{X}$	$\overline{Y}$	N	b	a	S_y	r
Etropus microstomus:								
Head length	29-123	73.70	17.13	100	0.200	2.388	1.592	0.972
Snout length	29-123	73.70	3.33	100	0.036	0.653	0.876	0.805
Snout to anus	29-123	73.70	17.13	100	0.200	2.388	1.592	0.972
Eye diameter	29-123	73.70	4.85	100	0.049	1.250	0.886	0.875
Upper jaw length	29-123	73.70	4.74	100	0.047	1.268	0.761	0.897
Depth at anus	29-123	73.70	26.37	100	0.378	-1.475	2.874	0.974
Depth behind anus	29-123	73.70	33.30	100	0.511	-4.350	2.937	0.977
Peduncle depth	29-123	73.70	8.35	100	0.114	-0.073	1.100	0.960
Citharichthys arctifrons:								
Head length	47-135	93.07	22.18	100	0.214	2.226	1.615	0.980
Snout length	47-135	93.07	4.29	100	0.034	1.102	0.779	0.852
Snout to anus	47-135	93.07	22.18	100	0.214	2.226	1.615	0.980
Eye diameter	47-135	93.07	7.18	100	0.063	1.283	1.193	0.891
Upper jaw length	47-135	93.07	7.19	100	0.046	2.895	1.130	0.834
Depth at anus	47-135	93.07	28.77	100	0.319	-0.925	2.652	0.976
Depth behind anus	47-135	93.07	34.63	100	0.439	-6.251	2.701	0.986
Peduncle depth	47-135	93.07	8.92	100	0.091	0.464	1.282	0.934

$\overline{X}$ - Mean value of X
$\overline{Y}$ - Mean value of Y
N - Number of specimens examined
b - Rate of increase of Y with respect to X
a - Y-intercept of regression line
S_y - Standard deviation of the regression
r - Correlation coefficient

relation to SL in *C. arctifrons* than in *E. microstomus* larvae except depth at anus and depth behind anus. Thus larval growth patterns support the fact that, as adults, *E. microstomus* is the deeper-bodied of the two, while *C. arctifrons* has larger eyes and a larger mouth.

In larvae of both species, the rate of increase of depth at anus is greater than the rate of increase of depth behind anus. Yet depth behind anus/depth at anus approaches and eventually exceeds 1 as the larvae undergo metamorphosis and depth behind anus becomes the deepest part of the body. Thus, the rate of increase of depth behind anus should be greater than depth at anus.

For juveniles and adults, head length, eye diameter, upper jaw length, and snout to anus length increase at a faster rate in *C. arctifrons* while all components of body depth (depth at anus, depth behind anus, peduncle depth) increase more rapidly in *E. microstomus*. Snout length in both species increases at about the same rate.

The data indicate decreases in rates of growth of head length, snout length, snout to anus length, upper jaw length, peduncle depth from larvae to adults of both species. Rate of growth of eye diameter is nearly the same in larvae and adults of both species. Depth at anus decreases and depth behind anus increases in growth rate from larvae to adults of both species.

Some degree of error exists in these calculations because of specimen shrinkage, wide area of collection, and varying lengths of time of preservation of specimens. Results presented here may differ from those obtained from newly preserved material.

Comparative Developmental Osteology

The discussion presented here is based entirely on stained material of approximately 100 larvae and of 10 juveniles and adults of each species. No dissections were made. The smallest stained larvae examined were 4 mm SL.

Sequences of ossification are consistent within each species, but the size at which specific bones begin to ossify may vary from specimen to specimen. The sizes given here indicate general trends of the larval specimens examined from VIMS 1962 collections.

This study is not intended to be a descriptive osteology of each species but rather a comparison of development of the two. Discussion of skull bones is mainly limited to those of the branchiocranium which are identifiable in early stages. Most bones of the neurocranium cannot be distinguished in stained larvae.

Terminology is based on Gregory (1933), Lagler, Bardach, and Miller (1962), Fraser (1968), and Wolcott, Beirne, and Hall (1968).

Fin Formation

A large finfold surrounds the body of early stage larvae from the head, around the tail tip, to the anus. The first fins to form are larval pectorals. Fin rays begin to ossify in larvae of 5-6 mm in dorsal, anal, caudal, and pelvic fins in both species (Table 6). Fin rays do not appear in the pectoral fins until metamorphosis. Fin formation in both species is completed in the following order: caudal, dorsal and anal, pelvic, and pectoral.

Incipient caudal fin rays become visible in the posteroventral region of the finfold as early as 4 mm in *E. microstomus*. Fin rays ossify after the urostyle begins to turn dorsad at about 5 mm in both species. The first rays to take up alizarin stain are in the center of the fin. Development proceeds dorsally and ventrally until the full complement of 17 caudal fin rays is attained by 7 mm in *E. microstomus* and 9 mm in *C. arctifrons*.

The proximal portions of incipient dorsal fin rays may appear in the center of the dorsal finfold as early as 4 mm in *E. microstomus*. Ossification of rays in the dorsal fin begins centrally at about 5 mm and proceeds anteriorly and posteriorly. The full complement is achieved by 8 mm. In *C. arctifrons*, a notch appears dorsally in the anterior portion of the finfold at about 4 mm. By 5 mm, three elongated fin rays become ossified in this region. These rays persist until the onset of metamorphosis, although they appear to get proportionately shorter with increasing age. Formation of the rest of the dorsal fin is smilar to that of *E. microstomus*. Ossification of fin rays begins centrally at about 6 mm and proceeds anteriorly and posteriorly. The full complement is attained by 10 mm. During dorsal fin formation in *C. arctifrons*, one fin ray appears anterior to the three elongated rays, which then become the 2d, 3d, and 4th rays. The 1st ray is inconspicuous and is best seen on the blind side. Only its base takes up alizarin stain until the three elongated anterior rays become reduced in size. With development, the dorsal fin moves progressively anteriorad in both species. As the right eye moves over the ridge

TABLE 6.—Ranges of meristic counts in early stages of *Etropus microstomus* and *Citharichthys arctifrons*.

Size group (mm)	Number of specimens	Dorsal fin rays	Anal fin rays	Caudal fin rays	Pelvic fin rays		Vertebral column					Branchiostegal rays (left)
							Neural spines		Hemal spines	Centra		
					Left	Right	Abdominal	Caudal	Caudal	Abdominal	Caudal + urostyle	
Etropus microstomus:												
4.00- 4.99	10	—	—	—	—	—	0-6	—	0-4	—	—	0-5
5.00- 5.99	15	0-60	0-40	0-15	0-3	LB[1]	0-9	0-22	0-23	0-9	0-1	5-7
6.00- 6.99	20	17-68	17-50	5-17	0-4	0-3	9-10	8-23	6-23	0-10	0-23	[1]7
7.00- 7.99	16	49-72	34-55	[2]17	2-4	2-5	9-10	16-23	13-23	8-10	2-25	7
8.00- 8.99	12	[2]68-80	[2]50-60	17	3-5	3-5	9-10	21-24	21-24	7-10	3-25	7
9.00- 9.99	10	72-83	55-62	17	4-6	4-6	[2]10	[2]23-24	[2]23-24	[2]10	[2]24-25	7
10.00-10.99	6	70-80	53-58	17	5-6	5-6	10	23-24	23-24	10	24-25	7
11.00-11.99	2	74	54	17	5-6	[2]6	10	23-24	23-24	10	24-25	7
12.00-12.99	7	77-79	58-60	17	[2]6	6	10	23-24	23-24	10	24-25	7
Citharichthys arctifrons:												
4.00- 4.99	6	—	—	—	—	—	—	—	—	—	—	0-3
5.00- 5.99	25	0-3	—	0-5	LB	LB	0-10	0-15	0-15	—	—	4-7
6.00- 6.99	23	3-68	0-52	6-17	0-3	0-4	3-10	9-26	3-26	—	0-1	[2]7
7.00- 7.99	12	45-74	31-57	9-17	2-4	3-4	9-10	19-25	23-25	0-10	0-27	7
8.00- 8.99	9	67-75	49-57	16-17	3-5	3-5	[2]10	23-25	23-25	6-10	1-26	7
9.00- 9.99	7	66-82	49-65	[2]17	3-5	3-5	10	[2]25-26	[2]25-26	[2]10	6-27	7
10.00-10.99	4	[2]82-83	[2]66-67	17	4-5	3-6	10	25-26	25-26	10	[2]27	7
11.00-11.99	5	77-81	62-66	17	4-6	5-6	10	25-27	25-26	10	26-28	7
12.00-12.99	3	77-82	64-66	17	5-6	[2]6	10	26	26	10	27	7

[1] Larval bud.
[2] Size range in which final or adult count is consistently achieved.

of the head, the anterior part of the fin is deflected to the blind side.

The anal fin forms similarly to the dorsal fin. Rays become ossified centrally first, with formation progressing both anteriorly and posteriorly. Ossified fin rays are evident by 5 mm in *E. microstomus* and 6 mm in *C. arctifrons.* The full complement of rays is achieved by 8 mm in *E. microstomus* and 10 mm in *C. arctifrons.*

Pelvic fin buds appear at 5 mm in both species. Ossification of fin rays begins from 5 to 6 mm in *E. microstomus* and at 6 mm in *C. arctifrons.* The right pelvic fin completes formation before the left fin. The full complement of six rays is consistently attained by 11-12 mm in *E. microstomus* and 12+ mm in *C. arctifrons* (Table 6). By about 8 mm in *E. microstomus* and 10 mm in *C. arctifrons,* the right pelvic fin base is located noticeably above the body midline on the blind side. Its origin is slightly anterior to that of the left pelvic fin base which is located on the body midline. These relative positions of pelvic fin bases become more obvious after the basipterygium ossifies (12 mm in *E. microstomus,* later in *C. arctifrons*) and are difficult to detect on unstained specimens until a larger size.

With metamorphosis, the larval pectoral fins transform to much smaller fins in relation to body size, as incipient fin rays form. The size at which pectoral fins are completely formed could not be determined because of a lack of specimens in the size range between those undergoing metamorphosis and juveniles of 20+ mm.

Vertebral Column and Median Fin Supports

Sequence of ossification of the vertebral column is the same for both species. Neural spines of the abdominal region ossify first, followed by neural and hemal spines of the caudal region. Development progresses posteriorily (Leonard, 1971a, Figure 18). Vertebral centra then begin to ossify in the posterior abdominal region with development progressing anteriorly. Centra of the caudal region ossify from anterior to posterior. The urostyle ossifies before the several centra immediately preceding it. The abdominal rod, which extends from the anteromost hemal spine to the position of the anus and supports the interhemal spines ventral to the gut cavity, begins to ossify before the elements of the hypural plate and after most centra are ossified. Ribs become evident on abdominal centra about the time the abdominal rod begins to ossify (7 mm for *E. microstomus* and 8-9 mm for *C. arctifrons*). Interneural and interhemal spines probably ossify near the completion of metamorphosis.

C. arctifrons generally lags behind *E. microstomus* in development (Table 6). Neural and hemal spines appear by 4 mm in *E. microstomus* and 5 mm in *C. arctifrons.* Centra may begin to ossify at 5 mm in *E. microstomus* and 6-7 mm in *C. arctifrons.* The adult vertebral complement, including neural and hemal spines and abdominal and caudal centra, is achieved by 9 mm in *E. microstomus.* Neural and hemal spines are all ossified by 9 mm in *C. arctifrons,* but not all centra are consistently stained until about 10 mm.

Structure of the vertebral column and dorsal, anal, and caudal fin supports is essentially the same in juveniles and adults of both species (Leonard, 1971a, Figures 19-21). The anterior interneural spines are inclined forward such that the first interneural spine, which is bifurcated (sometimes trifurcated in *C. arctifrons*), lies in a horizontal position. The abdominal rod, the distal portion of which is bifurcated, provides support for the 6-9 most anterior interhemal spines. The 17 rays of the caudal fin occur in a 4-5-4-4 sequence, supported by four hypural elements. Neural and hemal spines of the penultimate vertebra support no caudal fin rays.

Pectoral and Pelvic Girdles

The cleithrum (Leonard, 1971a, Figure 22) is ossified in the smallest stained specimens and observable as early as 2.3 mm in unstained larvae. The supracleithrum appears early in both species (Table 7). The posttemporal and postcleithrum ossify next, appearing first in *E. microstomus.* Ossification of the basipterygium (Figure 9) seems to coincide with achieve-

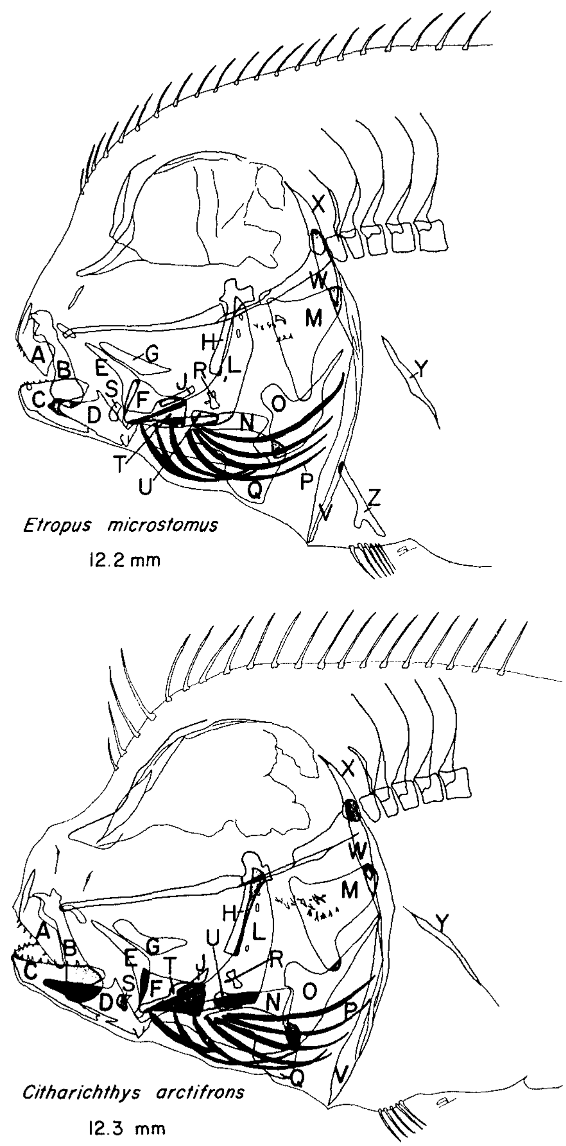

FIGURE 9.—Composite illustration of bones of the branchiocranium and of the pectoral and pelvic girdles (shaded) of young *Etropus microstomus* and *Citharichthys arctifrons*. The ossified part of the neurocranium including the parasphenoid is outlined. Upper and lower jaws: A - premaxillary, B - maxillary, C - dentary, D - articular and angular process. Oromandibular region: E - ectopterygoid, F - quadrate, G - endopterygoid, H - hyomandibular, J - symplectic. Opercular series: L - preopercle, M - opercle, N - interopercle, O - subopercle. Hypobranchial region: P - branchiostegal rays, Q - urohyal, R - interhyal, S - hypohyal, T - ceratohyal, U - epihyal. Pectoral and pelvic girdles: V - cleithrum, W - supracleithrum, X - posttemporal, Y - postcleithrum, Z - basipterygium.

TABLE 7.—Size in millimeters at which certain bones begin to ossify in *Etropus microstomus* and *Citharichthys arctifrons*.

Item	Bone[2] type	*Etropus microstomus*	*Citharichthys arctifrons*
Upper and lower jaws:			
A Premaxillary	D	?- 4.9	?- 4.9
B Maxillary	D	?- 4.9	?- 4.9
C Dentary	D	?- 4.9	?- 4.9
D Articular	C	?- 4.9	?- 4.9
Angular process	D	8.0- 8.9	7.0- 7.9
Oromandibular region:			
E Ectopterygoid	D	4.0- 5.9	4.0- 5.9
F Quadrate	C	5.0- 5.9	5.0- 6.9
G Endopterygoid	D	5.0- 6.9	6.0- 7.9
H Hyomandibular	C	5.0- 6.9	6.0- 7.9
J Symplectic	C	7.0- 7.9	8.0- 8.9
K Palatine	C	9.0- 9.9	11.0-11.9
K′ Metapterygoid	C	A M[3]	A M
Opercular series:			
L Preopercle	D	?- 4.9	?- 4.9
M Opercle	D	?- 4.9	?- 4.9
N Interopercle	D	5.0- 6.9	6.0- 7.9
O Subopercle	D	5.0- 6.9	6.0- 7.9
Hypobranchial region:			
P Branchiostegal rays	D	4.0- 5.9	4.0- 5.9
Q Urohyal	D	6.0- 6.9	7.0- 7.9
R Interhyal	C	7.0- 7.9	7.0- 7.9
S Hypohyals	C	7.0- 7.9	8.0- 8.9
T Ceratohyal	C	7.0- 7.9	8.0- 8.9
U Epihyal	C	7.0- 7.9	8.0- 8.9
U′ Basihyal	C	A M	A M
Pectoral and pelvic girdles:			
V Cleithrum	D	?- 4.9	?- 4.9
W Supracleithrum	D	4.0- 5.9	4.0- 5.9
X Posttemporal	D	5.0- 6.9	6.0- 7.9
Y Postcleithrum	D	5.0- 6.9	6.0- 7.9
Z Basipterygium	C	11.0-12.9	A M
Z′ Scapula	C	A M	A M
Z″ Coracoid	C	A M	A M
Z‴ Radials	C	A M	A M

[1] The smallest stained larvae examined were 4 mm.
[2] D - Dermal bone.
C - Cartilage replacement bone.
[3] A M - After metamorphosis.

ment of the adult complement of pelvic fin rays (Table 6) and possibly completion of metamorphosis—about 12 mm in *E. microstomus* and sometime before 16 mm in *C. arctifrons*. Time and sequence of ossification of the scapula, coracoid, and radials are unknown. They are ossified in juveniles of 40 mm. Ossification probably corresponds with pectoral fin formation.

Structurally, bones in these girdles are similar in both species. The posterior extension of the basipterygium on both sides is longer in juvenile and adult *E. microstomus* (Figures 10,11). The posttemporal of the eyed and blind side is relatively smaller in adult *C. arctifrons*.

Upper and Lower Jaws

By 4 mm, parts of the premaxillary, maxillary, dentary, and articular have begun to ossify in both species (Table 7). Development of the upper jaw (Leonard, 1971a, Figure 23) is similar to that described for other highly evolved forms of fishes (Berry, 1964). The toothless maxillary ossifies to a greater degree than the premaxillary in early stages and is included in the gape. As development proceeds, the premaxillary continues to grow posteriad and eventually eliminates the maxillary from the gape in *C. arctifrons* and nearly so in *E. microstomus* (Figures 9-11). Ossification of the jaw bones appears to be more advanced in *C. arctifrons* than in *E. microstomus* of equal size. This tendency is evident in the dentary and articular in *C. arctifrons* larvae of 4 mm. The angular process on the articular appears first in *C. arctifrons* (about 7 mm) and later (about 8 mm) in *E. microstomus.*

The fact that *C. arctifrons* has a larger jaw becomes evident by about 7 mm. The maxillary and premaxillary are longer than in *E. microstomus* and the processes of the dentary extend farther posteriorly. The anteromost process located laterally on the anterior knob of the maxillary becomes noticeably more elongate in *C. arctifrons* by about 12 mm (Figure 9). This maxillary process forms the osseous protuberance of the snout characteristic of adults (Figure 10). The premaxillary process, which occurs medially in the upper jaw, appears longer and narrower in *C. arctifrons* of about 12 mm, but not in juveniles and adults.

Teeth, distributed evenly in single rows on the left and right sides of the anterior portion of the premaxillary and dentary, are evident in the smallest stained larvae (in 3 mm unstained larvae) of both species. Teeth in adult *E. microstomus* are distributed mainly on the blind side (Figures 10, 11). This unequal distribution becomes apparent on the eyed side during metamorphosis (Figures 9, 10) as larval teeth are replaced. On the eyed side of juvenile and adult *E. microstomus*, teeth are more numerous on the lower jaw, e.g.:

	Upper jaw	*Lower jaw*
40 mm SL	7	13
60 mm SL	6	16

In juvenile and adult *C. arctifrons*, teeth on the eyed side are more numerous on the upper jaw, e.g.:

	Upper jaw	*Lower jaw*
40 mm SL	30	23
60 mm SL	40	25

Teeth on the blind side of the lower jaw are about equal in number to those of the upper jaw for each species. *C. arctifrons* has a greater total number of teeth corresponding to its larger mouth.

Oromandibular Region

The ectopterygoid is the first bone to ossify in this region, usually between 4 and 5 mm in both species (Leonard, 1971a, Figure 24). The quadrate, endopterygoid, hyomandibular, and symplectic become ossified in that order and at an earlier stage in *E. microstomus* than *C. arctifrons* (Table 7). By about 12 mm, degree of ossification of bones in this region is similar in both species (Figure 9). The palatine and metapterygoid become ossified sometime after metamorphosis (Figures 10, 11).

Structure of bones in this region is similar in the two species. The anterior wing of the hyomandibular extends farther ventrally along the central shaft of the bone in juvenile and adult *E. microstomus*, particularly on the eyed side.

Opercular Series

The opercle and preopercle are partly ossified in both species by 4 mm (Leonard, 1971a, Figure 25). The interopercle and subopercle ossify first in *E. microstomus* (Table 7) between 5 and 6 mm and by 7 mm in *C. arctifrons.*

Within this series, a major structural difference exists between larvae of these two species. Spines are present on the posterior preopercular margin of *E. microstomus* by 4 mm. (They may be seen on unstained larvae of 2.5 mm.) With development, the number of spines increases over the lateral surface of the preopercle. They begin to disappear at around 8 mm and can no longer be seen by 10 mm. *C. arctifrons* has no preopercular spines.

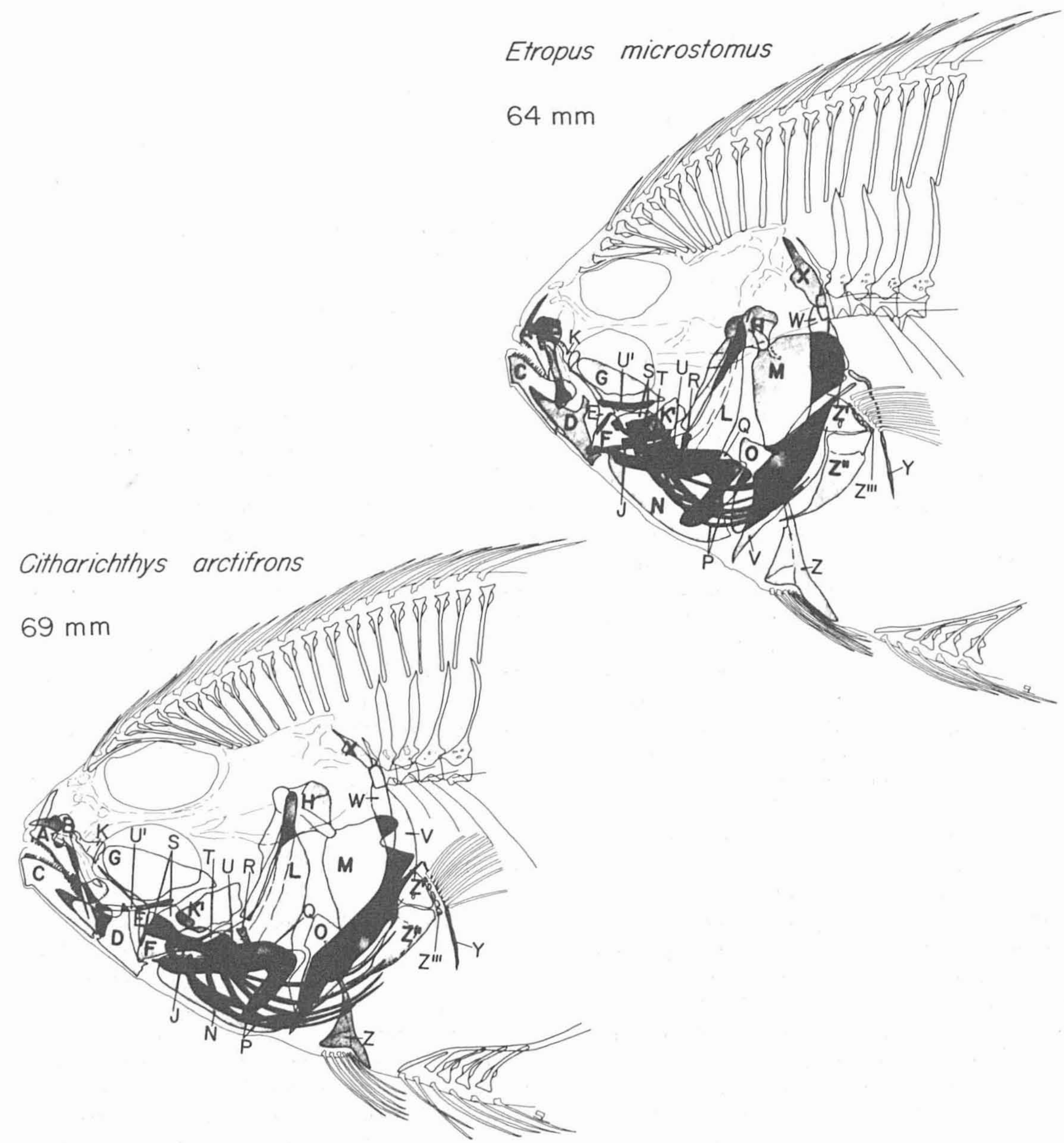

FIGURE 10.—Composite illustration of bones of the branchiocranium and of the pectoral and pelvic girdles (shaded) of the eyed side of adult *Etropus microstomus* and *Citharichthys arctifrons*. Upper and lower jaws: A - premaxillary, B - maxillary, C - dentary, D - articular and angular process. Oromandibular region: E - ectopterygoid, F - quadrate, G - endopterygoid, H - hyomandibular, J - symplectic, K - palatine, K' - metapterygoid. Opercular series: L - preopercle, M - opercle, N - interopercle, O - subopercle. Hypobranchial region: P - branchiostegal rays, Q - urohyal, R - interhyal, S - hypohyals, T - ceratohyal, U - epihyal, U' - basihyal. Pectoral and pelvic girdles: V - cleithrum, W - supracleithrum, X - posttemporal, Y - postcleithrum, Z - basipterygium, Z' - scapula, Z" - coracoid, Z''' - radials.

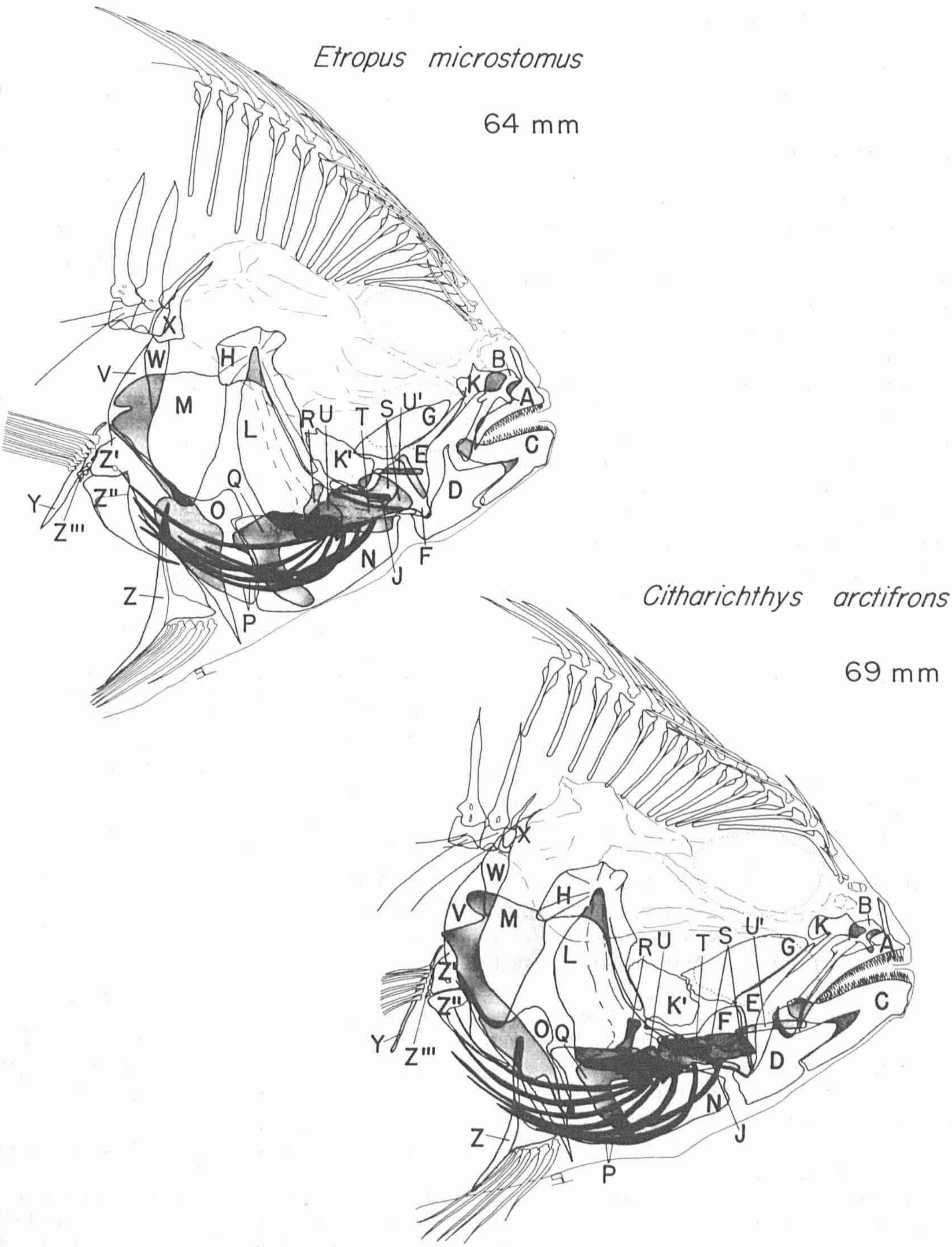

FIGURE 11.—Composite illustration of bones of the branchiocranium and of the pectoral and pelvic girdles (shaded) of the blind side of adult *Etropus microstomus* and *Citharichthys arctifrons*. See Figure 10 legend for the key.

The opercular bones in adults are structurally similar in both species except that the posterodorsal margin of the opercle may be more deeply indented in *C. arctifrons*.

Hypobranchial Region

Branchiostegal rays may become ossified by 4 mm in both species, although the total of seven may not be stained until 6 mm (Leonard, 1971a, Figure 26). The unpaired urohyal, which lies beneath the branchiostegals, ossifies at around 6 mm in *E. microstomus* and 7 mm in *C. arctifrons*. The interhyal is next, followed by the hypohyals, ceratohyal, and epihyal which ossify at about the same time. These bones usually become ossified at a smaller size in *E. microstomus* (Table 7). The basihyal ossifies after metamorphosis (Figures 10, 11).

Structural similarity between the two species is great. The first three branchiostegal rays appear to be supported by the ceratohyal and the remaining four by the epihyal in both species.

Additional Comments

The first bones to ossify in the branchiocranium are of dermal origin. Except for the quadrate and articular, which form the angle of the jaws, the only bones ossified in larvae of 4-5 mm in both species are dermal bones. These bones become ossified at about the same size in both species (Table 7). They include the premaxillary, maxillary, dentary, ectopterygoid, preopercle, opercle, branchiostegal rays, cleithrum, and supracleithrum. Ossification of cartilage bones follows.

The parasphenoid, a dermal bone of the neurocranium, is also prominent in 4-mm stained larvae of both species. This bone extends from the ethmoid region to the basioccipital in the basicranial region of the neurocranium (Figure 9).

In the smallest stained specimens, pharyngeal teeth in the form of sharp pointed cones, may be seen clearly. Together with the parasphenoid and the cleithrum, they are prominent features in 4-mm larvae of both species. They are still apparent in 12-mm larvae (Figure 9).

The sequences of ossification of bones discussed are the same for *E. microstomus* and *C. arctifrons*. Most bones become ossified at an earlier stage in *E. microstomus*. Major differences are the preopercular spines of *E. microstomus* and the small size at which the larger jaw of *C. arctifrons* becomes evident.

OCCURRENCE AND SPAWNING IN THE CHESAPEAKE BIGHT

Adults of *E. microstomus* and *C. arctifrons* occur throughout the Chesapeake Bight from Cape Henlopen, Del., to Cape Hatteras. Their distribution is limited by depth. *E. microstomus* is found in waters shallower than 37 m (20 fm) while *C. arctifrons* occurs in depths >37 m (Figure 12). Slight distributional overlap may occur around depths of 37 m. Adults of both species are present in the bight throughout

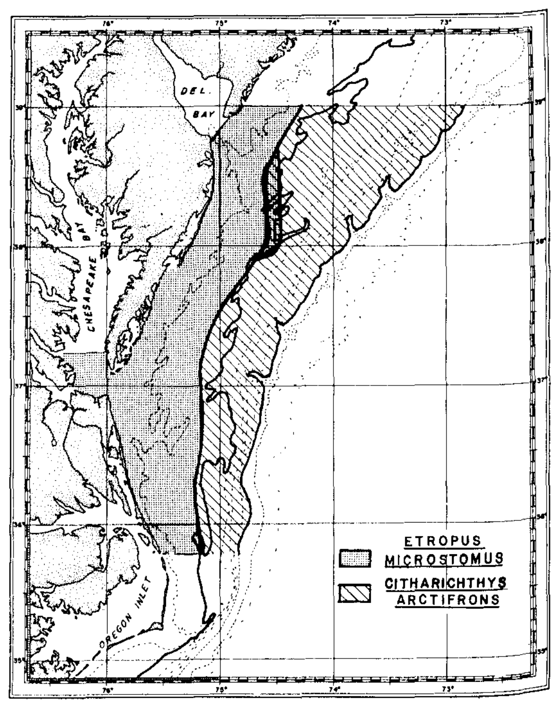

FIGURE 12.—Distribution of adult *Etropus microstomus* and *Citharichthys arctifrons* in the Chesapeake Bight. The 37-m (20-fm) and 183-m (100-fm) depth contours are emphasized. [From data collected by Virginia Institute of Marine Science in 1966. No tows were made beyond 183 m (100 fm).]

the year. Insufficient information is available to determine whether north-south or inshore-offshore movements occur, seasonal or otherwise.

Areal distribution of larvae, based on VIMS collections, is not as clearly defined. While most *E. microstomus* larvae were collected at stations inside the 37-m (20-fm) isobath, some were found out as far as the 183-m (100-fm) line. Most *C. arctifrons* larvae were taken outside the 37-m curve, but some were found near the 18-m (10-fm) line. Many samples contained larvae of both species. A greater number of *C. arctifrons* larvae were taken during 1962 when the sampling program was expanded to cover a greater offshore range.

Depths at which larvae occur in the water column may be a specific character (Simpson, 1956 Ahlstrom, 1960 Rae, 1965). Data from VIMS collections indicated that *E. microstomus* larvae were more common in the upper layers (0-12 m) while *C. arctifrons* larvae were more abundant in tows made at 12-18 m. Data from the Norfolk Canyon Collections (refer to section on Materials and Methods) showed *E. microstomus* larvae most abundant in the net towed at 2 m and *C. arctifrons* larvae most numerous in the net towed at 50 m. Additional sampling is needed to give accurate profiles of depth distribution for the two species.

The spawning peak for both species ranges from July through October, but spawning may occur sporadically through much of the year. Larvae have been taken as early as May and as late as December. Examination of ovaries of adults supports these conclusions.

ABUNDANCE AND ECONOMIC IMPORTANCE

Adults of *E. microstomus* and *C. arctifrons* are relatively numerous in the Chesapeake Bight. Seasonal records (Table 2) indicate that these two species together constituted about half of all flatfishes collected by VIMS in the spring and summer of 1966. Comparison of numerical catches of *E. microstomus* and *C. arctifrons* (Table 2) and the major commercially important flatfish species in the bight (*Paralichthys dentatus* and *Pseudopleuronectes americanus*) is noteworthy.

Larvae of *E. microstomus* and *C. arctifrons* were the most numerous of all flatfish species taken in VIMS plankton collections. Ahlstrom (1965) reported larvae of *Citharichthys* spp. (as a group) were similarly the most abundant of all flatfishes taken in the California Current System from 1955 to 1958. He stated, "Larvae of . . . sanddabs (*Citharichthys* spp.) are . . . [species] that represent present or potential commercial resources."

Despite the relative abundance of *E. microstomus* and *C. arctifrons* in the Chesapeake Bight, the two species alone do not represent sufficient biomass to make exploitation economically feasible. Lengths probably rarely exceed those given by Parr (1931) of 120 mm for *E. microstomus* and 150 mm for *C. arctifrons*. However, they could become part of the catch of miscellaneous trash fishes used for reduction into fish meal as has *E. rimosus* (Beaumariage, 1968), a species very similar to *E. microstomus*.

TAXONOMIC PROBLEMS

Original descriptions of the genera *Etropus* (Jordan and Gilbert, 1882) and *Citharichthys* (Bleeker, 1862) offer few characters to separate the two. The major difference between *Etropus* and *Citharichthys*, according to the original descriptions, is dentition. In *Etropus* "the teeth . . . [are] mostly on the blind side" while in *Citharichthys* the teeth on the eyed and blind sides of both jaws are well developed. Jordan and Evermann (1898) pointed out that " . . . this genus [*Etropus*] is very close to *Citharichthys*, from which it differs only in the very small size of the mouth, and in the correspondingly weak dentition."

The separation of 10 western Atlantic species of *Etropus* and *Citharichthys* into two genera has been disputed by Parr (1931). He claimed that length of the maxillary did not adequately segregate the species that he considered into two groups. He placed them all in the genus *Citharichthys*, apparently disregarding the dentition. Norman (1934) retained the separation of *Etropus* and *Citharichthys* in his monograph. He stated *Etropus* is "very close to *Citharichthys*," the major difference being the smaller mouth and more feeble dentition with teeth mostly on the blind side of *Etropus*.

Transitory larval characters may provide clues to taxonomic relationships. *Syacium*, *Cyclopsetta*, *Citharichthys*, and *Etropus* are four closely related genera of bothid flatfishes (Norman, 1934). *Syacium* and *Cyclopsetta* can be separated from *Citharichthys* and *Etropus* on the basis of transitory larval characters (Gutherz, 1970). Similarly, *Syacium* can be separated from *Cyclopsetta* (Gutherz, 1970). Such characters could yield new evidence to substantiate or discredit the validity of the generic separation of *Etropus* and *Citharichthys*. However, as yet too few life histories have been described for species of *Etropus* and *Citharichthys* to permit meaningful conclusions.

ACKNOWLEDGMENTS

We acknowledge the Medical College of Virginia for use of its x-ray facilities, the Sandy Hook Sport Fisheries Marine Laboratory of the National Marine Fisheries Service for use of its larval fish collections, and George C. Grant for use of his Norfolk Canyon plankton collections. We are grateful to Jane Davis for her guidance in the preparation of the illustrative material contained herein. We thank Jackson Davis, George C. Grant, John J. Norcross, and Marvin L. Wass for their review of the manuscript. Special thanks are given to Elbert H. Ahlstrom for reviewing and commenting on the paper.

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Appendix Table 1.—Body measurements and their proportions in percent SL (standard length) of larval stages of Etropus microstomus.

SL (mm)	Measurements (mm) Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth	Ratios (percent SL) Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth
3.53	0.76	0.25	1.39	0.25	0.25	0.88	0.50	0.13	21.4	7.1	39.3	7.1	7.1	25.0	14.3	3.6
3.78	.88	.13	1.64	.25	.25	1.01	.63	.13	23.3	3.3	43.3	6.7	6.7	26.7	16.7	3.3
4.03	.88	.25	1.51	.25	.25	.88	.50	.13	21.9	6.3	37.5	6.3	6.3	21.9	12.5	3.1
4.28	1.01	.25	1.76	.25	.38	1.01	.63	.13	23.5	5.9	41.2	5.9	8.8	23.5	14.7	2.9
4.28	1.01	.25	1.64	.25	.25	.88	.50	.13	23.5	5.9	38.2	5.9	5.9	20.6	11.8	2.9
4.28	1.01	.25	1.76	.25	.38	1.13	.63	.25	23.5	5.9	41.2	5.9	8.8	26.5	14.7	5.9
4.54	1.13	.25	1.76	.25	.38	1.01	.63	.13	25.0	5.6	38.9	5.6	8.3	21.8	13.9	2.8
4.79	1.13	.25	1.76	.38	.38	1.26	.76	.25	23.7	5.3	36.8	7.9	7.9	26.3	15.8	5.3
4.79	1.13	.25	1.76	.38	.38	1.26	.88	.25	23.7	5.3	36.8	7.9	7.9	26.3	18.4	5.3
4.79	1.13	.25	1.76	.25	.38	1.01	.63	.25	23.7	5.3	36.8	5.3	7.9	21.1	13.2	5.3
4.79	1.13	.25	1.76	.25	.38	.88	.63	.13	23.7	5.3	36.8	5.3	7.9	18.4	13.2	2.6
4.79	1.26	.25	2.14	.38	.50	1.39	1.01	.25	26.3	5.3	44.7	7.9	10.5	28.9	21.1	5.3
5.04	1.26	.25	2.02	.38	.38	1.51	1.01	.38	25.0	5.0	40.0	7.5	7.5	30.0	20.0	7.5
5.04	1.26	.25	1.89	.38	.50	1.01	.63	.25	25.0	5.0	37.5	7.5	10.0	20.0	12.5	5.0
5.29	1.26	.38	2.02	.38	.50	1.51	1.01	.38	23.8	7.1	38.1	7.1	9.5	28.6	19.0	7.1
5.29	1.26	.25	1.89	.38	.38	1.39	.88	.25	23.8	4.8	35.7	7.1	7.1	26.2	16.7	4.8
5.29	1.51	.25	2.14	.38	.50	1.39	1.01	.38	28.6	4.8	40.5	7.1	9.5	26.2	19.0	7.1
5.29	1.51	.38	2.39	.38	.50	1.51	1.01	.38	28.6	7.1	45.2	7.1	9.5	28.6	19.0	7.1
5.29	1.26	.25	2.14	.38	.50	1.13	.63	.25	23.8	4.8	40.5	7.1	9.5	21.4	11.9	4.8
5.29	1.39	.25	2.14	.38	.50	1.39	.88	.38	26.2	4.8	40.5	7.1	9.5	26.2	16.7	7.1
5.29	1.26	.25	2.27	.38	.50	1.39	.88	.38	23.8	4.8	42.9	7.1	9.5	26.2	16.7	7.1
5.54	1.51	.50	2.39	.38	.63	1.64	1.26	.50	27.3	9.1	43.2	6.8	11.4	29.5	22.7	9.1
5.80	1.64	.38	2.39	.38	.63	1.76	1.26	.63	28.3	6.5	41.3	6.5	10.9	30.4	21.7	10.9
5.80	1.39	.25	2.27	.38	.50	1.64	1.13	.38	23.9	4.3	39.1	6.5	8.7	28.3	19.6	6.5
5.80	1.76	.38	2.52	.50	.63	2.14	1.64	.63	30.4	6.5	43.5	8.7	10.9	37.0	28.3	10.9
5.80	1.51	.50	2.14	.50	.63	2.02	1.39	.50	26.1	8.7	37.0	8.7	10.9	34.8	23.9	8.7
5.80	1.51	.38	2.39	.38	.63	1.89	1.39	.50	26.1	6.5	41.3	6.5	10.9	32.6	23.9	8.7
6.05	1.51	.38	2.27	.38	.50	1.64	1.13	.50	25.0	6.3	37.5	6.3	8.3	27.1	18.8	8.3
6.05	1.76	.50	2.90	.50	.63	2.27	1.64	.76	29.2	8.3	47.9	8.3	10.4	37.5	27.1	12.5
6.05	1.51	.38	2.52	.50	.63	1.76	1.26	.50	25.0	6.3	41.7	8.3	10.4	29.2	20.8	8.3
6.05	1.64	.38	2.39	.50	.63	1.76	1.26	.63	27.1	6.3	39.6	8.3	10.4	29.2	20.8	10.4
6.05	1.51	.38	2.52	.38	.50	1.89	1.26	.50	25.0	6.3	41.7	6.3	8.3	31.3	20.8	8.3
6.30	1.51	.38	2.39	.38	.50	1.51	1.13	.50	24.0	6.0	38.0	6.0	8.0	24.0	18.0	8.0
6.30	1.76	.50	2.52	.50	.63	2.14	1.64	.50	28.0	8.0	40.0	8.0	10.0	34.0	26.0	8.0
6.30	1.64	.50	2.90	.38	.50	2.02	1.64	.63	26.0	8.0	46.0	6.0	8.0	32.0	26.0	10.0
6.30	1.76	.38	2.77	.50	.50	2.14	1.64	.63	28.0	6.0	44.0	8.0	8.0	34.0	26.0	10.0
6.30	1.51	.38	2.39	.38	.50	1.76	1.26	.50	24.0	6.0	38.0	6.0	8.0	28.0	20.0	8.0
6.30	1.64	.38	2.65	.50	.50	2.14	1.76	.63	26.0	6.0	42.0	8.0	8.0	34.0	28.0	10.0
6.30	1.64	.38	2.65	.38	.63	2.02	1.64	.50	26.0	6.0	42.0	6.0	10.0	32.0	26.0	8.0
6.30	1.51	.25	2.65	.38	.50	1.76	1.39	.50	24.0	4.0	42.0	6.0	8.0	28.0	22.0	8.0
6.55	1.76	.38	3.02	.50	.63	2.14	1.64	.63	26.9	5.8	46.2	7.7	9.6	32.7	25.0	9.6
6.55	1.76	.38	2.90	.50	.76	2.27	1.64	.63	26.9	5.8	44.2	7.7	11.9	34.6	25.0	9.6
6.55	1.89	.50	2.77	.50	.76	2.52	1.89	.76	28.8	7.7	42.3	7.7	11.5	38.5	28.8	11.5
6.55	1.76	.25	2.65	.50	.63	1.89	1.51	.63	26.9	3.8	40.4	7.7	9.6	28.8	23.1	9.6
6.80	2.02	.50	3.28	.50	.63	2.78	2.14	.88	29.6	7.4	48.1	7.4	9.3	40.7	31.5	13.0
6.80	1.89	.38	2.90	.50	.63	2.14	1.76	.63	27.8	5.6	42.6	7.4	9.3	31.5	25.9	9.3
6.80	1.76	.38	2.65	.50	.63	2.27	1.64	.63	25.9	5.6	38.9	7.4	9.3	33.3	24.1	9.3
7.06	1.89	.50	3.15	.50	.63	2.52	1.89	.76	26.8	7.1	44.6	7.1	8.9	35.7	26.8	10.7
7.06	1.89	.38	2.90	.38	.63	2.27	1.64	.63	25.0	5.4	41.1	5.4	8.9	32.1	23.2	8.9
7.06	1.89	.50	2.90	.50	.63	2.39	1.89	.76	26.8	7.1	41.1	7.1	8.9	33.9	26.8	10.7

APPENDIX TABLE 1.—Continued.

SL (mm)	Measurements (mm)								Ratios (percent SL)							
	Head length	Snout length	Snout to anus	Eye diam-eter	Upper jaw length	Depth at anus	Depth behind anus	Pedun-cle depth	Head length	Snout length	Snout to anus	Eye diam-eter	Upper jaw length	Depth at anus	Depth behind anus	Pedun-cle depth
7.06	1.89	.50	3.02	.50	.63	2.52	1.89	.76	26.8	7.1	42.9	7.1	8.9	35.7	26.8	10.7
7.06	1.89	.50	2.90	.50	.63	2.27	1.89	.76	26.8	7.1	41.1	7.1	8.9	32.1	26.8	10.7
7.13	2.02	.50	3.28	.50	.76	2.52	2.02	.88	27.6	6.9	44.8	6.9	10.3	34.5	27.6	12.1
7.13	2.14	.50	2.90	.50	.63	3.15	2.52	.76	29.3	6.9	39.7	6.9	8.6	43.1	34.5	10.3
7.13	1.89	.50	2.90	.50	.76	2.65	2.27	.88	25.9	6.9	39.7	6.9	10.4	36.2	31.0	12.1
7.13	2.02	.50	3.28	.50	.76	2.65	2.02	.88	27.6	6.9	44.8	6.9	9.4	36.2	27.6	12.1
7.13	1.89	.38	2.90	.50	.76	2.39	1.89	.76	25.9	5.2	39.7	6.9	8.6	32.8	25.9	10.3
7.13	2.02	.50	3.02	.50	.63	2.65	2.14	.88	27.6	6.9	41.4	6.9	8.6	36.2	29.3	12.1
7.56	2.02	.63	3.28	.50	.63	2.65	2.14	.88	27.7	8.3	43.3	6.7	8.3	35.0	28.3	11.7
7.56	1.89	.38	3.15	.50	.50	2.39	1.89	.76	25.0	5.0	41.7	6.7	6.7	31.7	25.0	10.0
7.56	1.89	.38	3.02	.50	.63	2.52	1.89	.76	25.0	5.0	40.0	6.7	8.3	33.3	25.0	10.0
7.81	2.27	.63	3.28	.50	.76	2.77	2.27	.88	29.0	8.1	41.9	6.5	9.7	35.5	29.0	11.3
7.81	2.02	.63	2.90	.50	.76	3.15	2.52	.88	25.8	8.1	37.1	6.5	9.7	40.3	32.3	11.3
8.06	2.27	.50	3.40	.63	.76	2.90	2.27	.88	28.1	6.3	42.2	7.8	9.4	35.9	28.1	10.9
8.06	2.27	.50	3.28	.63	.76	3.15	2.52	1.01	28.1	6.3	40.6	7.8	9.4	39.1	31.3	12.5
8.06	2.01	.50	3.28	.50	.63	2.39	1.89	.76	25.0	6.3	40.6	6.3	7.8	29.7	23.4	9.4
8.06	2.14	.50	3.02	.50	.76	2.77	2.27	.88	26.6	6.3	37.5	6.3	9.4	34.4	28.1	10.9
8.32	2.27	.50	3.15	.63	.76	3.15	2.52	1.01	27.3	6.1	37.9	7.6	9.1	37.9	30.3	12.1
8.32	2.27	.50	3.53	.50	.76	3.15	2.65	1.01	27.3	6.1	42.4	6.1	9.1	37.9	31.8	12.1
8.32	2.14	.50	3.28	.50	.76	2.77	2.39	.88	25.8	6.1	39.4	6.1	9.1	33.3	28.8	10.6
8.32	2.27	.50	3.28	.50	.76	3.28	2.77	1.01	27.3	6.1	39.4	6.1	9.1	39.4	33.3	12.1
8.82	2.27	.63	3.53	.63	.76	3.28	2.52	.88	25.7	7.1	40.0	7.1	8.6	37.1	28.6	10.0
8.82	2.39	.63	3.28	.63	1.01	3.65	3.02	1.13	27.1	7.1	37.1	7.1	11.4	41.4	34.3	12.9
8.82	2.39	.50	3.53	.50	.76	3.28	2.77	1.01	27.1	5.7	40.0	5.7	8.6	37.1	31.4	11.4
8.82	2.27	.50	3.02	.50	.76	3.15	2.65	1.01	25.7	5.7	34.3	5.7	8.6	35.7	30.0	11.4
9.07	2.39	.50	3.28	.63	.88	3.40	2.90	1.13	26.4	5.6	36.1	6.9	9.7	37.5	31.9	12.5
9.07	2.52	.63	3.40	.63	.76	3.78	3.15	1.13	27.8	6.9	37.5	6.9	8.3	41.7	34.7	12.5
9.07	2.14	.63	3.28	.50	.76	3.15	2.65	1.01	23.6	6.9	36.1	5.6	8.3	34.7	29.2	11.1
9.32	2.52	.50	3.53	.63	1.01	3.65	3.15	1.01	27.0	5.4	37.8	6.8	10.8	39.2	33.8	10.8
9.32	2.52	.63	3.65	.63	.88	3.28	2.77	1.13	27.0	6.8	39.2	6.8	9.5	35.1	29.7	12.2
9.32	2.52	.63	3.78	.63	.88	3.65	3.40	1.26	27.0	6.8	40.5	6.8	9.5	39.2	36.5	13.5
9.32	2.39	.50	3.65	.50	.76	3.28	2.90	1.13	25.7	5.4	39.2	5.4	8.1	35.1	31.1	12.2
9.58	2.65	.63	3.65	.63	.88	3.65	3.15	1.26	27.6	6.6	38.2	6.6	9.2	38.2	32.9	13.2
9.58	2.52	.63	3.78	.63	.88	3.78	3.40	1.39	26.3	6.6	39.5	6.6	9.2	39.5	35.5	14.5
9.83	2.52	.63	3.78	.63	.76	3.40	2.77	1.13	25.6	6.4	38.5	6.4	7.7	34.6	28.2	11.5
10.33	2.65	.63	4.03	.63	.88	3.78	3.28	1.26	25.6	6.1	39.0	6.1	8.5	36.6	31.7	12.2
10.33	2.65	.63	3.78	.63	.88	4.16	3.65	1.26	25.6	6.1	34.9	6.1	8.5	40.2	35.4	12.2
10.33	2.65	.50	3.78	.50	.88	4.28	3.78	1.26	25.6	4.9	34.9	4.9	8.5	41.5	34.9	12.2
10.33	2.65	.76	3.91	.50	.88	3.91	3.40	1.26	25.6	7.3	37.8	4.9	8.5	37.8	32.9	12.2
10.58	2.77	.76	4.16	.63	.88	3.91	3.40	1.26	26.2	7.1	39.3	6.0	8.3	36.9	32.1	11.9
10.84	2.77	.76	4.03	.50	1.01	4.16	3.78	1.26	25.6	7.0	37.2	4.6	9.3	38.4	34.9	11.6
11.09	2.90	1.01	4.03	.50	.76	4.41	4.03	1.39	26.1	5.7	36.4	6.8	9.1	39.8	36.3	12.5
11.59	2.90	.76	4.28	.63	.88	4.41	4.03	1.39	25.0	6.5	37.0	5.4	7.6	38.0	34.8	12.0
12.10	3.15	.63	4.28	.76	1.13	5.04	4.54	1.51	26.0	5.2	35.4	6.3	9.4	41.7	37.5	12.5
12.10	3.15	.76	4.03	.63	.88	4.79	4.16	1.51	26.0	6.3	33.3	5.2	7.3	39.6	34.4	12.5
12.35	3.15	.63	4.28	.76	.88	4.91	4.54	1.64	25.5	5.1	34.7	6.1	7.1	39.8	36.8	13.3
12.35	3.15	.76	4.28	.63	.88	4.54	3.91	1.39	25.5	6.1	34.7	5.1	7.1	36.7	31.6	11.2
12.60	3.40	.88	4.28	.76	.88	5.04	4.79	1.01	27.0	7.0	34.0	6.0	7.0	40.0	38.0	8.0
12.60	3.28	.76	4.16	.76	.88	4.79	4.66	1.13	26.0	6.0	33.0	6.0	7.0	38.0	37.0	9.0
12.60	3.28	.88	4.16	.76	1.13	4.79	4.41	1.64	26.0	7.0	33.0	6.0	9.0	38.0	35.0	13.0

APPENDIX TABLE 2.—*Body measurements and their proportions in percent SL (standard length) of larval stages of Citharichthys arctifrons.*

	Measurements (mm)								Ratios (percent SL)							
SL (mm)	Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth	Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth
4.54	0.88	0.13	1.64	0.25	0.38	0.88	0.50	0.13	19.4	2.8	36.1	5.6	8.3	19.4	11.1	2.8
4.54	1.01	.13	1.76	.38	.38	.88	.50	.13	22.2	2.8	38.9	8.3	8.3	19.4	11.1	2.8
4.79	1.13	.13	2.02	.38	.50	1.13	.63	.25	23.7	2.9	42.1	7.9	10.5	23.7	13.2	5.3
4.79	1.13	.38	1.89	.38	.50	1.01	.63	.25	23.7	7.9	39.5	7.9	10.5	21.1	13.2	5.3
4.79	1.01	.25	1.89	.38	.38	1.01	.50	.13	21.1	2.9	39.5	7.9	7.9	21.1	10.5	2.6
4.79	1.13	.25	1.89	.38	.38	.88	.38	.13	23.7	5.3	39.5	7.9	7.9	18.4	7.9	2.6
5.04	1.13	.38	1.89	.38	.50	1.13	.76	.25	22.5	7.5	37.5	7.5	10.0	22.5	15.0	5.0
5.04	1.26	.13	2.14	.38	.38	1.13	.76	.25	25.0	2.5	42.5	7.5	7.5	22.5	15.0	5.0
5.04	1.26	.38	2.14	.38	.63	1.26	.88	.25	25.0	7.5	42.5	7.5	12.5	25.0	17.5	5.0
5.04	1.13	.25	1.89	.38	.63	1.01	.50	.13	22.5	5.0	37.5	7.5	12.5	20.0	10.0	2.5
5.29	1.39	.38	2.14	.38	.63	1.26	.76	.25	26.2	7.1	40.5	7.1	11.9	23.8	14.3	4.8
5.29	1.39	.38	2.27	.38	.63	1.13	.63	.13	26.2	7.1	42.9	7.1	11.9	21.4	11.9	2.4
5.29	1.39	.38	2.14	.38	.50	1.26	.88	.38	26.2	7.1	40.5	7.1	9.5	23.8	16.7	7.1
5.29	1.39	.38	2.27	.38	.63	1.26	.88	.38	26.2	7.1	42.9	7.1	11.9	23.8	16.7	7.1
5.29	1.39	.38	2.14	.38	.50	1.39	.88	.25	26.2	7.1	40.5	7.1	9.5	26.2	16.7	4.8
5.29	1.13	.25	2.27	.38	.50	1.13	.63	.13	21.4	4.8	42.9	7.1	9.5	21.4	11.9	2.4
5.29	1.39	.38	2.39	.38	.63	1.26	.88	.25	26.2	7.1	45.2	7.1	11.9	23.8	16.7	4.8
5.54	1.39	.38	2.14	.50	.50	1.39	.88	.38	25.0	6.8	38.6	9.1	9.1	25.0	15.9	6.8
5.54	1.51	.38	2.39	.50	.63	1.51	1.01	.38	27.3	6.8	43.2	9.1	11.4	27.3	18.2	6.8
5.54	1.39	.25	2.27	.38	.63	1.39	.88	.13	25.0	4.5	40.9	6.8	11.4	25.0	15.9	2.3
5.54	1.39	.38	2.27	.38	.50	1.39	.76	.25	25.0	6.8	40.9	6.8	9.1	25.0	13.6	4.5
5.54	1.39	.38	2.27	.38	.50	1.26	.88	.25	25.0	6.8	40.9	6.8	9.1	22.7	15.9	4.5
5.54	1.51	.25	2.27	.38	.50	1.26	.76	.38	27.3	4.5	40.9	6.8	9.1	22.7	13.6	6.8
5.54	1.13	.25	1.89	.38	.50	1.13	.76	.25	20.5	4.5	34.1	6.8	9.1	20.5	13.6	4.5
5.54	1.26	.25	2.02	.38	.50	1.13	.76	.25	22.7	4.5	36.4	6.8	9.1	20.5	13.6	4.5
5.54	1.39	.38	2.27	.38	.50	1.51	.88	.25	25.0	6.8	40.9	6.8	9.1	27.3	15.9	4.5
5.54	1.39	.38	2.14	.38	.63	1.39	.88	.25	25.0	6.8	38.6	6.8	11.4	25.0	15.9	4.5
5.54	1.26	.38	2.27	.38	.50	1.26	.76	.25	22.7	6.8	40.9	6.8	9.1	22.7	13.6	4.5
5.80	1.39	.25	2.39	.50	.50	1.39	1.01	.38	23.9	4.3	41.3	8.7	8.7	23.9	17.4	6.5
5.80	1.64	.38	2.52	.50	.76	1.51	1.01	.38	28.3	6.5	43.5	8.7	13.0	26.1	17.4	6.5
5.80	1.39	.38	2.27	.38	.63	1.39	.88	.25	23.9	6.5	39.1	6.5	10.9	23.9	15.2	4.3
6.05	1.51	.38	2.39	.50	.50	1.39	1.01	.38	25.0	6.3	39.6	8.3	8.3	22.9	16.7	6.3
6.05	1.64	.38	2.52	.50	.63	1.51	1.01	.25	27.1	6.3	41.7	8.3	10.4	25.0	16.7	4.2
6.05	1.64	.50	2.39	.38	.76	1.64	1.13	.38	27.1	8.3	39.6	6.3	12.5	27.0	18.8	6.3
6.30	1.64	.38	2.52	.50	.76	1.76	1.13	.50	26.0	6.0	40.0	8.0	12.0	28.0	18.0	8.0
6.30	1.64	.38	2.52	.38	.63	1.76	1.13	.38	26.0	6.0	40.0	6.0	10.0	28.0	18.0	6.0
6.30	1.64	.38	2.52	.50	.63	1.64	1.13	.38	26.0	6.0	40.0	8.0	10.0	26.0	18.0	6.0
6.30	1.89	.50	2.77	.50	.63	1.89	1.26	.50	30.0	8.0	44.0	8.0	10.0	30.0	20.0	8.0
6.30	1.64	.38	2.52	.50	.63	1.76	1.26	.50	26.0	6.0	40.0	8.0	10.0	28.0	20.0	8.0
6.30	1.76	.38	2.65	.38	.63	1.51	1.01	.25	28.0	6.0	42.0	6.0	10.0	24.0	16.0	4.0
6.55	1.64	.38	2.65	.50	.63	1.76	1.13	.50	25.0	5.8	40.4	7.7	7.6	26.9	17.3	7.7
6.55	1.86	.38	2.65	.50	.76	2.02	1.39	.63	28.8	5.8	40.4	7.7	11.5	30.8	21.2	9.6
6.55	1.76	.50	2.65	.50	.63	1.64	1.13	.50	26.9	7.7	40.4	7.7	9.6	25.0	17.3	7.7
6.55	1.76	.50	2.65	.50	.76	1.89	1.39	.50	26.9	7.7	40.4	7.7	11.5	28.8	21.2	7.7
6.55	1.76	.50	2.65	.50	.63	1.89	1.26	.63	26.9	7.7	40.4	7.7	9.6	28.8	19.2	9.6
6.55	1.76	.50	2.65	.50	.63	1.76	1.13	.50	26.9	7.7	40.4	7.7	9.6	26.9	17.3	7.7
6.55	1.76	.38	2.90	.50	.63	1.89	1.26	.50	26.9	5.8	44.2	7.7	9.6	28.8	19.2	7.7
6.55	1.89	.50	2.77	.50	.76	1.89	1.26	.50	28.8	7.7	42.3	7.7	11.5	28.8	19.2	7.7
6.55	2.02	.50	3.02	.50	.76	1.89	1.39	.50	30.8	7.7	46.2	7.7	11.5	28.8	21.1	7.7
6.80	1.89	.50	3.02	.50	.76	1.89	1.26	.63	27.8	7.4	44.4	7.4	11.1	27.8	18.5	9.3

Appendix Table 2.—Continued.

SL (mm)	Measurements (mm): Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth	Ratios (percent SL): Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth
6.80	1.89	.50	2.90	.50	.76	2.14	1.64	.63	27.8	7.4	42.6	7.4	11.1	31.5	24.1	9.3
6.80	1.89	.50	3.02	.50	.63	2.14	1.51	.76	27.7	7.4	44.4	7.4	9.3	31.5	22.2	11.1
6.80	1.89	.38	2.90	.50	.63	1.76	1.26	.50	27.8	5.6	42.6	7.4	9.3	25.9	18.5	7.4
6.80	2.02	.50	2.90	.50	.63	1.89	1.39	.50	29.6	7.4	42.6	7.4	9.3	27.8	20.4	7.4
7.06	2.14	.50	3.15	.50	.88	2.27	1.76	.76	30.4	7.1	44.6	7.1	12.5	32.1	25.0	10.7
7.06	2.14	.50	3.15	.50	.76	2.27	1.64	.76	30.4	7.1	44.6	7.1	10.7	32.1	23.2	10.7
7.06	2.02	.50	2.90	.50	.63	2.14	1.51	.63	28.6	7.1	41.1	7.1	8.9	30.4	21.4	8.9
7.31	2.14	.38	3.15	.63	.76	2.39	1.76	.76	29.3	5.2	43.1	8.6	10.3	32.8	24.1	10.3
7.31	2.27	.63	3.28	.63	.88	2.39	1.86	.88	31.0	8.6	44.8	8.6	12.1	32.8	25.9	12.1
7.31	2.14	.50	3.02	.50	.63	2.27	1.76	.76	29.3	6.9	41.4	6.9	8.6	31.0	24.1	10.3
7.31	2.02	.50	3.15	.63	.76	2.27	1.64	.76	27.6	6.9	43.1	8.6	10.3	31.0	22.4	10.3
7.31	1.89	.50	3.28	.63	.76	2.14	1.64	.76	25.9	6.9	44.8	8.6	10.3	29.3	22.4	10.3
7.31	2.14	.63	3.15	.63	.76	2.27	1.64	.76	29.3	8.6	43.1	8.6	10.3	31.0	22.4	10.3
7.50	2.14	.50	3.28	.50	.76	2.52	2.02	.88	28.3	6.7	43.3	6.7	10.0	23.3	26.7	11.7
7.56	2.14	.50	3.40	.50	.76	2.27	1.51	.63	28.3	6.7	45.0	6.7	10.0	30.0	20.0	8.3
7.81	2.02	.50	3.15	.63	1.01	2.52	1.76	.76	25.8	6.5	40.3	8.1	12.9	32.3	22.6	9.7
8.06	2.27	.38	3.40	.63	.88	2.52	1.76	.76	28.1	4.7	42.2	7.8	10.9	31.3	21.9	9.4
8.06	2.39	.50	3.65	.63	.76	2.52	1.76	.76	29.7	6.3	45.3	7.8	9.4	31.3	21.9	9.4
8.06	2.27	.50	3.40	.63	.88	2.77	1.89	.76	28.1	6.3	42.2	7.8	10.9	34.4	23.4	9.4
8.32	2.27	.50	3.28	.63	.88	2.65	1.89	1.01	27.3	6.1	39.4	7.6	10.6	31.8	22.7	12.1
8.32	2.52	.63	3.78	.63	.88	2.52	1.89	.88	30.3	7.6	45.5	7.6	10.6	30.3	22.7	10.6
8.32	2.27	.50	3.40	.63	.88	2.52	1.89	.63	27.3	6.1	40.9	7.6	10.6	30.3	22.7	7.6
8.32	2.39	.63	3.53	.63	1.01	2.77	1.89	.88	28.8	7.6	42.4	7.6	12.1	33.3	22.7	10.6
8.57	2.39	.50	3.91	.63	.88	2.90	2.27	1.13	27.9	5.9	45.6	7.4	10.3	33.8	26.5	13.2
8.57	2.65	.63	3.78	.63	.76	2.65	2.02	.88	30.9	7.4	44.1	7.4	8.8	30.9	23.5	10.3
9.07	2.77	.76	3.78	.63	1.13	3.40	2.65	1.13	30.1	8.3	41.7	6.9	12.5	37.5	29.2	12.5
9.07	2.52	.63	4.03	.63	.88	2.90	2.27	.88	27.8	6.9	44.4	6.9	9.7	31.9	25.0	9.7
9.07	2.52	.63	4.16	.63	.88	3.28	2.27	1.01	27.8	6.9	45.8	6.9	9.7	36.1	25.0	11.1
9.32	2.52	.63	3.78	.63	1.13	3.40	2.39	1.01	27.0	6.8	40.5	6.8	12.2	36.5	25.7	10.8
9.32	2.65	.63	4.03	.63	1.01	3.02	2.27	1.01	28.4	6.8	43.2	6.8	10.8	32.4	24.3	10.8
9.58	2.77	.63	4.28	.63	1.01	3.28	2.65	1.13	28.9	6.6	44.7	6.6	10.5	34.2	27.6	11.8
9.83	3.02	.63	4.28	.63	.88	3.78	2.90	1.13	30.8	6.4	43.6	6.4	9.0	38.5	29.5	11.5
10.33	3.15	.76	4.41	.76	1.01	3.53	2.77	1.26	30.5	7.3	42.7	7.3	9.8	34.1	26.8	12.2
10.58	3.02	.76	4.16	.88	1.13	4.03	3.02	1.26	28.6	7.1	39.3	8.3	10.7	38.1	28.6	11.9
10.58	3.02	.76	4.41	.76	.88	3.78	2.65	1.26	28.6	7.1	41.7	7.1	8.3	35.7	25.0	11.9
10.58	2.90	.63	4.54	.76	1.26	3.91	2.90	1.26	27.4	6.0	42.9	7.1	11.9	37.0	27.4	11.9
11.09	3.15	.88	4.54	.76	1.26	3.91	3.15	1.51	28.4	8.0	40.9	6.8	11.4	35.2	28.4	13.6
11.09	3.02	.76	4.41	.76	1.26	3.91	3.02	1.26	27.3	6.8	39.8	6.8	11.4	35.2	27.3	11.4
11.34	3.02	.63	4.54	.88	1.13	4.16	3.28	1.39	26.7	5.6	40.0	7.8	10.0	36.7	28.9	12.2
11.34	3.28	.88	4.16	.76	1.26	4.16	3.53	1.39	28.9	7.8	36.7	6.7	11.1	36.7	31.1	12.2
11.59	3.28	.76	4.41	.76	1.13	4.28	3.15	1.39	28.3	5.6	38.0	6.5	9.8	37.0	27.2	12.0
12.10	3.28	.88	4.79	.76	1.26	4.16	3.40	1.26	27.1	7.3	39.6	6.3	10.4	34.4	28.1	10.4
12.35	3.40	.88	4.41	.76	1.26	4.41	3.65	1.39	27.6	7.1	35.7	6.1	10.2	35.7	29.6	11.2
12.35	3.53	1.01	4.91	.76	1.13	4.54	3.65	1.39	28.6	8.2	39.8	6.1	9.2	36.7	29.6	11.2
12.35	3.53	.76	4.91	.88	1.26	4.28	3.53	1.51	28.6	6.1	39.8	7.1	10.2	34.7	28.6	12.2
12.35	3.28	.88	4.41	.88	1.26	4.41	3.65	1.39	26.5	7.1	35.7	7.1	10.2	35.7	29.6	11.2
12.60	3.78	1.01	5.04	.88	1.26	4.54	3.53	1.51	30.0	8.0	40.0	7.0	9.0	36.0	28.0	12.0
13.36	3.78	1.13	4.66	.88	1.39	4.66	4.03	1.15	28.3	8.5	34.9	6.7	10.4	34.9	30.2	11.3
13.86	3.65	.88	5.42	.88	1.26	5.42	4.28	1.64	26.4	6.4	39.1	6.4	9.1	39.1	30.9	11.8
14.36	3.78	1.01	5.17	1.01	1.13	5.04	4.41	1.64	26.3	7.0	35.8	7.0	7.9	35.1	30.7	11.4

APPENDIX TABLE 3.—Body measurements and their proportions in percent SL (standard length) of selected juvenile and adult specimens of *Etropus microstomus*.

SL (mm)	Measurements (mm) Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth	Ratios (percent SL) Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth
29	8	2	8	2	2	10	12	3	27.6	6.9	27.6	6.9	6.9	34.5	41.4	10.3
40	10	2	10	3	3	13	16	4	25.0	5.0	25.0	7.5	7.5	32.5	40.0	10.0
45	11	2	11	3	3	16	18	5	24.4	4.4	24.4	6.7	6.7	35.6	40.0	11.1
50	12	2	12	3	3	17	20	5	24.0	4.0	24.0	6.0	6.0	34.0	40.0	10.0
56	13	3	13	4	4	18	23	6	23.2	5.4	23.2	7.1	7.1	32.1	41.1	10.7
60	14	3	14	4	5	21	25	6	23.3	5.0	23.3	6.7	8.3	35.0	41.7	10.0
65	16	3	16	5	5	22	27	7	24.6	4.6	24.6	7.7	7.7	33.8	41.5	10.8
70	17	3	17	5	5	26	34	8	24.3	4.3	24.3	7.1	7.1	37.1	48.6	11.4
75	17	3	17	5	5	25	31	8	22.7	4.0	22.7	6.7	6.7	33.3	41.3	10.7
80	19	3	19	6	5	32	38	10	23.8	3.8	23.8	7.5	6.3	40.0	48.8	12.5
85	20	4	20	5	5	29	39	10	23.5	4.7	23.5	5.9	5.9	34.1	45.9	11.8
90	21	4	21	6	6	32	43	10	23.3	4.4	23.3	6.7	6.7	35.6	47.8	11.1
95	22	4	22	6	6	34	46	11	23.2	4.2	23.2	6.3	6.3	35.8	48.4	11.6
104	22	4	22	6	6	37	47	12	21.2	3.8	21.2	5.8	5.8	35.6	45.2	11.5
115	24	4	24	6	6	40	51	13	20.9	3.5	20.9	5.2	5.2	34.8	44.3	11.3
123	27	5	27	7	7	44	58	14	22.0	4.1	22.0	5.7	5.7	35.8	47.2	11.4

APPENDIX TABLE 4.—Body measurements and their proportions in percent SL (standard length) of selected juvenile and adult specimens of *Citharichthys arctifrons*.

SL (mm)	Measurements (mm) Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth	Ratios (percent SL) Head length	Snout length	Snout to anus	Eye diameter	Upper jaw length	Depth at anus	Depth behind anus	Peduncle depth
47	12	2	12	5	6	14	15	5	25.5	4.3	25.5	10.6	12.8	29.8	31.9	10.6
55	13	3	13	5	5	16	19	5	23.6	5.5	23.6	9.1	9.1	29.1	34.5	9.1
63	16	3	16	5	6	19	22	6	25.4	4.8	25.4	7.9	9.5	30.2	34.9	9.5
66	17	4	17	5	6	19	22	6	25.8	6.1	25.8	7.6	9.1	28.8	33.3	9.1
70	17	3	17	5	6	23	25	7	24.3	4.3	24.3	7.1	8.6	32.9	35.7	10.0
75	18	4	18	6	6	22	25	7	24.0	5.3	24.0	8.0	8.0	29.3	33.3	9.3
80	19	4	19	6	7	24	27	7	23.8	5.0	23.8	7.5	8.8	30.0	33.8	8.8
85	20	4	20	6	6	24	29	8	23.5	4.7	23.5	7.1	7.1	28.2	34.1	9.4
90	20	4	20	6	7	27	32	9	22.2	4.4	22.2	6.7	7.8	30.0	35.6	10.0
95	23	4	23	7	8	30	37	11	24.2	4.2	24.2	7.4	8.4	31.6	38.9	11.6
101	25	5	25	9	9	31	38	10	24.8	5.0	24.8	8.9	8.9	30.7	37.6	9.9
105	25	5	25	8	8	36	41	11	23.8	4.8	23.8	7.6	7.6	34.3	39.0	10.5
110	27	5	27	9	8	36	44	10	24.5	4.5	24.5	8.2	7.3	32.7	40.0	9.1
115	26	5	26	9	8	37	45	10	22.6	4.3	22.6	7.8	7.0	32.2	39.1	8.7
119	27	5	27	8	8	36	48	11	22.7	4.2	22.7	6.7	6.7	30.3	40.3	9.2
123	29	6	29	9	8	37	45	10	23.6	4.9	23.6	7.3	6.5	30.1	36.6	8.1
135	31	5	31	10	10	42	53	13	23.0	3.7	23.0	7.4	7.4	31.1	39.3	9.6