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Systematics and Distributional Ecology of *Etropus* (Pisces, Bothidae) on the Atlantic Coast of the United States with Description of a New Species

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***Etropus cyclosquamus* new species, the shelf flounder and three sympatric congeners from the eastern coast of the United States—*E. rimosus, E. microstomus* and *E. crossotus*—are diagnosed and a key presented. Patterns and microstructure of the scales are sufficient to identify adults of these four species, but gill-raker counts, shapes of the body and jaws and color patterns are also useful distinguishing characters. *E. cyclosquamus* is distinguished from all known bothids except *E. rimosus* and *E. microstomus* by having small accessory scales on the exposed surfaces of scales on the eyed and blind sides; *E. microstomus* is distinguished from *E. cyclosquamus* and *E. rimosus* by having a symmetrical mandible (vs asymmetrical with upturned symphyseal knob) and less developed accessory scales; *E. cyclosquamus* is distinguished from *E. rimosus* by having cycloid scales on the blind side (ctenoid in *rimosus*) and relatively simple ctenoid scales on the snout that rarely extend forward beyond the nostril (vs specialized, heavily ctenoid scales extending forward beyond nostril, often to premaxillary groove). *E. cyclosquamus* is distributed from North Carolina to Mississippi and is most abundant at depths of 10–30 m, while *E. rimosus* occurs from North Carolina to northern Florida in the Gulf of Mexico with greatest abundance at depths of 30–60 m. *E. microstomus* is most abundant on the continental shelf from New York to North Carolina; during warmer months of the year, it interfaces sharply with *E. cyclosquamus* and *E. rimosus* near the 17 C isotherm in the Gulf Stream edge at approximately 35°40′N latitude (just north of Cape Hatteras). In the winter, *E. microstomus* disperses southward along shore, occasionally reaching South Carolina or slightly farther; no specimens have been found from the Gulf of Mexico or the Caribbean. *E. crosostus* occurs from Virginia to northern South America and in the eastern tropical Pacific; between North Carolina and Texas, it is most common inshore and regularly enters estuaries.**

SPECIES of the New World flatfish genus *Etropus* (Pleuronectiformes, Bothidae), are among the smallest of bothids. They may be localy abundant and may be important forage for larger fishes, but because of their small size they are commercially exploited only by pet food industries (Beaumariage, 1968). Eight species of *Etropus* are currently recognized. Of these, three occur along the Atlantic coast of the United States: *E. crossotus*; *E. microstomus* (Gill, 1864); and *E. rimosus* Goode and Bean, 1885.

We have discovered a new species similar to and broadly sympatric with *E. rimosus.* In addition, we have found that many published records for *E. microstomus,* including all records from the Gulf of Mexico, are based on misidentifications. Objectives of the study are to: 1) describe the new species of *Etropus,* 2) clarify systematics and geographic ranges of the other three species of *Etropus* occurring on the Atlantic coast of the United States and 3) compare and contrast their distributional ecology.

METHODS

Counts and measurements follow Hubbs and Lagler (1958) unless otherwise indicated. Measurements greater than 10 mm were made with a pair of dividers and a millimeter rule to the nearest 0.5 mm and measurements less than 10 mm with an ocular micrometer to the nearest 0.1 mm (some earlier measurements were made with dividers and a millimeter rule and expressed to the nearest 0.5 mm). All dorsal and anal rays were counted separately. Gill rakers

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of the first gill arch were counted on the ocular side; rudimentary gill rakers near angle of the arch were included in count of that limb of the arch with which they were most closely associated. Depth above lateral line is distance from first pored lateral-line scale to dorsal margin of body (exclusive of dorsal fin) perpendicular to a horizontal line between tip of upper jaw and middle of caudal-fin base. Fin-ray counts and measurements were taken for both ocular and blind sides. Vertebral counts, from radiographs, are expressed as precaudal plus caudal vertebrae, including urocentrum (e.g., 10 + 25). Body lengths are given as standard length, SL.

Specimens examined were borrowed from: American Museum of Natural History (AMNH); The Academy of Natural Sciences of Philadelphia (ANSP); California Academy of Sciences (CAS); Field Museum of Natural History (FMNH); Florida Department of Natural Resources Marine Laboratory, St. Petersburg (FSBC); Florida State University (FSU); Gulf Coast Research Laboratory Museum, Ocean Springs, Mississippi (GCRL); Grice Marine Biological Laboratory (GMBL); Harbor Branch Consortium, Fort Pierce, Florida (HBC); United States Bureau of Commercial Fisheries, Pascagoula, Mississippi (PML); Skidaway Institute of Oceanography, Georgia (SIO); The Florida State Museum, University of Florida (UF); University of Miami Marine Laboratory (UMML); University of North Carolina, Morehead City (UNC); University of South Alabama (USA); National Museum of Natural History (USNM); Virginia Institute of Marine Science (VIMS); University of Wisconsin Zoological Museum, Madison (UWZM). In the Specimens examined sections, the number of specimens is given in parentheses after the catalogue number for each lot and the names of research vessels which precede station numbers are abbreviated as follows: Silver Bay (SB), Combat (CO), Albatross (AL), Pelican (PE), Oregon (OR).

SYSTEMATICS

Etropus Jordan and Gilbert

Etropus Jordan and Gilbert, 1882:364; type species *E. crossotus* Jordan and Gilbert, 1882, by monotypy.

Diagnosis.—Mouth small, extending to or slightly beyond anterior margin of lower orbit (upper jaw 18–30% head length); jaw teeth developed more strongly on blind side than on eyed side, but generally feeble. Pelvic-fin bases about equal in length, placed asymmetrically with fin on eyed side attached along mid-abdominal ridge; lateral line relatively straight to slightly curved above pectoral fin, not strongly arched; gill rakers on lower limb of first arch 3–9, short, stout and simple, without upper margins dentate; and pectoral fin present on blind side. Eyes typically on left side in metamorphosed fish.

Comments.—The foregoing diagnosis is a synthesis of information in Gutherz (1967) and Topp and Hoff (1972). Form of the pelvic fins places *Etropus* in Paralichthyinae; therein, the relatively straight lateral line distinguishes *Etropus* from all genera except *Cyclopsetta* Gill, *Citharichthys* Bleeker and *Syacium* Ranzani. A small mouth and feeble dentition distinguish species of *Etropus* from most species of the latter three genera, but mouth size of *Citharichthys arctifrons* Goode is intermediate between *Etropus* and *Citharichthys.* It was because of this apparent intergradation that Parr (1931) synonymized *Etropus* with *Citharichthys.* Norman (1933, 1934) chose to recognize *Etropus* as separate from *Citharichthys* on the basis of its small mouth and feeble dentition which is developed mostly on the blind side (vs teeth well developed on both sides of the jaws in *Citharichthys*); most subsequent workers have followed Norman. It seems that Parr's (1931) classification is an equally viable hypothesis that deserves further study; Richardson and Joseph (1973) commented on this problem, but did not have the data needed to resolve it. There has never been a comprehensive study of the osteology of bothid flatfishes.

The nine species of *Etropus* can be divided into two groups, those with secondary scales on the primary scales and those without secondary scales. The group without secondary scales includes *E. crossotus* from the Atlantic coast of the United States, both coasts of Central America, and probably also the Atlantic coast of South America. Three other nominal taxa of this group have been described from the Atlantic coast of South America—*E. longimanus* Norman, 1933; *E. intermedius* Norman, 1933; and *E. delsmani delsmani* Chabanaud, 1940—and three from the Pacific coast of South America—*E. ectenes* Jordan, in Jordan and Goss, 1889; *E. peruvianus* Hildebrand, 1946; and *E. delsmani pacificus* Nielsen, 1963. *E. crossotus* and its neotropical congeners are in need of revision and such a study

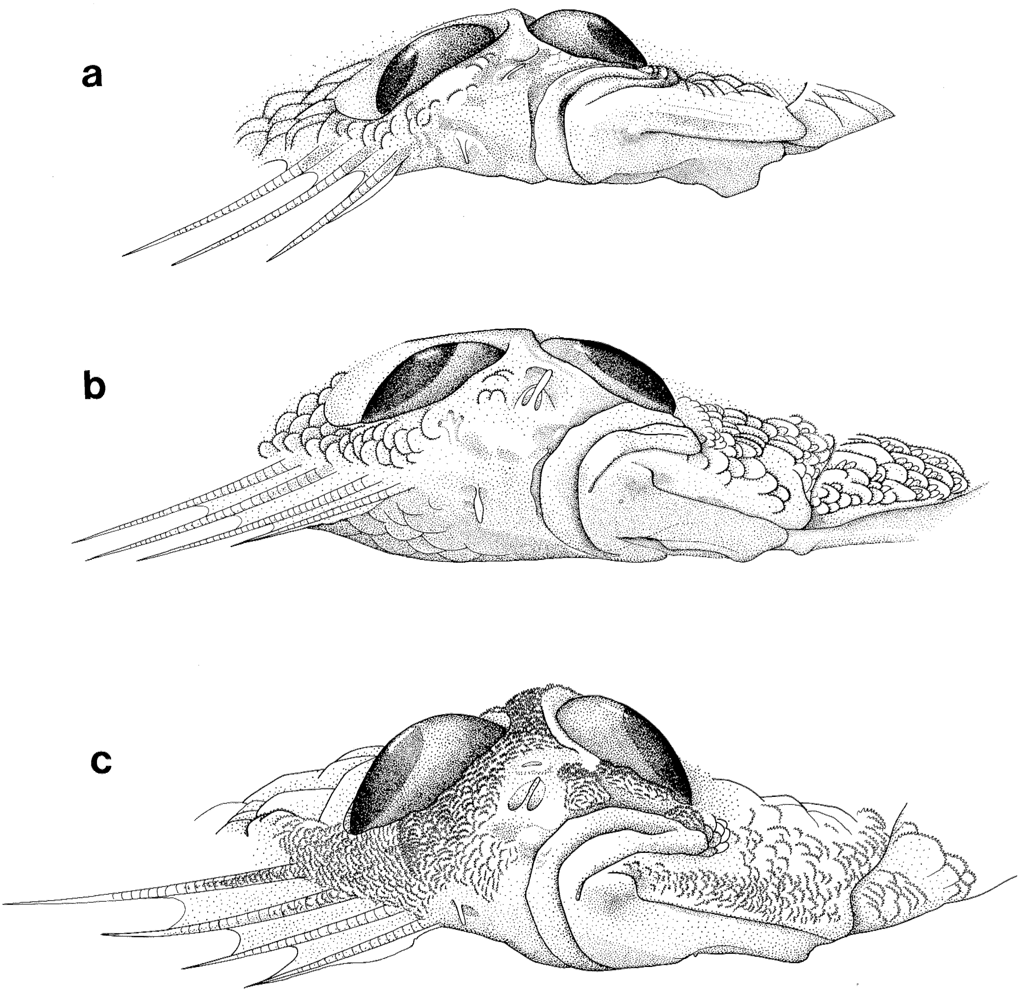

Fig. 1. Anterior view of head illustrating snout squamation and shape of the mandible in: a) *Etropus microstomus,* UWZM uncat., 90 mm SL, female; b) *E. cyclosquamus,* FMNH 87525, holotype, 90 mm SL, male; and c) *E. rimosus,* UWZM uncat., 92 mm SL, male.

is likely to result in synonymy of one or more nominal species. For example, Nielsen (1963) considers *E. intermedius* a synonym of *E. crossotus.* We cannot describe the full range of variation for *E. crossotus* or determine its southern limit of distribution until the neotropical species of *Etropus* have been revised.

The three species of *Etropus* with secondary scales are restricted to the Atlantic coast of the United States. The emphasis of this study is on this group, but comparable data for populations of *E. crossotus* from the eastern United States are included to make this study complete in a regional sense.

Identification.—*Etropus* as small as 30 mm SL can be identified with reasonable confidence, but smaller fish must be identified using a microscope. Squamation characters are important as indicated in the following key, yet scales of *Etropus* species, especially in juvenile fishes, are relatively deciduous so it is important to preserve these fishes carefully. Secondary squamation and scale cteni develop progressively as *Etropus* grow from about 30 mm SL to maturity at about 50 mm SL and cteni begin to develop at a smaller size in males than in females. Squamation characters used in the following key are easier to see if the fish has been in alcohol for at least a short period and if the scales are dried slightly with an air stream.

Key to the Species of *Etropus* on the Atlantic Coast of the United States

A. Accessory scales absent; gill rakers on lower limb of first arch 6–9, modally 7–8; without scales on snout; often with dark margin on caudal fin .... *E. crossotus* Jordan and Gilbert

AA. Accessory scales present; gill rakers on lower limb of first arch 3–6 (rarely 7); with scales on snout; without dark margin on caudal fin .... B

B. Mandible relatively symmetrical (Fig. 1a); accessory scales cover one-half or less of exposed surface of primary scales in fish larger than about 60 mm SL (Fig. 2); greatest body depth usually less than 50% SL; number of gill rakers on upper limb of first arch usually equal to or less than number on lower limb .... *E. microstomus* (Gill)

BB. Mandible not symmetrical (Fig. 1b, c); accessory scales cover three-fourths of exposed surface of primary scales in fish larger than about 60 mm SL (Fig. 2); greatest body depth usually more than 50% SL; number of gill rakers on upper limb of first arch usually exceeds number on lower limb C

C. Snout scaled forward of a line between eyed- and blind-side nostrils in fishes over 30 mm SL (Fig. 1c), cteni on snout scales highly modified, especially in large males (Fig. 2); primary scales of blind side ctenoid, but cteni may be indistinct on fish less than 50 mm SL; without dark circles on eyed side .... *E. rimosus* Goode and Bean

CC. Snout not scaled forward of a line between eyed- and blind-side nostrils (Fig. 1b), or rarely, 1–2 scales present in large specimens, cteni on snout scales simple (Fig. 2); primary scales of blind side cycloid; often with row of four to six small dark circles on eyed side above and below lateral line (Fig. 3), but circles may be indistinct on fish collected over dark substrate .... *E. cyclosquamus* n. sp.

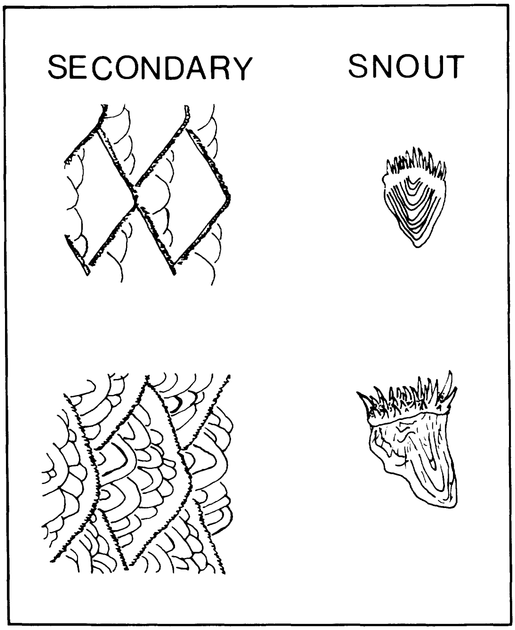

Fig. 2. Pattern of secondary squamation on eyed side of: (above) *Etropus microstomus* and (below) *E. rimosus* and *E. cyclosquamus.* Typical snout scale from: (above) *E. microstomus* and *E. cyclosquamus* and (below) *E. rimosus.*

Etropus **cyclosquamus**, sp. nov.
Shelf flounder
(Fig. 3)

Diagnosis.—Scales on blind side cycloid; primary scales on eyed side with accessory scales covering most of their surface; scales present on snout, rarely extending anterior to a line connecting anterior nostrils, cteni on snout scales simple. Upper limb of first gill arch typically with at least one more gill raker than lower limb; gill rakers on lower limb of first arch 3–6, modally 4–5. Mandible asymmetrical, upturned distally with noticeable symphyseal knob. Caudal vertebrae 23–25, modally 24. Color dusky gray to dusky brown, often with discrete dark rings arranged in two rows (above and below lateral line); in life, center of these rings often a light rust color.

Description.—Meristic and morphometric data are given in Tables 1 to 3. Body symmetrically pear-shaped, seldom attaining 104 mm SL; body depth usually greater than 50% SL; dorsal profile distinctly convex. Caudal fin rounded, its length about equal to head length (94–114%, average 102% head length). Primary scales ctenoid on eyed side, cycloid on blind side, with accessory scales covering most of their surface; snout scales with simple cteni, not in advance of anterior nostril; tubules of lateral line not branched. Mouth small, maxilla extending posteriorly only to anterior portion of lower orbit; mandible asymmetrical, mandibular symphysis

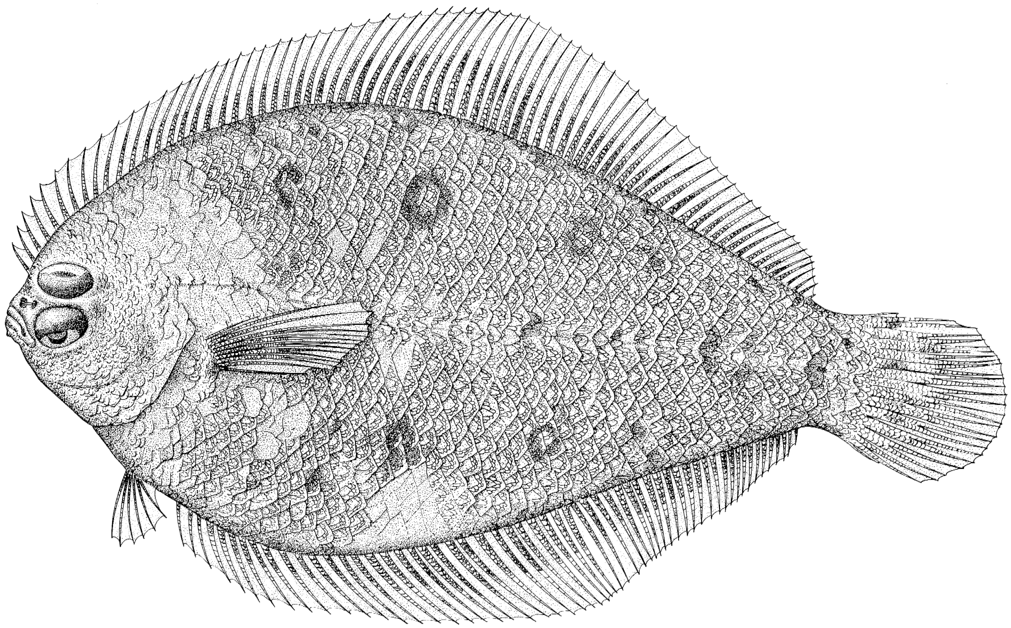

Fig. 3. Lateral view of *Etropus cyclosquamus*, FMNH 87525, holotype, 90 mm SL, male.

with distinct knob (Fig. 1b); jaw teeth conical, in single row, more pronounced on blind side; gill rakers short and stout. Anterior rim of lower orbit usually not in advance of upper orbit.

Eyed side usually dusky gray to light brown; often with discrete dark rings arranged in two rows, above and below lateral line (Fig. 3); center of rings often rusty colored in fresh material; development of rings variable and dependent on substrate at location of collection; three dark blotches usually present along lateral line, most distinct blotch about size of eye and located about one-third body length anterior to caudal-fin base; snout pigmentation rather diffuse; caudal fin dusky gray, sometimes with pair of diffuse, darker spots symmetrically arranged on proximal third; iridescent white pigmentation sometimes present on axillary region and anterior margins of dorsal and anal fins of fresh specimens and some of better preserved material. Blind side immaculate.

Distribution.—Just north of Cape Hatteras, North Carolina, to about Palm Beach on east coast of Florida and in Gulf of Mexico from about Fort Myers, Florida, to Mississippi; apparently rare or absent in southern Florida (Fig. 4). Clockwise rotation of the major oceanic currents in the Gulf of Mexico east of the Mississippi delta apparently precludes settlement west of the delta by the relatively offshore, pelagic eggs and larvae of *E. cyclosquamus.*

Specimens examined.—The types were all collected on the continental shelf off North Carolina on the University of Wisconsin's R/V EASTWARD cruises during Aug. (cruise #E5-77) and Oct. (#E8-77), 1977 (Fig. 4).

Holotype.—FMNH 87525, 90.0 mm SL, male, E5-77, Sta. 239, 35°1.4'N, 75°33.9'W, 31 m, 13 Aug.

Paratypes.—FMNH 87524 (32) 23.1–89.1 mm SL, and FMNH 87527–87534 (8) alizarin preparations, E5-77, Sta. 260, 35°5.7'N, 75°21.5'W, 30 m, 14 Aug.; FMNH 87526 (11) 37.7–81.1 mm SL, E5-77, Sta. 28, 35°5.7'N, 75°21.2'W, 31 m, 4 Aug.; FMNH 87542 (9) 28.0–79.0 mm SL, E5-77, Sta. 253, 35°1.6'N, 75°33.1'W, 32 m, 14 Aug.; FMNH 87535 (25) 62.5–87.5 mm SL, CAS 55894 (2), USNM 268481 (2) and ANSP 153541 (2), E8-77, Sta. 248, 35°32.8'N, 75°14.1'W, 32 m, 28 Oct.; FMNH 87536 (12) 59.5–89.5 mm SL, E8-77, Sta. 135, 35°29.8'N, 75°14.7'W, 32 m, 23 Oct.; FMNH 87537 (6) 68.2–89.7 mm SL, E8-77, Sta. 1, 34°34.0'N, 76°11.3'W, 36 m, 17 Oct.; FMNH 87538 (12) 54.1–71.7 mm SL, E8-77, Sta. 169, 35°3.2'N, 75°35.1'W, 30 m, 24 Oct.; FMNH 87539 (12) 59.0–73.3 mm SL, E8-77, Sta. 159, 35°3.9'N, 75°26.1'W, 30 m, 24 Oct.; FMNH 87540 (11) 56.5–79.1 mm SL, E8-77, Sta. 168, 35°3.8'N, 75°33.4'W, 29 m, 24 Oct.; FMNH 87541 (9) 54.9–84.0 mm SL, E8-77, Sta. 202, 35°16.1'N, 75°13.5'W, 28 m, 26 Oct.; UWZM 8592 (7) 60.0–70.0 mm SL, E8-77, Sta. 136, 35°29.8'N, 75°13.4'W, 34 m, 23 Oct.

The following specimens are excluded from the type series.

North Carolina.—UMML uncat. (4) 10 mi. south of Beaufort; UMML uncat. (1) SB 2923, 34°45'N, 75°57'W; UMML uncat. (2) SB 4002, 34°31'N, 76°03'W; UMML 10576 (1) CO 385, 34°46'N, 75°37'W; UMML uncat. (1) SB 1240, 34°38'N, 76°49'W; UMML uncat. (1) SB 3640,

TABLE 1. COMPARISON OF MORPHOMETRIC CHARACTERS FOR FOUR SPECIES OF *Etropus* FROM THE ATLANTIC COAST OF THE UNITED STATES. Values are in thousandths of standard length or head length (*) for adults greater than 69 mm standard length. Data for the types of *E. cyclosquamus* are based on FMNH 87525 (holotype), FMNH 87535 (15 of 31 paratypes) and FMNH 87537 (5 of 6 paratypes).

	cyclosquamus				*rimosus*		*microstomus*		*crossotus*	
Character (N)	Holotype	Paratypes (20)	Nontypes (95)	Mean	Nontypes (73)	Mean	Nontypes (77)	Mean	Nontypes (38)	Mean
SL, mm	90.0	69.0–89.7	69.5–104		69.5–111		69.5–117		70.5–115	
Body depth	537	492–557	468–605	527	506–591	546	405–506	462	526–599	564
Caudal-peduncle depth	142	121–146	119–156	138	126–156	143	107–133	120	121–147	137
Depth above lateral-line origin	178	160–191	146–210	182	169–238	200	128–173	148	140–210	175
Head length	228	236–253	216–261	240	217–262	237	206–254	233	193–239	218
Upper-jaw length (*)	229	214–247	222–286	250	209–302	250	214–294	260	180–264	254
Lower-orbit length (*)	288	264–295	274–356	308	275–378	317	239–312	273	218–297	256
Pectoral-fin length:										
Eyed-side	224	188–235	156–229	198	123–235	207	154–211	181	138–173	154
Blind-side	151	129–151	97–152	133	116–169	137	98–132	113	112–135	122

34°38'N, 75°49'W; UMML uncat. (1) SB 1239, 34°31'N, 76°03'W; UMML uncat. (1) CO 383, 22 mi. SSE of Cape Hatteras; UMML uncat. (1) SB 3620, 34°20'N, 75°57'W; USNM 143136 (3) Cape Hatteras, AL 2279, 35°20'55"N, 75°20'55"W; USNM 134256 (1) Cape Hatteras, 35°21'15"N, 75°23'15"W; USNM 156423 (1) off Cape Hatteras, AL 2295, 35°32'41"N, 75°04'30"W; USNM 143202 (6) vicinity of Cape Hatteras, AL 2265 or 2281, 37°08'–35°21'N, 75°W; USNM 148856 (4) Cape Hatteras, AL 2287, 35°22'30"N, 75°26'00"W; USNM 131283 (3) Cape Hatteras, AL 2290, 35°23'00"N, 75°24'30"W; UNC 6190 (2) between Beaufort and Cape Lookout; UNC 8090 (1) Beaufort; UNC 6441 (1) south of Beaufort; VIMS 00546 (3) 34°25.5'N, 76°19.5'W; UWZM uncat., material from University of Wisconsin's R/V EASTWARD cruises: 63 lots, 1094 specimens cruise #E2-77; 76 lots, 1110 specimens, cruise #E5-77; 66 lots, 374 specimens, cruise #E8-77; 47 lots, 454 specimens, cruise #E1-78.

South Carolina.—GMBL 73-313 (3) 33°39.8'N, 78°05.8'W; GMBL 73-298 (1) 32°12'N, 79°07'W; GMBL uncat. (1) Georgetown County, north inlet, 33°19.4'N, 79°9.6'W; GMBL 73-296 (1) 32°41'N, 79°40'W; UMML uncat. (5) SB 5424 32°57'N, 79°11'W; UMML uncat. (15) SB 5425, 32°55'N, 79°07.5'W.

Georgia.—UNC 3960 (2) 31°45'N, 80°45'W; SIO uncat. (8) 31°04.8'N, 79°53.5'W; USNM 156039 (2) PE 58.

East Florida.—FSBC 4361 (2) Ponce de Leon Inlet, New Smyrna-Edgewater; GMBL uncat. (1) SB 4259, 28°20'N, 80°15'W; UF 10235 (1) Flagler County; UF 11769 (1) 27°47.5'N, 80°13.5'W; UF 13242 (1) St. Johns County; UF uncat. (5) Bowers 108, Buoy 2, 28°49.6'N, 80°29.2'W; UMML uncat. (2) SB 5097, 27°50'N, 80°04.5'W; UMML uncat. (2) SB 2032, 28°26'N, 80°12'W; UMML uncat. (2) SB 3203, 28°33.5'N, 80°15.5'W; UMML uncat. (4) OR 5119, 28°33'N, 80°11'W; UMML uncat. (1) SB 3698, 28°20'N, 80°15'W; UNC 1558 (1) 29°38'N, 80°15'W; UNC 2864 (5) 28°17'N, 80°08'W; USNM 156291 (1) PE 168-3, 28°09.5'N, 80°12'W; USNM 126776 (1) Fernandina; USNM 156357 (1) PE 207-8, 28°21.5'N, 80°21.5'W.

Tampa-Tortugas, Florida.—FSBC 4408 (1) 27°35'N, 82°50'W; FSBC 6466 (2) 27°37'N, 83°07'W; FSBC 10363 (2) 8 mi. WSW Boca Grande Sea Buoy, Lee County; FSBC 9790 (1) 9–17 mi. WSW Boca Grande, Lee County.

Florida Big Bend.—FSU 17057 (7) off St. Andrews; FSU 18917 (1) St. Andrews; FSU 19456 (21) Okaloosa County, Choctawhatchee Bay; PML uncat., 7 lots, 33 specimens, St. Andrews Bay; UF 12044 (2) Levy County.

Perdido Bay, Florida.—USA uncat. (8) RLS 673-2 Perdido Bay; USA uncat. (11) Perdido Bay; USA uncat. (17) RLS 673-3, Perdido Bay.

Alabama.—FSU 20428 (8) 29°42'N, 88°00'W; FSU 20941 (2) 29°44.5'N, 88°00'W; USA uncat. (2) July 1, 1973; USA uncat. (4) July 1, 1973; USNM 155579 (1) 30°07'N, 88°14.5'W.

Mississippi.—GCRL 3013 (1) Mississippi Sound; GCRL 6512 (8) Mississippi Sound.

Etymology.—From the Latin *cyclus*, circle and *squama*, scale, in reference to the cycloid scales on the blind side which distinguish this species from *E. rimosus*.

Etropus rimosus Goode and Bean
Gray flounder
(Fig. 5a)

Etropus rimosus Goode and Bean, 1885:593 (type locality: eastern Gulf of Mexico, 28°28'N, 84°25'W, Albatross Station 2408, depth 38 m).

Diagnosis.—Scales on blind side ctenoid; scales on eyed side with accessory scales covering most of their surface; snout scales extend anteriorly

TABLE 2. COMPARISON OF COUNTS FOR MEDIAN-FIN RAYS AND LATERAL-LINE PORES IN FOUR SPECIES OF *Etropus* FROM THE ATLANTIC COAST OF THE UNITED STATES. Counts for the holotype of *E. cyclosquamus* (FMNH 87525) indicated by asterisks.

Species	Dorsal-fin rays																
	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
cyclosquamus			1		2	7	7	10*	18	16	12	12	8	1	1		
rimosus			1			2	1	10	10	15	20	9	5	1	1	1	
microstomus	1		1	2	1	3	12	11	10	9	9	8	5	3	2	1	
crossotus						1		1	2	6	10	8	4	3	2		1

Species	Anal-fin rays													
	53	54	55	56	57	58	59	60	61	62	63	64	65	67
cyclosquamus		1	4	6	8	14*	22	23	8	6	3	1		
rimosus	1			1	1	3	7	14	20	17	9	3		
microstomus	2	2	11	9	11	12	15	8	4	4				
crossotus					1		4	6	5	7	8	3	4	1

Species	Lateral-line pores									
	36	37	38	39	40	41	42	43	44	45
cyclosquamus	1	2	9	18*	27	13	15	2	5	4
rimosus	1	4	7	15	18	12	13	3	2	1
microstomus	1		4	7	10	13	19	18	5	1
crossotus			1	4	1	10	7	6	5	5

TABLE 3. COMPARISON OF COUNTS FOR GILL RAKERS, CAUDAL VERTEBRAE AND EYED-SIDE PECTORAL-FIN RAYS IN FOUR SPECIES OF *Etropus* FROM THE ATLANTIC COAST OF THE UNITED STATES. Counts for the holotype of *E. cyclosquamus* (FMNH 87525) indicated by asterisks.

Species	Gill rakers on upper limb							
	1	2	3	4	5	6	7	8
cyclosquamus				6	24*	41	24	2
rimosus					5	11	43	16
microstomus	2		11	33	27	5		
crossotus			5	17	14	3		

Species	Gill rakers on lower limb								
	1	2	3	4	5	6	7	8	9
cyclosquamus			1	67*	23	6			
rimosus				9	46	21			
microstomus				21	41	15	1		
crossotus						5	15	18	1

Species	Gill rakers on upper limb minus lower limb									
	−5	−4	−3	−2	−1	0	1	2	3	4
cyclosquamus				1	4	8	29*	37	17	1
rimosus					2	4	18	36	11	2
microstomus		2		12	32	23	8	1		
crossotus	3	13	6	15	2					

Species	Caudal vertebrae				Pectoral-fin rays			
	23	24	25	26	8	9	10	11
cyclosquamus	3	52*	21		1	34	27*	1
rimosus		7	31	5			30	17
microstomus		51	61	2		19	5	
crossotus[1]		3	81	21	4	29	4	

[1] Data in part from Tucker (1982).

beyond nostril to near premaxillary groove, with elaborate dorsally directed cteni (Fig. 2). Upper limb of first gill arch typically with at least one more gill raker than lower limb, lower-limb count 4–6, modally 5. Mandible asymmetrical, upturned distally, with noticeable symphyseal knob. Caudal vertebrae 24–26, modally 25. Color of adults typically dusky gray on eyed side, never with rows of discrete dark rings.

Description.—Meristic and morphometric data are presented in Tables 1 to 3. Body symmetrically pear-shaped, seldom attaining 110 mm SL; body depth usually greater than 50% SL; dorsal profile distinctly convex. Caudal fin rounded, typically longer than head length (96–125%, average 108% head length). Primary scales on eyed and blind sides ctenoid with accessory scales covering most of their surface; highly modified snout scales extend anteriorly almost to premaxillary groove; lateral-line tubules not branched. Mouth small, maxilla extending posteriorly only to anterior portion of lower orbit; mandible asymmetrical, mandibular symphysis with a distinct knob (Fig. 1c); jaw teeth conical, in a single row, larger on blind side; gill rakers short and stout. Anterior rim of lower orbit not in advance of upper orbit.

Eyed side usually dusky gray-brown; three dark blotches usually present along lateral line, most distinct of which is size of eye and located about one-third body length anterior to caudal-fin base; mottling variable but never in form of rows of light-centered dark rings; snout pigmentation rather diffuse; caudal fin usually with little or no pigmentation; iridescent white pigmentation sometimes present on axillary region and anterior margins of dorsal and anal fins of fresh specimens and some better preserved material. Blind side immaculate.

Distribution.—Just north of Cape Hatteras, North Carolina, to Florida Big Bend (29°01′N) in the Gulf of Mexico (Fig. 4). Collections from near Dry Tortugas, Florida, indicate the possiblity that Atlantic and Gulf populations are continuous. Borodin's (1928) record of young "*E. rimosus*" from Cuban waters are probably *E. crossotus.* No adult *E. rimosus* are known from Cuba and colonization by larvae spawned off Florida is unlikely due to predominantly northward-flowing oceanic currents between Cuba and Florida. The depth of the Florida Straits (730 m) may also prevent southward dispersal of adult *E. rimosus*; they have never been found in such deep water.

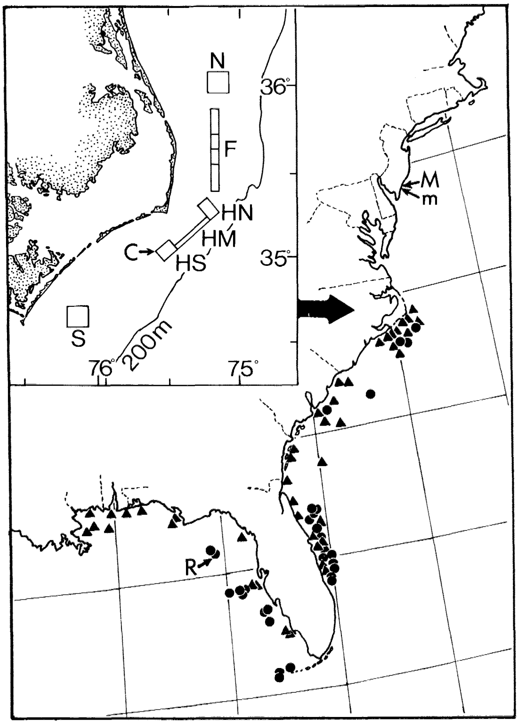

Fig. 4. Distribution of *Etropus cyclosquamus* (▲) and *E. rimosus* (●) on the continental shelf of the eastern United States. Localities plotted do not include material from the four R/V EASTWARD cruises (see Fig. 6 for details of distribution near Cape Hatteras). Inset shows detail of study area for the R/V EASTWARD cruises. Trawl samples were taken within the blocked areas labelled as follows: S = South, off Cape Lookout; HS = Hatteras-South, HM = Hatteras-Mid and HN = Hatteras-North, three grids spanning Cape Hatteras; f = Front, four strata spanning the typical location of the front between Gulf Stream and Virginian water masses; and N = North, northeast of Oregon Inlet. Location of type localities are also indicated for *E. cyclosquamus* (C, on inset), *E. rimosus* (R) and *E. microstomus* (M; *E. micros*, m, =synonym).

Comments.—Goode and Bean (1885) implied that their description of *E. rimosus* was based on more than one specimen and that the holotype was the 100 mm specimen of the series (USNM 37332). Parr (1931) indicated that the type series included two specimens which, together with two nontypes examined by him were "all measuring between 85 and 100 mm exclusive of the caudal fin." Efforts to locate the types at USNM were unsuccessful; presumably, they are lost. It seems likely that Goode and Bean (1895: plate CIV, fig. 360) would have illustrated the holotype, but the figure caption notes only "from

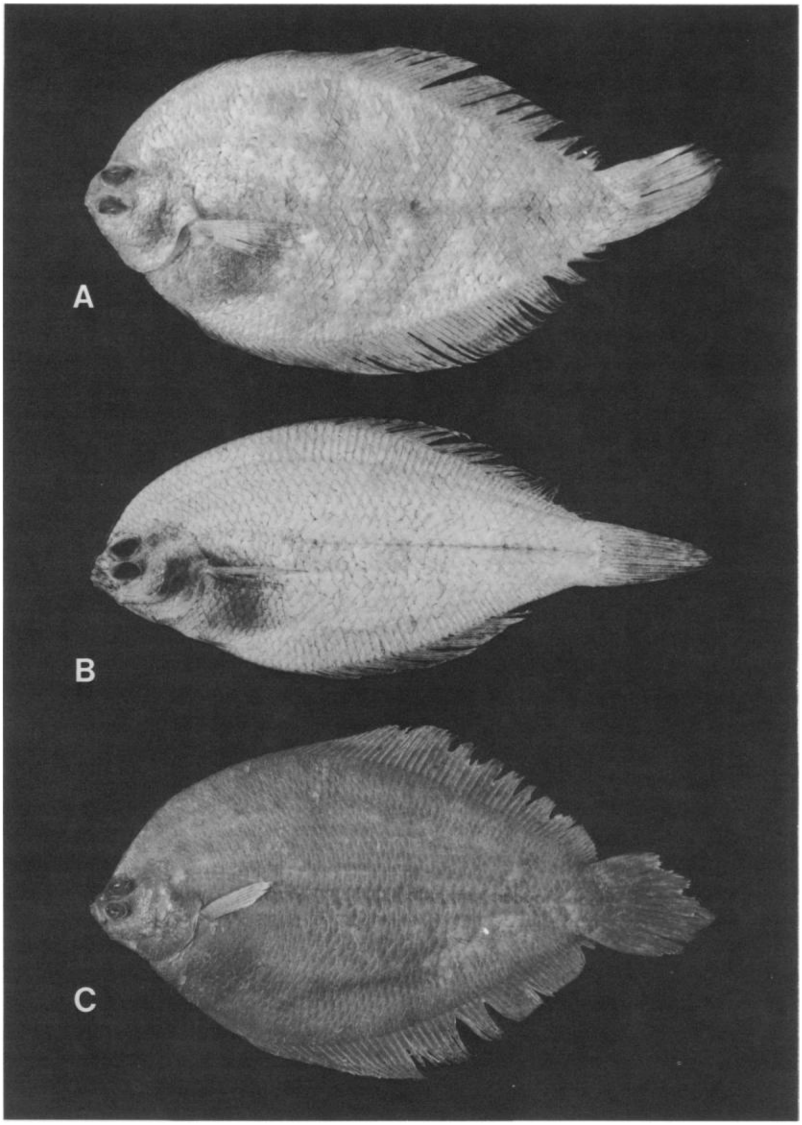

Fig. 5. Lateral views of : A) *Etropus rimosus*, UWZM uncat., 92 mm SL, male; B) *E. microstomus*, UWZM uncat., 90 mm SL, female; and C) *E. crossotus*, FMNH 40327, 114 mm SL, female.

type No. 37332." The illustration which was "enlarged about one-half," measures about 150 mm SL in agreement with the 100 mm holotype. Without knowing the size of the paratype, however, we cannot be absolutely certain that the holotype was illustrated.

The following data provided the basis for establishing the identify of *E. rimosus*. In the original description of *E. rimosus*, Goode and Bean (1885) stated that: 1) scales are "strongly pectinate" on both sides of the fish, 2) the head is entirely covered with scales and 3) normal scales are covered with "numerous small supernumerary scales." The latter feature (Figs. 2, 3; Goode and Bean, 1895: fig. 360; Parr, 1931: fig. 3) distinguishes *E. rimosus*, *E. cyclosquamus* and *E. microstomus* from all other known bothids; the first character (Parr, 1931: fig. 3) distinguishes *E. rimosus* from *E. cyclosquamus* and *E. microstomus*. The second character given above is at best a vague reference to another diagnostic feature for *E. rimosus*—extensively developed snout scales which extend forward to the maxillary groove (Fig. 1c; Parr, 1931; Goode and Bean, 1896: fig. 360). Parr (1931: fig. 2) was the first to describe the highly modified snout scales which are also diagnostic for *E. rimosus* (Fig. 2). Parr based his redescription of *E. rimosus* on the two types and two other specimens from 190 m depth off Cape Fear, North Carolina, implying that features described applied equally to all four specimens.

Specimens examined.—North Carolina.—UMML 10562 (2) CO 394; UMML 10563 (1) CO 392; UNC 2708 (1) Cape Lookout; UWZM uncat., material from University of Wisconsin's R/V EASTWARD cruises: 38 lots, 499 specimens, cruise #E2-77; 57 lots, 682 specimens, cruise #E5-77; 8 lots, 14 specimens, cruise #E8-77; 8 lots, 35 specimens, cruise #E1-78; illustrated specimens (Figs. 1, 5) from E5-77, Sta. 260, 30 m, 35°5.7'N, 75°21.5'W.

South Carolina.—USNM Acc. 272254 (1) SB 1693; USNM 151952 (2) off Cape I., AL III 14536 31-b, Station 7; USNM 44671 (2) AL 2417.

East Florida.—HBC 107-1414 (1); HBC 107-1421 (1); HBC 107-1420 (1); HBC 107-1407 (1); HBC 107-1415 (6); HBC 107-1416 (2); HBC 107-1418 (2); HBC 107-1412 (3); HBC 107-1404 (1); HBC 107-1417 (1); HBC 107-1406 (2); HBC 107-1405 (6); HBC 107-1417 (1); HBC 107-1413 (1); HBC 107-1409 (5); UF 12842 (1); UF 12843 (2); UF 12880 (6); UF 12860 (11); UMML uncat. (1) SB 2771, 29°11'N, 80°22'W, UMML uncat. (2) SB 3065, 27°36'N, 80°04'W; UMML 28686 (6) OR 5338; UMML uncat. (1) SB 5107, 27°59'N, 80°01'W; UMML uncat. (1) SB 2721, 27°40'N, 79°58'W; UMML 10564 (1) CO 488; UMML 10570 (4) CO 333, 28°58'N, 80°13'W; UMML uncat. (7) SB 5108, 28°02.5'N, 79°58.5'W; UNC 1562 (2); UNC 1556 (1); USNM Acc. 261501 (1) OR 5353 Cr. 99; USNM 156219 (1) PE 201-3; USNM 156189 (1) PE 176-6; USNM Acc. 261501 (1) SB 5357 Cr. 51; USNM uncat. (1) OR 5826; USNM 156308 (3) USFWS 204-1.

Tampa-Tortugas, Florida.—FSBC 5256 (2); FSBC 4609 (1); FSBC 3769 (1); FSBC 2718 (9) Station 9; FSBC 7751 (1); FSBC 5186 (2); FSBC 2915 (2); FSBC 4618 (1); FSBC 4494 (1); FSBC 2909 (1); FSBC 6479 (3); FSBC 4391 (8); FSBC 2707 (12); FSBC 5095 (83); FSBC 10386 (2); FSBC 9855 (2).

Florida Big Bend.—FSU 20888 (4); FSU 20361 (2); UMML 19282 (5) G-574; USNM Acc. 261501 (1) Hernan Cortez Station 147; USNM Acc. 275068 (19).

Etropus microstomus (Gill)
Smallmouth flounder
(Fig. 5b)

Citharichthys microstomus Gill, 1864:223 (type locality: Beesley's Point, New Jersey, by Baird).
Citharichthys micros Fowler, 1911:200 (type locality: Corson's Inlet, Cape May County, New Jersey, by R. J. Phillips, 17 Sept. 1910).

Diagnosis.—Scales on blind side cycloid; scales on eyed side with accessory scales covering less than half their surface; scales on snout with simple cteni, not extending anteriorly beyond anterior nostril (Fig. 1a). Upper limb of first gill arch typically with equal number or one less gill raker than on lower limb, lower-limb counts 4–7, modally 5. Mandible symmetrical, not upturned distally and without noticeable symphyseal knob (Fig. 1a). Caudal vertebrae 24–26, modally 25. Color of adults typically light brown, sometimes with olive-brown markings, but not forming discrete rings.

Description.—Meristic and morphometric data are presented in Tables 1 to 3. Body usually not symmetrically pear-shaped, seldom attaining 120 mm SL; antero-dorsal margin of body relatively flat or slightly convex; body depth usually less than 50% of SL. Caudal fin rounded, usually equal to or less than head length (89–103%, average 96% head length). Primary scales ctenoid on eyed side, cycloid on blind side, accessory scales cover one-half or less of their surface; scales on snout with simple cteni; lateral-line tubules not branched; mouth small, maxillary extending posteriorly only to anterior portion of lower orbit; mandible symmetrical, symphysis without knob (Fig. 1a); jaw teeth conical, in single row, larger on blind side; gill rakers short and stout. Anterior rim of lower orbit often slightly in advance of upper orbit.

Eyed side usually light brown; two or three dark blotches about size of eye usually present, equally spaced along lateral line; sometimes with olive-brown mottlings but these never forming discrete rings; snout pigmentation rather diffuse; often with diffuse dark spots in a row along proximal parts of dorsal and anal fins (Richardson and Joseph, 1973: fig. 8); iridescent white pigmentation present on axillary region and anterior margins of dorsal and anal fins of fresh specimens and some better preserved material. Body immaculate on blind side.

Distribution.—New York to North Carolina with occasional strays as far south as Florida; appears to migrate or disperse southward in winter. We have seen only four specimens from South Carolina and none from Florida, but W. Roumillat (pers. comm., South Carolina Wildlife and Marine Resources Department, Charleston) informs us that he has collected *E. microstomus* in South Carolina and northern Florida. Specimens from west of the Mississippi delta, the Caribbean and South America identified by previous workers as *E. microstomus* are all probably *E. crossotus* or one of the various nominal species of *Etropus* from South America. Tropical *E.*

crossotus often do not attain the robust body depth of subtropical or temperate specimens and could be confused with *E. microstomus.* We examined Fowler's (1915) specimen of "*E. microstomus*" from Trinidad (ANSP 45049) and identified it as *E. crossotus.* Regan's (1914) specimen of "*E. microstomus*" from Brazil was later designated holotype of a new species, *E. longimanus,* by Norman (1933). Specimens of "*E. microstomus*" from Fort Pierce, Florida, were examined and identified as *E. rimosus.* Other records of *E. microstomus* from Georgia (Fowler, 1935) and Florida (Borodin, 1934) should be rechecked.

Comments.—The holotype of *E. microstomus* (Gill), a specimen "little more than three inches long," was not illustrated by Gill (1864) and there is no evidence in the literature that the specimen has been examined by anyone since its original description. Gill did not mention where his type specimen was deposited and we were not able to locate it. Fortunately, the original description was sufficiently detailed to establish the identity of *E. microstomus,* at least among all bothids known to occur off New Jersey. The only uncertainty is the remote possibility that *E. cyclosquamus* could stray that far north. There is nothing in Gill's description that would unequivocably distinguish *E. microstomus* from *E. cyclosquamus.* The following features mentioned in Gill's (1864) description distinguish *E. microstomus* from all other known bothids (except *E. cyclosquamus*) when taken together: 1) mouth small, upper jaw 25% head length, 2) scales "covered with smaller ones, especially near the point of junction of contiguous ones," 3) cycloid scales on blind side and 4) body depth 36–37% total length. If further field work reveals that both *E. microstomus* and *E. cyclosquamus* occur off New Jersey, it may be necessary to designate a neotype for *E. microstomus* to clarify its systematic status.

Fowler (1911) described *C. micros* from New Jersey and compared his specimens to *C. arctifrons, C. unicornis* and *C. spilopterus* but not to any species of *Etropus.* Jordan et al. (1930) referred *C. micros* to the genus *Etropus.* Parr (1931) synonymized *C. micros* with *C. microstomus* without comment in spite of the fact that fin-ray counts given by Fowler for dorsal (62–67), anal (45–53) and pectoral (16 on left side) are mostly outside the range for *E. microstomus.* No bothid has 16 pectoral rays. We find that the holotype of *E. micros* (ANSP 37841) has $A = 59$, $P_1O = 9$ and $P_1B = 8$, which is similar to *E. microstomus.* The second lateral-line scale of the holotype has a small secondary scale on each side of the lateral-line tubule. These data combined with gill-raker count (2+6) and morphometric data presented by Fowler (1911) indicate that Parr was correct in synonymizing *E. micros* with *E. microstomus.*

Musick (1972) synonymized *Neoetropus macrops* Hildebrand and Schroeder (1928) with *E. microstomus,* attributing reported morphometric differences between the two nominal taxa to juvenile proportions of the small holotype of *N. macrops. N. macrops* was originally described as a pleuronectid on the basis of a single dextral (eyes on right side) specimen from Smith's Point, Virginia. Based on counts, measurements and a radiograph provided by B. Collette and J. Russo (NOAA Systematics Laboratory, USNM), we conclude that *N. macrops* is most likely a reversed *C. arctifrons.* The high anal-ray count (67) in combination with low body depth (31.8% of SL), large eyes (36.0% of HL) low caudal-peduncle depth (8.9% of SL) and high vertebral count (10+27) all support our conclusion. No accessory scales could be seen because almost all scales had been lost from the type specimen. *N. macrops* lacks the osseous protuberance on the snout characteristic of large *C. arctifrons*; however, this is often lacking in *C. arctifrons* similar in size to the type of *N. macrops* (42.8 mm). *N. macrops* is therefore removed from the synoymy of *E. microstomus.*

Specimens examined.—Holotype of *C. micros*: ANSP 37841, 47 mm SL, New Jersey, Corson's Inlet, Cape May County, 17 Sept. 1910. Paratypes of *C. micros*: ANSP 37842 (1) and 37850 (1), taken with the holotype.

New York.—AMNH 20088 (4); AMNH 33414 (1); AMNH 33416 (1); AMNH 17362 (2).

New Jersey.—AMNH 7796 (1); AMNH 20080 (12); ANSP uncat., 8 lots, 29 specimens, Cape May County; ANSP uncat. (2) McCries Shoal; ANSP uncat. (3) east of Wildwood; ANSP uncat. (2) Delaware Bay; ANSP uncat. (5) Atlantic County, 6 mi. north of Atlantic City; ANSP uncat. (9) east of Wildwood at five fathom bank; ANSP uncat. (4) Cape May County, Cold Springs Harbor; ANSP uncat. (6) Cape May County, near Cape May Point; USNM 118322 (24); USNM 118332 (6).

Virginia.—VIMS 00432 (3); VIMS 00211 (24).

North Carolina.—FSU 13447 (2); UNC 4831 (1); UNC 6405 (1); UNC 6442 (1); UNC 8496 (1); VIMS 00443 (2); VIMS 00427 (2); VIMS 00442 (1); VIMS 00440 (5); VIMS 00444 (7); UWZM uncat., material from University of Wisconsin's R/V EASTWARD cruises: 26 lots, 95 specimens, cruise #E2-77; 6 lots, 17 specimens, cruise #E5-77; 14 lots, 46 specimens, cruise #E8-77; 50 lots 656 specimens, cruise #E1-78; illustrated specimen (Figs. 1, 5) from E1-78, Sta. 131, 36 m, 35°57.0'N, 75°14.5'W.

South Carolina.—UMML uncat. (3) SB 5442, 32°49.5'N, 79°32'W; UMML uncat. (1) SB 5421, 32°48'N, 79°36.5'W.

Etropus crossotus Jordan and Gilbert
Fringed flounder
(Fig. 5c)

Etropus crossotus Jordan and Gilbert, 1882:364 (type locality: Astillero at Mazatlan, Pacific coast of Mexico).
Citharichthys crossotus atlanticus Parr, 1931:16 (orig. descr., no type designated).

Diagnosis.—Scales on blind side cycloid; primary scales on eyed side without accessory scales; snout without scales. Gill rakers on lower limb of first arch 6–9, modally 7–8. Mandible asymmetrical, slightly upturned distally, with noticeable symphyseal knob. Caudal vertebrae 24–26, modally 25. Color of adults generally uniform dark olive brown; often with dark distal margin on caudal fin. (This diagnosis may not distinguish *E. crossotus* from all of its nominal neotropical congeners.)

Description.—Meristic and morphometric data are presented in Tables 1–3. Body pear-shaped but antero-dorsal profile rather flat, reaching 115 mm SL (Parr, 1931, reports 153 mm SL for Pacific material); body depth usually greater than 50% SL. Caudal fin rounded, longer than head length (114–137%, average 123% head length). Primary scales ctenoid on eyed side, cycloid on blind side and devoid of accessory scales; lateral-line tubules branched; scales absent on snout. Mouth small, maxilla extending posteriorly only to anterior portion of lower orbit; mandible asymmetrical, mandibular symphysis with noticeable knob; jaw teeth conical, in single row, larger on blind side; gill rakers short and stout. Anterior rim of lower orbit usually in advance of upper orbit.

Eyed side usually uniform dark olive brown; two to three dark blotches along lateral line sometimes present; eyed and blind side of snout usually darkly pigmented; iridescent white pigmentation present on axillary region, and anterior margins of dorsal and anal fins of fresh specimens and some better preserved material. Blind side immaculate.

Distribution.—Virginia to the Gulf of Mexico, Caribbean Islands and Atlantic and Pacific coasts of Central America; probably to northern South America in Atlantic and Pacific but southern limits of the range are uncertain.

Comments.—*E. crossotus* was originally described from the Pacific coast of Mexico (holotype = USNM 28124); however, Nielsen (1963) reported that the holotype does not exist and was probably destroyed in a fire at Indiana University in 1883. Parr (1931) compared Pacific and Atlantic populations of *E. crossotus* and designated the latter as a new subspecies, *E. c. atlanticus,* on the basis of its having relatively isometric change in body depth with increasing size versus positive allometry of body depth in the Pacific population. Unfortunately, Parr did not designate a type series for his new taxon or list materials used for his analysis. Most subsequent workers (Briggs, 1958, and Moe and Martin, 1965, are exceptions) have chosen not to recognize the taxon *atlanticus* (e.g., Norman, 1934; Gutherz, 1967), yet Parr's hypothesis of two subspecies has never been evaluated critically.

Specimens examined.—North Carolina.—FMNH 40327 (1); USNM uncat. (1) SB 5664, 34°56.5′N, 75°44′W; UWZM uncat., material from University of Wisconsin's R/V EASTWARD cruises: 1 lot, 1 specimen, cruise #E2-77; 2 lots, 2 specimens, cruise #E5-77; 1 lot, 1 specimen, cruise #E8-77; 1 lot, 1 specimen, cruise #E1-78.

East Florida.—HBC 107-1408 (1); HBC 107-1410 (1); HBC 107-1411 (3).

Florida Big Bend.—FSU 18383 (8); FSU 23478 (2); FSU 23496 (2); FSU 26864 (17).

Perdido Bay, Florida.—USA uncat. (10) Perdido Bay.

Alabama-Mississippi.—UMML 10610 (1).

Distributional Ecology

Methods for ecological analyses.—Some 615 bottom-trawl samples were taken on the continental shelf off North Carolina (by DJS and colleagues from the University of Wisconsin, Madison) as part of a detailed study of the distribution of fishes and benthic macroinvertebrates in relation to the Gulf Stream front (Magnuson et al., 1981). These were taken using Duke University's R/V EASTWARD on cruises during June (N = 157 trawl samples), Aug. (N = 169) and Oct. (N = 161), 1977 and January (N = 128), 1978. Each sample was a 15 min haul (bottom time) of a semiballoon otter trawl with 9.43 m headrope, 11.6 m footrope, 3.8 cm stretch-mesh body and 0.6 cm stretch-mesh codend liner. Most *Etropus* (5,088 of 6,760 specimens, 75%) were preserved in formalin in the field and identified in the laboratory. Many of the discarded specimens could be identified in the field, but at a few stations, random subsamples of large catches of *Etropus* were preserved

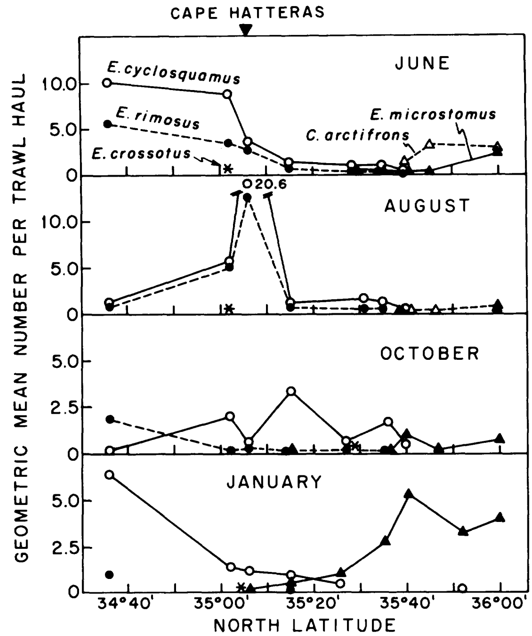

Fig. 6. Distribution of four species of *Etropus* and *Citharichthys arctifrons* with respect to latitude at four different times of the year on the continental shelf off North Carolina. Samples were taken by bottom trawl and mostly along the 30 m depth contour.

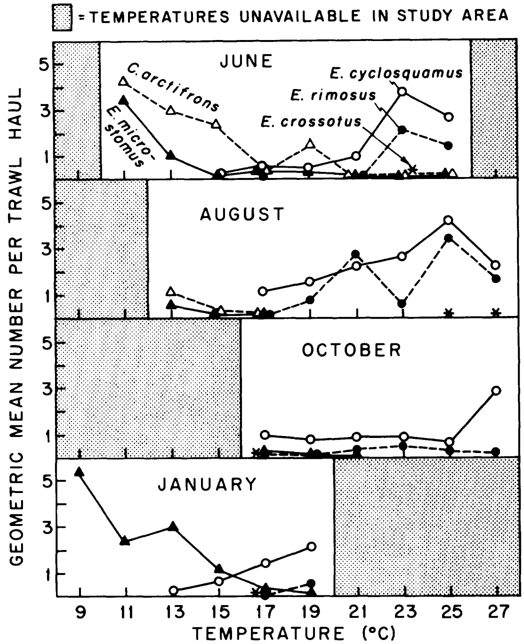

Fig. 7. Distribution of four species of *Etropus* and *Citharichthys arctifrons* with respect to temperature at four different times of the year on the continental shelf off North Carolina. Samples were taken by bottom trawl and mostly along the 30 m depth contour.

and species composition of the catch was estimated from the subsample.

The original sampling design called for nine day and nine night samples from each of five geographically fixed study grids (Fig. 4: S, HS, HM, HN and N) on each of the four cruises mentioned above. For sampling near the Gulf Stream front (Fig. 4: F), about 70 trawl samples were taken on each cruise by trawling parallel to isotherms and thereby distributing effort across the various water temperatures available. Bottom-water temperatures estimated for each trawl sample were based on bathythermograph (BT) casts taken with each sample. In the frontal area, values from BT casts taken at the start and end of each trawl haul were averaged, or a continuous reading from a thermistor mounted on the trawl was periodically subsampled and values averaged.

To evaluate seasonal changes in latitudinal distribution of the four species of *Etropus* and the superficially similar bothid *C. arctifrons*, trawl catches for each cruise were averaged by computing geometric mean catch from within each of the blocked areas in Fig. 4 (inset), regardless of water temperatures. Catch data were transformed to ln(X + 1) where X is number of individuals per trawl haul of the species being considered; means were then computed and retransformed to geometric means by taking the antilog and subtracting one. These values were plotted in Figure 6 at the average latitude of the samples taken in each stratum. Only one of the geometric means in Figure 6 was based on less than six trawl hauls and 80% were based on over ten samples (N varied from 3–36). Total catches of *Etropus* were 2,412 specimens in June, 2,565 in Aug., 632 in Oct. and 1,150 in Jan. (see Specimens Examined sections for number of specimens preserved for each species). Confidence limits for each mean were not plotted because they would confound the already crowded plots and the relatively qualitative inferences presented below do not hinge on small differences between means.

To evaluate seasonal changes in distribution with respect to temperature for the same five species, the series of trawl samples discussed above was restratified by temperature, regardless of geographic location. Geometric mean catch was then computed for each species in each 2 C temperature stratum (Fig. 7, values were plotted at the midpoint of each 2 C stratum). All geometric means plotted in Fig. 7 were based on at least seven trawl samples and 80% had more than ten.

Results and discussion of ecological analyses.—*E. cyclosquamus* was most abundant south of Cape Hatteras in Aug. and just north of the Cape in Oct. (Fig. 6). In Jan., greatest abundance was again south of the Cape. The northern limit for *E. cyclosquamus* was near 35°40′N latitude, which was close to the typical location of the front between Gulf Stream and Virginian water masses during warmer months of the year (Herbst et al., 1979; Magnuson et al., 1981). Most *E. cyclosquamus* were collected at water temperatures of 17 C or greater, but a few individuals were found in water as cool as 15 C in June and 13 C in Jan. (Fig. 7). Their greatest abundance during each sampling period was at or near the warmest temperature available in the study area. From these data, we infer that *E. cyclosquamus* may move north of Cape Hatteras during warmer months of the year and migrate southward again in late fall. Alternatively, these apparent movements could have resulted, in part, from inshore-offshore migrations. Reduction in numbers of individuals north of Cape Hatteras between Oct. and Jan. also could have been due to mortality from environmental stress or predation.

The distribution of *E. rimosus* was nearly identical to that of *E. cyclosquamus* (e.g., northern limit near 35°40′N, minimum water temperature 17 C), but *E. rimosus* was generally less abundant than *E. cyclosquamus* (Fig. 6). In Oct. and Jan., *E. rimosus* all but disappeared from Cape Hatteras and areas northward. From this comparison of seasonal changes in distribution, we infer that *E. cyclosquamus* may be more eurythermal (or eurytopic) than *E. rimosus.*

A comparison of relative abundance of *E. cyclosquamus* and *E. rimosus* in various depth intervals based on a composite of data from materials in various museums (Fig. 8) reveals that *E. cyclosquamus* was most abundant at depths of 10–30 m. In contrast, *E. rimosus* was most abundant at depths of 30–60 m. This apparent depth segregation was independently confirmed by W. Roumillat (per. comm., South Carolina Wildlife and Marine Resources Department, Charleston) who used a draft of the key to species presented above to identify catches from his trawling survey off the coast of South Carolina. These

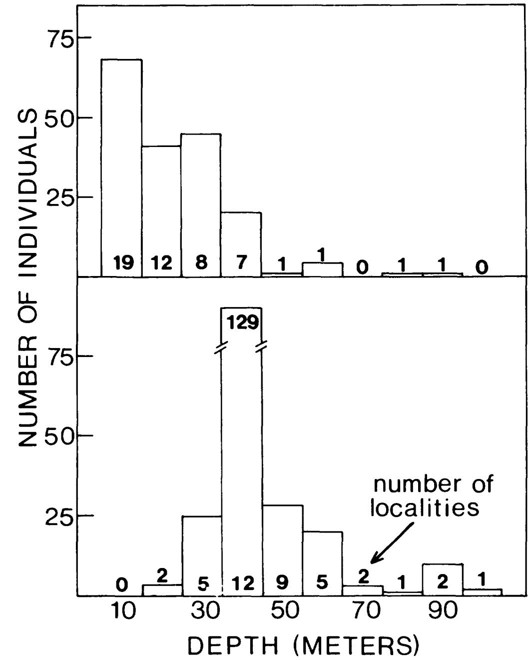

Fig. 8. Relative abundance of *Etropus cyclosquamus* (above) and *E. rimosus* (below) in various depth intervals on the continental shelf of the eastern United States. Values on the depth axis represent the midpoint of 10 m depth intervals. Localities (or lots) included are essentialy those plotted in Fig. 4; they represent a large proportion of specimens deposited in various museums (exclusive of materials from the four R/V EASTWARD cruises).

data also support the inference that *E. cyclosquamus* is more eurythermal than *E. rimosus* because shallower, nearshore waters are more strongly influenced by seasonal temperature cycles, whereas, the more offshore habitat of *E. rimosus* is influenced throughout the year by northward-flowing, tropical currents. Habitat segregation of these two species is most noticeable in the Gulf of Mexico (Fig. 4) where *E. cyclosquamus* closely follows the shoreline from southern Florida to Mississippi and *E. rimosus* occurs farther offshore with its northern limit on the North Florida Shelf as defined by Topp and Hoff (1972:104, fig. 37).

Distributions of *E. microstomus* and *C. arctifrons* off North Carolina are largely complementary to *E. cyclosquamus* and *E. rimosus* (Fig. 6), with an interface at or near the typical position of the Gulf Stream front (35°40′N) during June and Aug. The sharp decline in abundance of *E. microstomus* and *C. arctifrons* from the study

TABLE 4. NUMBER OF FEMALES WITH CLASS 2 OOCYTES (TOPP AND HOFF, 1972) VS TOTAL NUMBER OF FEMALES 50 MM SL AND LARGER EXAMINED FOR FOUR SPECIES OF *Etropus*. Data for *E. crossotus* include summarized results from reports of occurrence of larvae and ripe females by Moe and Martin (1965) and Tucker (1982).

Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
cyclosquamus												
Total ripe	12	3	3	11	—	—	3	0	1	1	1	0
Total females	17	4	3	21	—	—	6	12	22	12	3	8
rimosus												
Total ripe	—	3	—	2	13	4	3	—	0	0	—	4
Total females	—	3	—	2	13	5	3	—	1	1	—	4
microstomus												
Total ripe	0	—	—	0	—	2	—	12	2	22	20	0
Total females	13	—	—	11	—	9	—	18	6	28	22	6
crossotus						X	X	X	X	X	X	

area may have been due to migration out of the area in response to progressive erosion of cold-water habitat as the year progressed (Fig. 7). *E. microstomus* had returned to the study area in abundance by Jan. and presumably, *C. arctifrons* returned later in the winter. We infer from these results that *E. microstomus* may be relativley more eurythermal than *C. arctifrons.* This inference is supported by the observation that *E. microstomus* is distributed from near shore to about 37 m depth (Richardson and Joseph, 1973); distributional ecology of these two species is, in many ways, analogous to the situation with *E. cyclosquamus* and *E. rimosus.*

Representatives of *E. microstomus* apparently extend their range southward during the late fall and winter. The occurence of both *E. microstomus* and *C. arctifrons* in water as warm as 25 C during June (Fig. 7) may reflect stragglers from their winter distributions, but also reflects, in part, rapid day-to-day movements of the Gulf Stream front which may overrun relatively sedentary organisms (Magnuson et al., 1981). It is not known whether most of these stragglers eventually migrate northward (or offshore) to cooler bottom waters or perish. The occurrence of a few *E. microstomus* as far south as Florida suggests that they can survive in warmer waters, but perhaps they do not reproduce there.

Specimens of *E. crossotus* were relatively uncommon in the study area, but at least one specimen was collected on each cruise. All were collected between Hatteras-South and the warm side of the front (Figs. 4, 6); like *E. rimosus,* none were collected at water temperatures cooler than 17 C (Fig. 7). The area between Hatteras-South and the front is best characterized as a seasonally unstable, mixing zone between northern and southern water masses and associated faunas (Cowden and Stewart, unpubl. data). The occurrence of *E. crossotus* in that area is perhaps consistent with its predominantly southern nearshore and estuarine distribution (Dahlberg, 1975; Wenner et al., 1982).

Smith et al. (1975: figs. 20–22) reported large numbers of *E. microstomus* larvae on the shelf off Raleigh Bay, North Carolina and suggested that larvae had been transported there by the Gulf Stream. These larvae were collected predominately in Nov. through Feb. which contrasts with the observation that most *E. microstomus* of the Middle Atlantic Bight spawn from June to Oct. (Richardson and Joseph, 1973; Smith et al., 1975: figs. 17–19). Smith et al. (1975) inferred that *E. microstomus* south of Cape Hatteras were spawning during winter. Identification of the Raleigh Bay material should be rechecked because the few adult *E. microstomus* known from south of Cape Hatteras were all taken near shore. Specimens of *E. cyclosquamus* and *E. rimosus,* on the other hand, are abundant on the shelf south of Cape Hatteras and appear to spawn primarily during winter (Table 4).

It is clear from the above that species of *Etropus* of the eastern United States are at least partially segregated from each other by depth and along temperature (and correlated salinity, etc.) gradients. It also appears that differences in season and location of spawning may help prevent introgression of some of the species. Available data are not sufficient to determine if *E. cyclosquamus* and *E. rimosus* differ in timing of peak spawning, but it seems likely that distribution of their larvae will show segregation by depth (or distance from shore) similar to that of their respective adults. The best approach to finding distinguishing features for their larvae should be to compare nearshore and offshore winter larvae. When larvae for the latter two species can be distinguished, a precise analysis of spawning times and areas will be possible.

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