PLEURONECTIFORMES Flatfishes

This section of the guide includes 21 species in five families of Pleuronectiformes which occur in the western North Atlantic (see table, p. 347).

Larval characteristics

- Larval stage can be prolonged; some reach large size before transformation.
- Midbrain protrudes dorsally to varying degrees.
- Gut coiled, bulging out from body outline; preanus length usually <50% SL.
- Dorsal and anal fins usually long-rayed and long-based, with high ray counts; dorsal fin extends from head to base of caudal fin.
- Other special characters include elongate rays, spines on head, preopercle, opercle and scales.
- Body symmetrical and compressed, then marked transformation during which one eye migrates to other side of head, gut is pulled to within ventral body outline, pectoral fin shrinks and pectoral rays form, and pigment increases on eyed (ocular) side.

Family differences

	Bothidae- Scophthalmidae	Pleuronectidae	Soleidae	Cynoglossidae
Oil globules	1 to 2-3	None	Multiple	Multiple
Elongate rays	Often	None	Possible	Possible
Preanus length	About 50% TL (decreases)	About 40% TL (most)	40 to about 50% TL	About 40% TL
Protruding midbrain	Slight (most)	Slight (most)	Prominent	Prominent
Mouth	Terminal	Terminal	Lateral	Oblique, twisted
Eye migration	Right to left	Left to right	Left to right	Right to left
Transformation size	Most <15 mm, (few larger S. of 35° N)	18–35 mm ^ª 7–16 mm ^b	3–5 mm	About 10 mm

^a Boreal-temperate species.

^b Temperate species.

Flatfishes

PLEURONECTIFORMES

				Larval size (mm)		 mm)
		Fin_r	ays	At	At	At trans-
Family/Species	Vertebrae	Dorsal	Anal	hatch	flexion	formation
Scophthalmidae						
Scophthalmus aquosus	34–36	63–73	4 6 –56	~2.0	\sim 5.5	~6.5+
Bothidae						
Hippoglossina oblonga ^a	41-42	71-86	58-72	~2.9	6-8	10-12+
Paralichthys dentatus	41-42	80-96	61-73	~2.5	9–10	9 –13
Citharichthys arctifrons	36–39	75-87	58-71	b 	5–9	13–15
Etropus microstomus	34–35	67–84	50–63	ь 	5-7	10–12
Syacium papillosum	35–36	7 9 -94	6275	b	5–7	15–22
Cyclopsetta fimbriata	36-37	78–87	5 9- 67	ь. 	58	14–15
Bothus ocellata	35–37	76-91	58-68	^b	6–7	9 –42 [°]
Monolene sessilicauda	45-48	92-109	76-89	b	8-12	>33
Engyophrys senta	37–39	71-85	60-69	, b	4.5-6.5	1 9– 20
Trichopsetta ventralis	40-41	89-95	69–75	ь ^b	6–10	28–36
Pleuronectidae						
Glytocephalus cynoglossus	58-60	97-117	86-102	4-6	14-20	22-35
Hippoglossoides platessoides	45-48	78-98	60-79	46	9–19	18–34
Hippoglossus hippoglossus	50-51	98-106	69-84	6-7	13-24	20-34
Reinhardtius hippoglossoides	61-63	92-104	66-80	≥7	17-36	≥30
Limanda ferruginea	40–44	73-91	5168	2.0-3.5	5-10	~14
Liopsetta putnami	34-38	48-59	35-41	3.0-3.6	~6–7	7–13
Pseudopleuronectes americanus	34-40	60–76	44–58	~2.4	5.0-7.6	7–13
Soleidae						
Trinectes maculatus	2829	50-56	36-46	1.7-1.9	~3.8	<5
Achirus lineatus	25–27	47-58	35–44	<2	3-4	3–5
Cynoglossidae						
Symphurus plagiusa	4648	85-92	6 9 -78	<1.3	6.0-8.5	~10

Meristic and other characters

^a (=Paralichthys oblongus).
 ^b Egg and hatchling undescribed,
 ^c Most transform at 16-21 mm.

PLEURONECTIFORMES

Flatfishes

Position of pelvic fins at flexion in 17 genera



Ref. — Norman 1934; Gutherz 1967, 1970; Futch and Hoff 1971; Richardson and Joseph 1973; Futch 1977; Hensley 1977.

Flatfishes

PLEURONECTIFORMES

	Citharichthys, Etropus, Cyclopsetta, Paralichthys, Hippoglossina, Syacium	Bothus, Trichopsetta, Engyophrys, Monolene
Body	Relatively thick, short	Thin, diaphanous
Transformation size	<15 mm	>15 mm
Air bladder disappears	During transformation	Before transformation
Eye migrates	Anterior to dorsal fin origin (except <i>Cyclopsetta</i>)	Under dorsal fin origin (includes Cyclopsetta)
Spines	Opercle; sometimes post- temporals and frontals	Absent or only urohyal, basipterygia, cleithra, otic
Elongate rays	0-11 anterior dorsal rays, usually pigmented sheath	1st or 2nd dorsal ray; some- times pigmented sheath
Pigment	Relatively heavy	Relatively light
Posterior basiptervoium process	Short	Long, extending almost to vent

Larval characters in genera of family Bothidae

Caudal formulae in genera of family Bothidae

Counts are ventral to dorsal. Each number indicates number of principal rays associated with the haemal spine of PU_2 , each of the four hypural elements (four hypurals plus one epural in *Paralichthys* and *Hippoglossina* where H₅ and EP not fused), and the neural spine of PU_2 .

Genus			Fo	rm	ula	_	
Paralichthys	1	2	5	6	2	1	1
Hippoglossina	1	3	4	5	3	1	1
Citharichthys	0	4	4	5	4	0	
Etropus	0	4	4	5	4	0	
Syacium	0	4	4	5	4	0	
Cyclopsetta	0	4	4	5	4	0	
Bothus	1	4	3	4	4	1	
Engyophrys	1	3	4	5	3	1*	
Trichopsetta	1	3	4	5	3	1*	
Monolene	1	3	4	5	3	1*	



* Illustrated diagrammatically.

Temporal and spatial distribution (Smith et al. 1975)

Most species spawn within narrow temperature ranges. Spawning in spring proceeds from south to north, and spawning in autumn from north to south. Bothids have longer spawning seasons than pleuronectids. Most bothids spawn in southern part of Middle Atlantic Bight from spring through autumn, whereas pleuronectids spawn in the northern part of the bight in spring.

Ref. — Woolcott et al. 1968; Gutherz 1970; Richardson and Joseph 1973; Evseenko 1977a; Futch 1977; Hensley 1977.

PLEURONECTIFORMES Flatfishes

Temporal and spatial distribution (cont'd)

Scophthalmidae

— Scophthalmus aquosus. Spawning in spring and also in autumn south of Chesapeake Bay, summer to fall peak off New Jersey, into December from southern New England to Virginia, with most late spawning activity off New Jersey. Most larvae are collected over inshore half of continental shelf off New Jersey, but larvae are present throughout entire Middle Atlantic Bight at certain times of the year.

Bothidae

- -- Hippoglossina oblonga. Spawning from May through summer into autumn. Most larvae are found from southern New England to New Jersey over mid-depths on continental shelf.
- Paralichthys dentatus. Spawning occurs from late summer to mid-winter. Larvae are concentrated from Southern New England to New Jersey, mostly over inshore half of continental shelf but extend to shelf edge.
- Citharichthys arctifrons. Spawning from spring through summer into autumn. Larvae are found over offshore half of continental shelf with concentrations from southern New England to Virginia. Also, larvae found on the Scotian Shelf (Markle et al. 1980).
- Etropus microstomus. Spawning from June into autumn north of Cape Hatteras and throughout the year south of Cape Hatteras. Most larvae found off Virginia Capes and near Cape Hatteras over mid-depths on continental shelf, but some extend into southern New England waters.
- Syacium papillosum. Spawning from spring through summer into autumn. Larvae found over offshore edge of continental shelf and Gulf Stream waters near Cape Hatteras.
- Cyclopsetta fimbriata. Spawning from April to autumn with peaks in June and September. Larvae common near Cape Hatteras.
- Bothus ocellatus. Spawning throughout the year. Most larvae found between Chesapeake Bay and Cape Hatteras, but few more northerly near continental shelf edge and in Gulf Stream waters.
- Monolene sessilicauda. No spawning north of Cape Hatteras, although adults range to New England. Larvae collected during spring and summer near Cape Hatteras.
- Engyophrys senta and Trichopsetta ventralis. No evidence of spawning north of Cape Hatteras, but larvae may occur as strays carried by the Gulf Stream.

Pleuronectidae

- Glyptocephalus cynoglossus. Spawning from May to August on Georges Bank, and from March to April north to Newfoundland. In Middle Atlantic Bight, most larvae over offshore part of continental shelf off Long Island.
- Hippoglossoides platessoides. Spawning in spring. Larvae in Middle Atlantic Bight restricted to southern New England waters.
- Hippoglossus hippoglossus. Spawning from January to June. Larvae occur from Georges Bank north to subarctic waters.
- Reinhardtius hippoglossoides. Spawning from spring through summer. Larvae occur from Georges Bank north to subarctic waters.
- Limanda ferruginea. Spawning from spring through summer. Larvae abundant from western Gulf of Maine south to New Jersey.
- Liopsetta putnami. Spawning in late winter to early spring. Larvae occur in estuaries and coastal areas from Rhode Island to northern Labrador.

 — Pseudopleuronectes americanus. Spawning in late winter to spring. In Middle Atlantic Bight, larvae found nearshore from southern New England to Chesapeake Bay.

Soleidae and Cynoglossidae

 Larvae of these families occur near Cape Hatteras, are presumably spawned in the South Atlantic Bight and transported north by the Gulf Stream; *Trinectes* spawns in estuaries.

Family Pleuronectidae

The figure below illustrates correlation of ranges of dorsal and anal fin ray and vertebral counts. Species numbered 1–3 exhibit relatively low numbers of dorsal and anal fin rays and vertebrae, and small sizes at flexion and transformation. Species numbered 4–7 have higher numbers of dorsal and anal fin rays and vertebrae, and larger sizes at flexion and transformation. A similar figure for Bothidae was not prepared due to overlapping meristic characters in most species.



SCOPHTHALMIDAE Scophthalmus aquosus (Mitchill)

Spawnii	ng: Spring to autumn.	Meristic features
Eggs	 Pelagic, spherical. Diameter: 0.95-1.05 mm. Shell: smooth. Yolk: homogeneous. Oil globules: 1 or multiple. O.G. diameter: 0.16-0.20 (when 1). Perivitelline space: narrow. 	Myomeres: 34–36 Vert: 11+23–25 D: 63–73 A: 46–56 Plv: 6/6 P: 11
Larvae	 Hatching occurs at about 2 mm. 	

- Body deep, especially in gut area, and compressed; preanus length <50% TL.
- Flexion begins at about 5.5 mm; transformation occurs at relatively small size, beginning at about 6.5 mm TL.
- Pectoral fin rays form after transformation; all fin rays complete at about 8.5 mm TL; no elongate rays.
- Pelvic fins unequal in size, both bases long with left longer, both origins on urohyal, left base on ventral midline, right base above midline.
- Pigmentation: early larvae heavily pigmented from head to midtail, with posterior 1/3 unpigmented; in late larvae, bars of pigment form and extend onto fins, with pronounced contrast between pigmented and unpigmented areas; compare to early stages of Tautoga onitis (Labridae, p. 292).





BOTHIDAE Hippoglossina oblonga (Mitchill)

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- Eggs Pelagic, spherical.
 - Diameter: 0.86-0.98 mm.
 - Shell: smooth.
 - Yolk: homogeneous.
 - Oil globules: 1.
 - O.G. diameter: 0.10-0.19 mm.
 - Perivitelline space: narrow.
- Larvae Hatching occurs at about 2.9 mm; eyes unpigmented; preanus length about 50% TL.
 - Head and gut deep and compressed
 - Preanus length <50% NL at 4.2 mm; anus shifts anteriorly in later larvae.
 - Few serrations appear on preopercle at 4.2 mm, and disappear by about 7 mm.
 - Flexion occurs between 6 and 8 mm.
 - Transformation begins at about 10 mm and is complete at >12 mm (right eye migrates over middorsal ridge; dorsal fin origin moves anteriorly and is deflected to right side).
 - Sizes at beginning of ossification and completion of fin rays and vertebrae:

Caudal rays	6-8 mm NL	8 mm SL
Dorsal and anal rays	~6	9– 10
Pelvic rays	(buds) \sim 8	11
Vertebrae	_	~9

- Anterior dorsal fin rays may be slightly elongate.
- Pelvic fins equal in size, with both bases above midline and both origins posterior to cleithral symphysis.
- Pigmentation: in early larvae, spots evenly scattered over head, trunk and yolk sac; no pigment posterior to midtail bar which extends onto finfolds; in late larvae, midtail bar restricted to body, spreading anteriorly and posteriorly; unpigmented areas remain at caudal base and a zone on side over pectoral fin; at transformation, round ocellated spots form on body postanally.
- **Note:** This species is referred to as *Paralichthys oblongus* by some authors (see Robins *et al.* 1980).

Myomeres: 41-42 Vert : 11+30-31 D : 71-86 A : 58-72 Plv : 6/6 P : 10-12

Meristic features

Fig. - A, Miller and Marak 1962; B-E, Leonard 1971 (all redrawn).



BOTHIDAE Paralichthys dentatus (Linnaeus)

Spawning: Autumn into winter.

- Eggs - Pelagic, spherical.
 - Diameter: 0.95-1.03 mm.
 - Shell: smooth and transparent.
 - Yolk: homogeneous.
 - Oil globules: 1.
 - O.G. diameter: 0.17-0.23 mm.
 - Perivitelline space: narrow.
- Hatching occurs at about 2.4-2.8 mm NL; eyes unpigmented; mouth not formed; Larvae oil globule posterior in yolk.
 - Head length 23-27% NL/SL throughout development.
 - Preanus length decreases from 48% NL to 30% SL: body depth increases from 14% NL to 45% SL at transformation.
 - Flexion occurs at 9–10 mm SL; transformation begins at about 9.5 mm SL and is complete at 12-13 mm SL.
 - Teeth first visible at about 9.5 mm SL.
 - Spines: 1 cranial spine on each side near dorsum at hatching, increases to 2-3 per side, directed anteriorly; 5-7 preopercle spines at 4.5-9.5 mm SL; 2-5 opercle spines at 8.6-9.5 mm SL; all spines disappear during transformation.
 - Ossification of vertebrae complete at about 9.5 mm SL.
 - Sizes at beginning of ossification and completion of fin rays:

Dorsal rays	6.0 mm NL	10.5-11.0 mm SL
Caudal rays	7.0	10.0
Anal rays	8.0	10.5-11.0
Pelvic rays	9.5 (buds)	12.0

- Anterior dorsal fin rays (4th-8th) may be elongate.
- Pelvic fins equal in size, with both bases above midline and both origins posterior to cleithral symphysis.



Note: Meristic characters in three Paralichthys found south of Cape Hatteras are as follows:

Species	Vertebrae	Dorsal	Anal
P. squamilentus P. lethostigma	10+27-29 10-11+27-28	76-85 80-95	59-65 63-74
P. albigutta	10+27	71-85	53-63

- Fig. A-E. Smith and Fahay 1970 (redrawn).
- Ref. Deubler 1958; Rothschild and Deubler 1960; Gutherz 1967; Woolcott et al. 1968.

Vert : 11+30-31

: 80-96

: 61-73 Plv : 6/6

: 12-13

Myomeres: 41-42

D

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BOTHIDAE Citharicht

Citharichthys arctifrons Goode

Spawning: Summer-autumn (mostly July-October).

- Myomeres: 34-35 Eggs Undescribed. Vert : 10-11+26-28 - Head length 19-25% SL in early larvae, and 26-30% SL Larvae D : 75-87 at transformation. Α : 58-71 Preanus length 36–42% SL in early larvae, and 35–40% Plv : 6/6 SL at transformation. Ρ : 9-11
 - Body depth 18-25% SL in early larvae and 34-39% SL at transformation; relative depth less than in similar sizes of *Etropus microstomus* (p. 360).
 - Flexion occurs at 5-9 mm, and transformation at 13-15 mm.
 - No preopercle spines; 2nd, 3rd and 4th dorsal fin rays elongate in larvae 4.5-12.0 mm SL.
 - Sizes at beginning of ossification and completion of fin rays and vertebrae:

Caudal rays	5 mm SL	9 mm SL
Dorsal and anal rays	6	10
Pelvic rays	5 (buds)	12+
Vertebrae	6-7	10+

- Pelvic fins: left base longer than right; right origin anterior to left, both posterior to cleithral symphysis; left base on midline, and right base above midline.
- Pigmentation: 3 postanal, horizontal bars >4-5 mm; internal spots on notochord only near the 3 postanal bars in sizes >5 mm; no prominent ventral edge clusters between anus and preanal bars, but an irregular row of spots instead; less overall pigment than in *Etropus microstomus* (p. 360).

Pigment Comparison in Early Larvae of Two Species

Pigment	C. arctifrons	E. microstomus
Lower jaw	Absent	Present
Air bladder	Present	Present
Ventral edge (tail)	Present	Present
Finfold	May be present	Absent
Mid-tail	3 bars at about 3 mm	2–3 bars at<3 mm
Ventral gut anterior		
to anus	Absent	Present



(Richardson and Joseph 1973) (redrawn)

Fig. - A-F, Richardson and Joseph 1973 (redrawn).

Ref. — Markle et al. 1980; Tucker 1982.

Meristic features

Citharichthys arctifrons





BOTHIDAE Etropus microstomus (Gill)

Spawning: Summer-autumn (mostly July-October).

- **Eggs** Undescribed (see note (1) below).
- Larvae Head length 21–25% SL in early larvae, and 25–27% SL at transformation.
 - Preanus length 36–43% SL in early larvae, and 33–35%
 SL at transformation.
 - Body depth 20-26% SL in early larve and 36-41% SL at transformation; relative depth greater than in similar sizes of *Citharichthys arctifrons* (p. 358).
 - Flexion occurs at 5–7 mm, and transformation at 10–12 mm.
 - Preopercle spines prominent from 2.5 to 8.0 mm and disappear by 10 mm; no elongate fin rays.
 - Sizes at beginning of ossification and completion of fin rays and vertebrae:

Caudal rays	5 mm SL	7 mm SL
Dorsal and anal rays	5	8
Pelvic rays	5 (buds)	11-12
Vertebrae	5	9

- Pelvic fins: same position as in Citharichthys arctifrons (p. 358).

 Pigmentation: 3 postanal, horizontal bars>3-4 mm; internal spots along length of notochord>4 mm; 2 prominent ventral edge clusters between anus and postanal bars at sizes >4 mm; 1-2 spots on pectoral fin base.

Note:

- (1) Scherer and Bourne (1980) provide a description of egg development, but it may not adequately account for the presumably similar egg of *Citharichthys arctifrons*.
- (2) For comparison with early larvae of C. arctifrons, see p. 358.
- (3) Of the several western North Atlantic species in the genera *Etropus* and *Citharichthys*, only *E. microstomus* and *C. arctifrons* occur commonly north of Cape Hatteras.

Fig. - A-F, Richardson and Joseph 1973 (redrawn by Barbara Sumida MacCall).

Ref. - Tucker 1982.

Meristic features

Plv : 6/6

Vert : 10+24-25

: 67-84

: 50-63

: 9-12

Myomeres: 31-33

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Etropus microstomus

BOTHIDAE



Fine pigment forms on fins at transformation

BOTHIDAE Syacium papillosum (Linnaeus)

Spawning: April-November (Florida west coast).

- Eggs Undescribed.
- Larvae Teeth visible at about 3 mm SL.
 - Bulge in forehead profile at 4-6 mm SL.
 - Head length 26-34%; preanus length 48-39% (decreases), and body depth 24-43% (increases).
 - Flexion occurs at 5-7 mm SL, and transformation at 15-22 mm SL.
 - Cranial spines (1 per side, large) at 2-8 mm SL.
 - Preopercle spines 4-7; large angle spine develops a spur.
 - Sizes at begining of ossification and completion of fin rays and vertebrae:

Dorsal rays	3 mm SL	10-13 mm Sl
Pelvic rays	\sim 4 (buds)	7
Caudal rays	5	6-7
Anal rays	5	10-13
Vertebrae	?	6

- Anterior 5-8 dorsal rays elongate (form about 3 mm); no elongate pelvic rays, but left fin longer than right until transformation.
- Pelvic fins: left base longer than right; right origin anterior to left; left base on midline and right base above midline.
- Pigmentation: note spots on distal 1/3 of pelvic fin (see illustrations opposite).

- Meristic features Myomeres: 33-36
 - Vert : 10+25-26 D : 79-94 A : 62-75 Plv : 6/6
 - P : 11-12



Fig. — A-D, Futch and Hoff 1971 (redrawn).

Ref. - Evseenko 1979.



BOTHIDAE Cyclopsetta fimbriata (Goode and Bean)

Spawning: April-October (south of Cape Hatteras).

- Eggs Undescribed.
- Larvae Head length 27-34% SL; preanus length 50-40% SL (decreases); body depth 30-42% SL (increases).
 - Flexion occurs at 5-8 mm SL, and transformation at 14-15 mm SL.
 - Right eye moves under dorsal fin at transformation.
 - Cranial spines (1 per side, small) until transformation.
 - Preopercle spine's 4-6 (smaller than in Syacium); angle spine develops a spur.
 - Sizes at beginning of ossification and completion of fin rays:

Dorsal rays	2.1 mm SL	\sim 8 mm SL
Pelvic rays	\sim 3 (left)	~7
Caudal rays	~5	~8
Anal rays	~6	~8

- Anterior 3 dorsal rays elongate (from about 2.1 mm) and then 8-11 become elongate; 1-3 pelvic rays elongate on left side at about 3 mm and rays on right side form at 5.3 mm SL.
- Pelvic fins: left and right bases equal and origins even; left base on midline and right base above midline.
- Pigmentation: 3 dorsal and 2 ventral clusters at 3 mm; 1 dorsal and 1 ventral cluster added at about 5 mm; 1 dorsal cluster added at about 7 mm (see illustrations opposite for other pigment).



Note: See Evseenko (1979) for description of C. chittendeni.

- Fig. A-D, Gutherz 1970 (A-C redrawn).
- Ref. -- Evseenko 1979.

Meristic features

Plv : 6/6

Vert : 10+26-27

: 78-87

: 59-67

: 11-12

Myomeres: 36-37

D

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BOTHIDAE



BOTHIDAE

366

Bothus ocellatus (Agassiz)

Spawning: Year round, with possible peak in July.

- Eggs Undescribed.
- Larvae Blunt profile, with well-developed jaws.
 - Flexion occurs at 6–7 mm, and transformation in most at 16–21 mm (extreme range 9–42 mm).
 - Right eye migrates through head under dorsal fin during transformation.
 - At 14 mm SL, head length = 25% SL, preanus length = 26% SL, and body depth = 59% SL.
 - First dorsal ray elongate at 3-13 mm.
 - Pelvic fins: left base much longer than right; left origin on urohyal, and right origin posterior to cleithral symphysis; left base on midline, and right base above midline.
 - Pigmentation: few spots on elongate dorsal ray, on caudal fin, and on posterior dorsal and anal finfolds in early larvae, but no pigment at sizes >10 mm.

Monolene sessilicauda Goode (see Notes below)

Spawning: Possibly in summer (larvae taken near edge of continental shelf).

Eggs — Undescribed.

Larvae — Body very thin and transparent.

- Head length 17–23% SL, preanus length 31–43%
 SL, and body depth 25–42% SL.
- Flexion occurs at 8–12 mm SL, and transformation at >33 mm SL.
- Right eye migrates through head under dorsal fin during transformation.
- First dorsal fin ray elongate.
- Sizes at beginning of ossification and completion of fin rays and vertebrae:

Dorsal and anal rays	~7.3 mm SL	~14 mm SL
Caudal rays	~7.9	14.3
Pelvic rays	11.6	14.3
Vertebrae	~7.3	14.3

- Pelvic fins: left base long, with origin anterior to cleithral symphysis; right base shorter with origin posterior to cleithral symphysis; left base on midline, and right base above midline.
- Pigmentation: sparse and irregular; light spots on head and 1st dorsal ray sheath, and few internal gut spots.
- Note: (1) Description may include *M. antillarum* Norman, unless latter is synonymous (Evseenko, 1977a); larval evidence supports two species (D. F. Markle, 1982, pers. comm.; S. A. Evseenko, 1982, pers. comm.).
 - (2) *Monolene* and *Bothus* larvae may drift north with Gulf Stream to the Scotian Shelf.

Fig. — A-B, Jutare MS 1962; C, Evseenko 1978; D-E, Futch 1971 (A, B, D, E redrawn).

Ref. — Colton 1961; Evseenko 1977a.

Myomeres	:	35-37
Vert	:	10+25-27
D	:	76-91
А	:	58-68
Plv	:	6/6
P		8-10

Meristic features



Myomeres	:	45-46
Vert	:	10-11+35-38
D	:	92-109
А	:	76-89
Plv	:	6/6
Р	:	11-14

Meristic features

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Bothus ocellatus

BOTHIDAE



Monolene sessilicauda



BOTHIDAE Engyophrys senta Ginsburg

Spawning: Gulf of Mexico (may drift north via Florida Current).

Eggs — Undescribed.

Larvae — Body deep and compressed; head profile concave.

- Head length 33-22% SL (decreases); preanus length 51-22% SL (decreases); body depth 55-65-55% SL (increases then decreases).
- Flexion occurs at 4.5–6.5 mm SL, and transformation at 19–20 mm SL.
- Otic spines: increase from 3 in early larvae to 4 at >8 mm.
- Cleithral spines: increase from 3-4 in early larvae to 10-12.
- Urohyal spines: increase from 7-10 in early larvae to 20-27.
- Basipterygial spines: increase from 3-6 in early larvae to 14-18.
- All spines lost at transformation.
- Papillae develop over eyes at about 15 mm.
- Right eye migrates through body under anterior dorsal fin.
- Sizes at beginning of ossification and completion of fin rays:

Dorsal rays	3.3 mm SL	~6.5 mm SL
Anal rays	4.0	\sim 6.5
Caudal rays	4.5	~6.5
Pelvic rays	4.5 (buds)	~13.0

- Second dorsal ray elongate.

- Pelvic fins: left base slightly longer than right; left origin just anterior to cleithral symphysis; left base on midline, and right base above midline.
- Pigmentation: except for few tiny spots on lower head, near anus and cleithral symphysis in early larvae, no pigment until transformation.

Fig. — A-E, Hensley 1977.

Ref. — Evseenko 1977b; Futch 1977.

0D

Meristic features

Plv : 6/6

Vert : 10+27-29

: 71-85

: 8-10

: 60-69

Myomeres: 37-39

D

Α

Р



19.6 mm SL

BOTHIDAE Trichopsetta ventralis (Goode and Bean)

Spawning	: Gulf of Mexico (may drift north via Florida Current).	Meristic features
Eggs	- Undescribed.	Myomeres: 40-41
Larvae	 Body deep and compressed; head profile concave. Head length 29-19% SL (decreases); preanus length 50-19% SL (decreases); body depth 39-61% SL (increases). Flexion occurs at 6-10 mm SL, and transformation at 28.5-35.7 mm SL. Otic spines: increase from 2 in early larvae to 3 	Vert : 10+30-31 D : 89-95 A : 69-75 Plv : 6/6 P : 12-13

- Cleithral spines: increase from none in early larvae to 1 at 7-9 mm and then to 3-8.
- Urohyal spines: increase from 0-10 at 10-12 mm to 10-15.
- Basipterygial spines: increase from 2-5 at 13-20 mm to 5-15.
- All spines lost during transformation.
- Right eye migrates through body under anterior dorsal fin.
- Sizes at beginning of ossification and completion of fin rays and vertebrae:

Dorsal and anal rays	<6 mm SL	9–10 mm SL
Caudal	<6	\sim 10
Pelvic rays	6 (buds)	~10
Vertebrae	?	\sim 26

- Anterior few rays of dorsal fin become slightly elongate.
- Pelvic fins: same as in Engyophrys senta (p. 368).
- Pigmentation: in larvae >17 mm, series of spots on dorsal and ventral edges, and on midline of left side only, retained after transformation.
- **Note:** *T. orbisculus* (larvae undescribed) shares vertebral and fin-ray counts with *T. ventralis* and is only distinguished by a lower limb gillraker count of 7–8 (9–11 in *T. ventralis*) (Anderson and Gutherz 1967); *T. orbisculus range* off Nicaragua and Venezuela but young stages taken on Scotian Shelf (D. F. Markle, 1982, pers. comm.).

Fig. — Futch 1977.

Ref. — Anderson and Gutherz 1967; Hensley 1977.



BOTHIDAE



PLEURONECTIDAE Glyptocephalus cynoglossus (Linnaeus)

Spawning:	May-August on Georges Bank, March-April in	Meristic featu
	northern areas on continental slope.	Myomeres: 58-60

- Eggs - Pelagic, spherical. - Diameter: 1.25-1.35 mm. Shell: smooth.Yolk: homogeneous. - Oil globules: none.
 - Perivitelline space: narrow.
- Hatching occurs at 4-6 mm; eyes unpigmented. Larvae
 - Body long, thin and transparent; preanus length (<33% TL) shorter than in Hippoglossoides and Hippoglossus.
 - Body proportions inferred from figures (Ehrenbaum 1905):

mm SL	5.9	12.0	15.5	25.5	42.0
Head length (% SL)	~13	20	23	22	22
Preanus length (% SL)	30	30	32	31	29
Body depth (% SL)	9	12	20	27	30

- Flexion occurs at 14–20 mm, and transformation at 22–35 mm (sometimes delayed to larger sizes).
- Preopercle spines: 3-4 on posterior edge, and 5-6 on anterior parts at about 16 mm, increasing to 17-19 spines (not shown in figures).
- Sizes at beginning of ossification and completion of fin rays:

Dorsal and anal rays	~15 mm TL	>20 mm TL
Caudal rays	~15	<25
Pelvic rays	~22	

- Pigmentation: intensifies with development; 6 bands on body and fins, 3 prominent and 3 less so (3 bars do not extend onto finfold in *Hippoglossoides*).
- Note: Early eggs are similar to Gadus morhua (p. 178) and Melanogrammus aeglefinus (p. 182).

Ref. - Norman 1934; Nichols 1971; Evseenko and Nevinsky 1975.

res

yomeres :	58-60
Vert :	11-12+45-47
D :	97-117
A :	86-102
Plv :	6/6
P :	9-13



A-E (eastern Atlantic material)

PLEURONECTIDAE *Hippoglossoides platessoides* (Fabricius)

Spawning:	March-May.	Meristic features
Eggs 	Spherical. Diameter: 1.5-2.8 mm (to 3.5 mm?). Shell: smooth. Yolk: homogeneous. Oil globules: none. Perivitelline space: wide (see note below).	Myomeres: 44–47 Vert : 13–14+32–35 D : 78–98 A : 60–79 Plv : 6/6 P : 9–12

- Larvae Hatching occurs at about 4-6 mm, light pigment scattered over body.
 - Body not as elongate and preanus length (>33% TL) longer than in Glyptocephalus (p. 372).
 - Body proportions (% SL) inferred from figures (Ehrenbaum 1905):

mm SL	7.2	9.0	11.3	19.0	31.5
Head length	<20	20	25	25	23
Preanus length	35	36	40	41	35
Body depth	12	18	19	25	42

- Flexion occurs at 9–19 mm, and transformation at 18–34 mm (usually >25 mm SL).
- Preanal finfold retained until about 10 mm.
- Sizes at beginning of ossification and completion of fin rays:

Caudal rays	12-13 mm TL	18 mm TL
Dorsal and anal rays	12-13	18
Pelvic rays	\sim 24 (buds)	~30

- Pigmentation: early larvae develop 5 clusters which do not extend onto finfold (1 over gut, 1 at anus, and 3 postanal); scattered spots between clusters; at 12-13 mm, clusters split into dorsal and ventral pairs; spots appear on fins.
- Note: This is the only pleuronectid genus known with a wide perivitelline space.

Fig. - A, Nichols 1971: B-D, Petersen 1904 (all redrawn).

Ref. - Norman 1934; Colton and Marak MS 1969; Van Guelpen 1980.



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PLEURONECTIDAE Hippoglossus hippoglossus (Linnaeus)

Spawning	g: January-June (and into summer) on continental	Meristic features		
	slope.	Myomeres: 50-51		
Eggs	- Spherical and buoyant (but float at depths, ~90 m)	Vert : 16+34-35		
	— Diameter: 3.0-3.8 mm (to 4+ mm).	D : 98-106		
	- Shell: smooth and thick.	A : 69–84		
	 Yolk: homogeneous. 	Plv : 6/6		
	- Oil globules: none.	P : 15–17		
	- Perivitelline space: narrow.			

Larvae — Hatching occurs at 6-7 mm; eye unpigmented, no body pigment. — Large head with upturned snout, and long straight lower jaw.

- Peduncle short (compare to other pleuronectids).
- Body proportions (% SL) inferred from illustrations (Schmidt 1904):

mm SL	13.5	16.4	18.0	22.0	27.0	34.0
Head length	21	25	27	27	31	29
Preanus length	40	45	44	43	38	32
Body depth	20	27	30	36	44	38

- No spines on head or preopercle.

- Flexion occurs at 13-24 mm, and transformation at 20 to >34 mm.
- Sizes at beginning of ossification and completion of fin rays:

Caudal rays	~13 mm TL	~25 mm TL
Dorsal and anal rays	~18	20–22
Pelvic rays	~20 (buds)	~24
	20 (6003)	

— Pigmentation: in 13 mm larvae, faint undulating rows of spots on body, none along midline, faint spots near dorsal and anal margins, row of fine spots along preanal ventral midline; in 20–22 mm larvae, 3 dorsal and 3 ventral clusters develop on body and spread onto fins, 2 undulating rows remain, double ventral rows anterior to anus, converge at isthmus; in 34 mm larvae, 2 clusters form on proximal part of caudal fin, 1 dorsal and 1 ventral to midline.

Fig. - A-D, Schmidt 1904 (redrawn).

Ref. - Cox 1924; Bigelow and Schroeder 1953; Nichols 1971.



PLEURONECTIDAE Reinhardtius hippoglossoides (Walbaum)

Spawning	: May-September in depths to 600 m (Greenland to	Meristic features		
	Georges Bank).	Myomeres: 61–63		
Eggs -	 Spherical, buoyant, but float at depths. 	Vert : 17-19+43-45		
-	– Diameter: 4.0-4.5 mm.	D : 92–104		
-	– Shell: smooth.	A : 66-80		
-	– Yolk: homogeneous.	Plv : 6/6		
-	- Oil globules: none.	P : 13-15		
-	- Permienne space. narrow.			

- Larvae Hatching occurs at 7+ mm.
 - Body elongate; very long lower jaw; no spines on head or preopercle.
 - Peduncle much longer than wide (compare to other pleuronectids).
 - Body proportions (% SL) inferred from illustrations (Schmidt 1904; Nichols 1971):

mm SL	17	27	34	36.5	45	51	65
Head length	16	23	23	25	26	27	28
Preanus length	38	41	37	38	36	37	31
Body depth	12	16	13	19	26	22	32

- Flexion occurs at 17–36 mm, and transformation at 30+ mm; juveniles pelagic until about 70 mm.
- Sizes at beginning of ossification and completion of fin rays:

Caudal rays	\sim 25 mm TL	36.5 mm TL
Dorsal and anal rays	~32	36.5

- Left eye completes migration to final position on mid-dorsal ridge at about 73 mm.
- Pigmentation; in early larvae, body and marginal fin pigment very light, no bands or patches on body and fins; in late stages, myosepta become pigmented and indistinct bands form on fins.
- Note: (1) Number of vertebrae and body shape will separate this species and *Hippoglos-sus* (p. 376)
 - (2) Preanus length >33% SL (compare to Glyptocephalus, p. 372).

- Fig. A-C, Schmidt 1904; D, Jensen 1935 (all redrawn).
- Ref. Ehrenbaum 1905; Andriyashev 1954; Nichols 1971.



PLEURONECTIDAE Limanda ferruginea (Storer)

Spawning:	March-September, in western Gulf of Maine to	Meristic features		
	southern New England.	Myomeres: 38-42		
Eggs —	- Pelagic, spherical.	Vert : 10-12+30-33		
_	- Diameter: 0.80-0.90 mm.	D : 73–91		
_	- Shell: smooth.	A : 51–68		
	- Yolk: homogeneous.	Plv : 6/6		
	- Oil globules: none.	P : 10		
	Perivitelline space: narrow.			

- Larvae Hatching occurs at 2.0-3.5 mm; eyes unpigmented.
 - Body proportions (% NL or SL) inferred from illustrations (Miller MS 1958; Bigelow and Welsh 1925):

	5.9 mm NL	10.3 mm SL	14.0 mm SL
Head length	20	22	32
Preanus length	36	38	39
Body depth	20	22	40

- Flexion occurs from about 5 to 10+ mm NL, and transformation at 11.6–16.0 mm SL (most about 14 mm SL).
- Sizes at beginning of ossification and completion of fin rays:

Caudal rays	\sim 5 mm TL	~14 mm TL
Dorsal and anal rays	<10	~14

- Pigmentation: significant row of spots develops along body between midline and ventral edge (on myosepta).
- Note: Early eggs similar to Tautogolabrus adspersus (p. 292).

- Fig. A-B, Miller MS 1958; C-D, Bigelow and Welsh 1925 (all redrawn).
- Ref. Colton and Marak MS 1969; Van Guelpen 1980; Evseenko and Nevinsky 1981.



Row of spots forms between midline and ventral edge

PLEURONECTIDAE Liopsetta putnami (Gill)

Spawnin	g: Late winter to early spring in nearshore waters.	Meristic fe	atures
Eggs	 Demersal, non-adhesive. Diameter: 1.1-1.4 mm. Oil globules: none. Perivitelline space: narrow. 	Myomeres : Vert : D : A :	34-38 34-38 48-59 35-41
Larvae	 Hatching occurs at 3.1-3.6 mm NL; eyes pigmented. Relative body proportions: 	Plv : P :	6/6 10–11

	Yolk-sac	Preflexion	Flexion	Postflexion
Head length	12-14% NL	14-19% NL	15-21% NL	21-28% SL
Preanus length	39–50	38-46	37-44	36-37
Body depth	5-12	6-15	11-17	21-32

- Flexion occurs at 5.9-7.1 mm NL, and transformation at 7-13 mm NL.

 Dorsal, anal and caudal fin rays begin to ossify at about 6.5 mm NL, and all are complete by 13 mm SL.

- Pigmentation: (see illustrations opposite).

Note: See table of comparative characteristics of *L. putnami* and *Pseudopleuronectes americanus* (p. 384).



Liopsetta putnami



PLEURONECTIDAE Pseudopleuronectes americanus (Walbaum)

Spawning	g: Late winter to early spring in nearshore waters.	Meristic features
Eggs	 Spherical, demersal, adhesive. Diameter: 0.71-0.96 mm. Yolk: homogeneous. Oil globules: none. Perivitelline space: narrow. 	Myomeres: 34-40 Vert : 10+26 D : 60-76 A : 44-58 Ply : 6/6
Larvae	 Hatching occurs at about 2.4 mm SL; eyes unpigmented. 	P : 10-11

- Relative body proportions:

	Yolk-sac	Preflexion	Flexion	Postflexion
Head length	12-16% NL	16-22% NL	18-25% NL	24-29% SL
Preanus length	30-38	34-41	32-41	31-40
Body length	4-6	5-14	11-23	23-34

- Flexion occurs at 5.0-7.6 mm, and transformation at 7.0-13.0 mm.

- Fin rays begin to ossify at about 7 mm, and all are complete by 13 mm SL.

- Pigmentation: (see illustrations opposite).

Note: Larvae strongly bottom-oriented from yolk-sac stage through transformation.

	Liopsetta putnami	Pseudopleuronectes americanus
Vertebrae/myomeres	34-38	34-40
Dorsal fin rays	48-59	60-76
Anal fin rays	35-41	44-58
Hatch length (mm NL)	3.1-3.6	~2.4
Eyes at hatch	Pigmented	Unpigmented
Yolk absorbed (mm NL)	5.2	3.7
Gut forms loop (mm NL)	\sim 5.5	4.2-4.4
Flexion size (mm SL)	5. 9- 7.1	5.0-7.6
Transformation size (mm SL)	<7-13	7–13
Fins formed (mm SL)	8–13	7–13
Mean preanus length (yolk sac)	43.6% NL	33.3% NL
Mean preanus length (preflexion)	41.2% NL	37.6% NL
Pigment — Anal finfold	None until	Scattered at
	postflexion	\sim 3.6 mm
— Internal notochord	Absent	Present
 Median fins (post- flexion) 	Broken proximal band	Bars form

Comparison of Two Species

Fig. — A-H, Laroche 1981.

Ref. - Sullivan 1915; Pearcy 1962.

Pseudopleuronectes americanus PLEURONECTIDAE



SOLEIDAE Trinectes maculatus (Bloch and Schneider)

Spawning:May-September, in inshore waters and estuaries.Meristic featuresEggs— Spherical to slightly oval, buoyant in oceanic salinities
but demersal in lower salinities.Myomeres: 28-29
Vert: 9+19-20

- but demersal in lower salinities. — Diameter: 0.67-1.22 mm (smaller in higher salinities).
 - Shell: smooth (greenish).
 - Oil globules: multiple.
 - O.G. diameter: <0.06 mm.
 - Perivitelline space: very narrow.
- Larvae Hatching occurs at 1.7-1.9 mm; eyes unpigmented, prominent hump on head, and slender body.
 - Body becomes deep and laterally compressed at about 3.8 mm.
 - Mouth prominent, with projecting lower jaw.
 - Flexion occurs at about 3.8 mm, and transformation at <5.0 mm.
 - Left eye migrates through notch formed anterior to right eye at transformation.
 - Fin rays begin to form at about 3.8 mm and are complete by about 5 mm; no dorsal tentacle.
 - Pectoral fins lost at transformation.
 - Pelvic fins: right pelvic base longer than left, right origin anterior to left, right base on midline, left base above midline.
 - Pigmentation: in early larvae, scattered spots on head and body; in later larvae, bars form on body and fins.





D

Α

Ρ

Plv

: 50-56

: 36-46

: None

: 5/5



Note: Sizes inferred from discussion (Hildebrand and Cable 1938)

SOLEIDAE

Achirus lineatus (Linnaeus)

Spawning: Florida and south.

finfold.

- Pelagic, spherical.

Diameter: 0.71-0.76 mm.
Shell: smooth and thin.
Yolk: homogeneous.
Oil globules: multiple.

- O.G. diameter: 0.02-0.09 mm.

- Perivitelline space: moderate.

Meristic features

Myomeres:	25-27
Vert :	25-27
D :	47-58
A :	35-44
Plv :	5/5
P :	4-6*

 * Right fin only; left fin present until transformation.

 Body deep and laterally compressed; head with prominent hump and steep vertical forehead.

- Hatching occurs at <2 mm; eyes unpigmented; wide

- Head length increases from about 20% to 40% SL; preanus length decreases from <60% to about 44% SL; body depth increases from 38-46% to about 50% SL (includes width of dorsal fin).
- Head has 3 spiny ridges, and body has 4 rows of spinous scales.
- Flexion occurs at <3 to 4 mm, and transformation at 3–5 mm.
- Left eye migrates across midline under hook formed by dorsal fin at transformation.
- Dorsal fin tentacle develops as fleshy appendage, and is later supported by a ray.
- Caudal, dorsal and anal rays begin to form at about 3 mm and are complete at 4-5 mm; pelvic fin buds form at 2.5 mm and are complete by 3.3 mm.
- Left pectoral fin disappears after transformation.
- Pelvic fins: right pelvic base longer than left, right origin anterior to left, right base on midline, left base above midline.
- Pigmentation: none at hatching (see illustrations opposite).

 \square

Eggs

Larvae

Fig. — A-F, Houde *et al.* 1970. Ref. — Dovel *et al.* 1969.





С

SOLEIDAE

CYNOGLOSSIDAE Symphurus plagiusa (Linnaeus)

Spawning:	Summer.	Meristic features
Eggs —	Undescribed.	Myomeres: 46-48
Larvae — — —	Hatching occurs at <1.3 mm NL. Body tapered, gut protrudes, mouth large and oblique, eyes small in large larvae. Hump on dorsal edge over cleithra in early larvae. Head length $18-22\%$ NL; preanus length <50-35\% NL (decreases); body depth $15-27\%$ NL (increases).	Vert : 9+37-39 D : 85-92 A : 69-78 Plv : 4/0 P : None

- Flexion occurs at 6.2–8.5 mm SL, and transformation at about 10 mm.
- Sizes at begining of ossification and completion of fin rays:

Dorsal rays	<3 mm NL	\sim 6 mm NL
Anal rays	~4	\sim 6
Caudal rays	\sim 6	\sim 8.5
Pelvic rays	~6	

- Pectoral fins and right pelvic fin lost at transformation; anterior few dorsal rays elongate.
- Pigmentation: in early larvae, spots on brain and cleithral hump, 3 indistinct concentratons along dorsal edge, ventral row of spots from gut to isthmus and double row of ventral spots postanally; in late larvae, dorsal edge pigment increases, internal spots form along dorsal notochord, single spot appears at base of each anal ray.

Symphurus plagiusa



CYNOGLOSSIDAE