



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

BY

Joanne Lyczkowski-Shultz

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

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

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

March 2003

This Technical Memorandum series is used for documentation and timely communication of preliminary results, interim reports, or similar special-purpose information. Although the memoranda are not subject to complete formal review, editorial control, or detailed editing, they are expected to reflect sound professional work.

NOTICE

The National Marine Fisheries Service (NMFS) does not approve, recommend or endorse any proprietary product or material mentioned in this publication. No reference shall be made to NMFS or to this publication furnished by NMFS, in any advertising or sales promotion which would imply that NMFS approves, recommends, or endorses any proprietary product or proprietary material mentioned herein or which has as its purpose any intent to cause directly or indirectly the advertised product to be used or purchased because of this NMFS publication.

This report should be cited as follows:

J. Lyczkowski-Shultz. 2003. Preliminary guide to the identification of the early life history stages of tetraodontid fishes of the western central North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-494, 9 p.

W. J. Richards, Editor. NOAA Fisheries, 75 Virginia Beach Drive, Miami, FL

This report will be posted on the Bethune Cookman College NOAA Cooperative web site later in 2003 at URL: <http://www4.cookman.edu/NOAA/> and will also appear on the SEFSC web site at URL: <http://www.sefsc.noaa.gov/>

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

Author's address:

NOAA Fisheries

3209 Frederic Street

Pascagoula, MS 39567

E-mail: < Joanne.Lyczkowski-Shultz@noaa.gov >

Copies may be obtained by writing:

The author or

National Technical Information Center

5825 Port Royal Road

Springfield, VA 22161

(800) 553-6847 or (703) 605-6000

<http://www.ntis.gov/numbers.htm>

This morphologically distinct group of fishes comprise 18 genera and 95 species worldwide (Nelson 1994) with only 4 genera and 18 species found in the western central North Atlantic (WCNA). Oblong to rotund in shape tetraodontids are generally small to medium-sized fishes that lack median fin spines and pelvic fins entirely; have short dorsal and anal fins located opposite one another; are scaleless or have small prickles, scale-like dermal structures and/or lappets on the body; have a low modal vertebral count (17 to 19), and, as the family name indicates, jaw teeth that are fused into four plates, two on each jaw. The center of distribution for these fishes lies in the subtropics and tropics with a few species ranging into temperate latitudes. Species of *Canthigaster* and *Sphoeroides* usually occur as shallow water residents of the demersal fauna of sandy, reef or hardbottom areas. Species in the genus *Lagocephalus* live pelagically and species of *Colomesus* inhabit tropical, coastal freshwater streams and brackish waters. The tetraodontids are commonly named puffers because of their ability to enlarge their bodies by gulping water or air into a specialized ventral diverticulum of the stomach; although members of the family Diodontidae can also inflate by this means. Among tetraodontid larvae the ability to inflate may develop as early as preflexion (Leis 1984) or later in the juvenile stage as in *Sphoeroides maculatus* in which inflation can occur by 7 mm in length (Welsh & Breder 1922). Another adaptation to deter predation that is unique within the order to the puffers is the toxicity of their skin, viscera and gonads. The eggs and larvae of at least one Indo-Pacific species of *Canthigaster* have been shown to be unpalatable to egg-eating, reef fishes as well (Gladstone 1987).

Reproduction occurs by deposition of spherical, demersal, adhesive eggs that range in size from 0.61 to 0.91 mm and contain a cluster of oil globules. The egg membrane of several Indo Pacific species possess radial layers. Puffer larvae are robust and ovoid in shape with a preanal length of 50% of the body length increasing to 75% with development. Larvae hatch at lengths ranging from 1.3 to 2.4 mm and at varying degrees of development, i.e. undeveloped to functional

mouths, unpigmented to pigmented eyes, and no pectoral fin to fully formed bases and finfolds. A distinct, transparent to opaque dermal sac encompassing head and trunk, and in older larvae, dorsal and anal fin bases is present and may remain throughout development. Numerous tiny tubercles are present over the dermal sac of newly hatched larvae in two species of puffers (Welsh & Breder 1922; Stroud et al. 1989). It is not clear if these structures are precursors of the dermal spinules (prickles) that eventually develop in all puffer larvae beginning on the ventral surface of the abdomen and spreading over the body surface in what may prove to be species-specific patterns.

Formation of the pectoral, dorsal and anal fins begins during preflexion and can be complete before the end of flexion at ca. 5 to 6 mm when resemblance to adults is unmistakable.

Pigmentation on the head, visceral mass, trunk and tail may be light to heavy at hatching but generally increases with development dorsolaterally and caudad over the trunk and tail. Puffers do not have a distinct pelagic juvenile stage but in at least one Indo Pacific species of *Canthigaster* the pelagic larval phase appears to be prolonged, ranging from 64-113 days (Stroud et al. 1989).

Puffer larvae are most likely to be confused with the larvae of most ceratioid anglerfishes and the other rotund members of the order, the diodontids and ostraciids. This resemblance is due to the shared characteristics of absence of pelvic fins and presence of a dermal sac over head and trunk. Puffer larvae can be distinguished from larvae of most ceratioids by the smaller dermal sac that does not cloak the dorsal and anal fins in their entirety, pectoral fin bases that are not paddle-like, presence of skin prickles, and presence of pectoral fin rays prior to or in conjunction with median fin ray development. Small puffer larvae are more slender than the globular-shaped larvae of diodontids and ostraciids, and less pigmented. Typical number of pectoral rays ranges from 13 to 18 in puffers, 19 to 26 in diodontids and 11 to 13 in ostraciids. Dermal spinules (prickles) develop directly on the dermal sac of puffer larvae. In preflexion diodontid larvae fleshy tabs, in which spines later ossify, appear first while dermal plates, and not spines, develop in

ostraciid larvae. Tooth plate morphology will further serve to distinguish these larvae as early as the preflexion stage. Puffer larvae have medially sutured plates, diodontid larvae have a single unsutured tooth plate and ostraciid larvae do not have tooth plates.

Eggs (one species) and preflexion larvae of two species of puffers from the WCNA have been described, *Sphoeroides maculatus* (Welsh & Breder 1922), and *Canthigaster rostrata* (Sikkel 1990). In Welsh and Breder's description melanophores, as well as other chromatophores, i.e., those containing red, yellow, green, orange and purple pigment, are illustrated using various symbols. Subsequent reproduction of these illustrations without reference to the coding used by the original authors has led to an erroneous depiction of melanistic pigmentation in this species. Welsh and Breder's illustrations were redrawn and are presented here with only melanophores shown. Watson (1996bt) presents a more complete description of the development of two, eastern Pacific species of *Sphoeroides*. Eggs and preflexion larvae of two, Indo Pacific species of *Canthigaster* have been described (Stroud et al. 1989; Arai & Fujita 1988). A 3.6 mm larva,

tentatively attributed to the genus *Canthigaster* from the Great Barrier Reef, Australia, was illustrated in Leis (1984). Fujita (1966) described the complete egg and larval development of the Pacific species, *Lagocephalus lunaris*. Fujita's illustrations seem to indicate that prickle formation in *Lagocephalus* larvae, unlike that in *Sphoeroides* and *Canthigaster*, does not occur until the postflexion stage. Larvae of the genus *Colomesus* remain unknown.

Since tetraodontid genera are separable using meristics (Table Tetraodontidae 1) the following key may help separate larvae in which fin rays and other adult characters have developed. Larval and juvenile tetraodontids are numerous and frequently taken in bongo and neuston samples throughout the Gulf of Mexico during SEAMAP (Southeast Area Monitoring and Assessment Program) surveys. Examination of this material should result in additional larval descriptions because tetraodontid larvae acquire adult meristics at a small size and juveniles appear to have a relatively long pelagic existence. The presence or absence of prickles and their distribution on the body along with pigmentation may prove to be useful characters in distinguishing puffer larvae in the WCA.

Nominal Key to Larvae and Juveniles of Tetraodontidae genera in the western central North Atlantic:

- 1a. Dorsal rays ≤ 10 and anal rays ≤ 9 2
- 1b. Dorsal rays ≥ 11 and anal rays ≥ 11 3
- 2a. Dorsal rays 10 and anal rays 9; small spines (prickles) present in preflexion larvae but the pattern of development is unknown; dorsal ridge or keel developing between the eyes and the dorsal fin probably after flexion is complete *Canthigaster*
- 2b. Dorsal rays 6-9 and anal rays 6-9; prickles present in preflexion larvae, first appearing ventrally on the abdomen and increasing dorsolaterally with development; no dorsal ridge or keel develops in postflexion larvae *Sphoeroides*
- 3a. Dorsal rays 12-15 and anal rays 12-14; prickles not present until postflexion; in late larvae and juveniles body exhibits a distinct counter-shading with dorsolateral surface dark and ventrolateral surface white to silvery; caudal fin margin distinctly lunate in the largest juveniles. *Lagocephalus*
- 3b. Dorsal rays 11-12 and anal rays 11; condition of prickles in preflexion larvae unknown; most likely collected in fresh, brackish and/or inshore marine habitats off the east coast of South America. *Colomesus*

Table Tetraodontidae 1. Meristic characters for species of Tetraodontidae known to occur in the western central Atlantic. Number in () denotes range. Numbers in () in vertebral formulae signify a rare count. Sources of data: Moura and Castro (2002); Tyler (1980); Shipp (1974).

| Species | Dorsal | Anal | Pectoral | Caudal | Vertebrae |
|----------------------|-----------|-----------|--------------|--------|------------------------------|
| <i>Canthigaster</i> | | | | | |
| <i>rostrata</i> | 10(11) | 9 | 16(14-15) | 11 | 8+9=17 |
| <i>jamestyleri</i> | 9 | 9 | 16(15) | 11 | 17 |
| <i>figueiredoi</i> | 10(9) | 9 | 15(16) | 11 | 17 |
| <i>Lagocephalus</i> | | | | | |
| <i>laevigatus</i> | 14(12-15) | 12(11-14) | 17(15-19) | 11 | 8+11(10)=19(18) |
| <i>lagocephalus</i> | 14(13-15) | 12(11-13) | 14(13-16) | 11 | 8+10=18 |
| <i>Sphoeroides</i> | | | | | |
| <i>dorsalis</i> | 8 | 7 | 16(15-17) | | 8+9(8)=17(16) |
| <i>georgemilleri</i> | 8(9) | 7 | 16(15-17) | 11 | - |
| <i>greeleyi</i> | 8(7) | 7(6) | 14-15(13-16) | 11 | 8+9-10=17-18 |
| <i>maculatus</i> | 8(7) | 7 | 16(15-17) | 11 | 8+11(10)=19(18) |
| <i>nephelus</i> | 8(7-9) | 7(6) | 14(13-15) | 11 | 8(7-9)+10(9-11)=18(17-19) |
| <i>pachygaster</i> | 9(8-10) | 8(7-9) | 14(15-17) | 11 | 8+10=18 |
| <i>parvus</i> | 8(9) | 7(6-8) | 14-15(13-16) | 11 | - |
| <i>spengleri</i> | 8(7) | 7(6-8) | 13(14) | 11 | 8+9(10)=17(18) |
| <i>testudineus</i> | 8(7-9) | 7(6-8) | 15(13-16) | 11 | 8(7)+9-10(8-11)=17-18(16-19) |
| <i>tyleri</i> | 8(7) | 7(6) | 15(14-16) | 11 | - |
| <i>yergeri</i> | 8(7) | 7(6)] | 14(13-15) | 11 | - |
| <i>Colomesus</i> | | | | | |
| <i>asellus</i> | 11(10-12) | 10(8-11) | 15(13-16) | 11 | 8+11(10-12)=19(18-20) |
| <i>psittacus</i> | 11(10-12) | 10-11(9) | 18(17-20) | 11 | 8+11(10)=19(18) |

TETRAODONTIDAE***Canthigaster rostrata* (Bloch, 1786)****MERISTICS**

| | Range | Mode |
|--------------------------------|-------|------|
| Vertebrae: | | |
| Precaudal | 8 | |
| Caudal | 9 | |
| Total | 17 | |
| Number of Fin Spines and Rays: | | |
| First Dorsal | 0 | |
| Second Dorsal | 10-11 | 10 |
| Anal | 9 | 9 |
| Pectoral | 14-16 | 16 |
| Pelvic | 0 | |
| Caudal | 11 | 11 |
| Branchiostegals | 6 | 6 |

LIFE HISTORY

Range: South Carolina, USA, & Bermuda to Tobago & the Lesser Antilles

Habitat: Shallow tropical & subtropical reefs to 40 m; in seagrass beds & around patches of rock & coral near reefs

ELH Pattern: Oviparous; territorial females (males are harem) deposit demersal adhesive eggs in filamentous algal nests; no parental care; eggs may be toxic to predators; young ≥ 11 mm found in floating sargassum

Spawning: year round; around coral rubble with patches of filamentous algae

Fecundity: ca. 1000 eggs

LITERATURE

Clark (1950); Gladstone (1987); Sikkel (1990)

EARLY LIFE HISTORY DESCRIPTION**EGGS:**

Diameter: 0.65-0.66

No. of Oil Globules: many in a cluster

Hatch Size: 1.4 mm TL

LARVAE

Length at Flexion: unknown

Length at Transformation: unknown

Sequence of Fin Development: unknown

Pigmentation: tail of newly hatched larvae encircled by a pigment band between myomeres 12 and 15

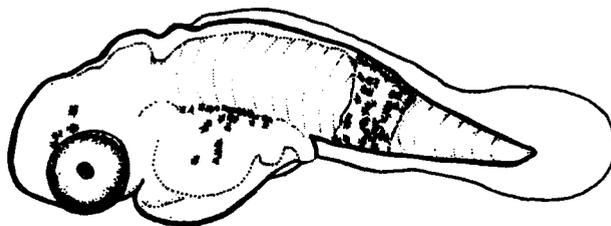
Diagnostic Characters: meristics; possibly the early presence of tail band and timing of prickles formation

JUVENILES: unknown

ILLUSTRATIONS

A 5 hour post hatch larva (Sikkel 1990)

A



ca 1.4 mm

TETRAODONTIDAE

Sphoeroides maculatus (Bloch and Schneider)

MERISTICS

| | Range | Mode |
|--------------------------------|-------|------|
| Vertebrae: | | |
| Precaudal | 8 | 8 |
| Caudal | 10-11 | 11 |
| Total | 18-19 | |
| Number of Fin Spines and Rays: | | |
| First Dorsal | 0 | |
| Second Dorsal | 7-8 | 8 |
| Anal | 7 | 7 |
| Pectoral | 15-17 | 16 |
| Pelvic | 0 | |
| Caudal | 11 | 11 |
| Branchiostegals | 6 | 6 |

LIFE HISTORY

Range: Newfoundland to northeast Florida

Habitat: Demersal in nearshore, coastal and estuarine waters during summer months, moves offshore in winter

ELH Pattern: Oviparous, demersal, strongly adhesive eggs deposited in shallow depressions; no parental care; planktonic larvae phototrophic

Spawning: May through October over all nearshore habitats occupied by adults

Fecundity (total annual): 40,400 to 449,200 eggs

Age at First Maturity: 1 year and at ≥ 88 mm

Longevity: 5 years (Laroche & Davis 1973)

LITERATURE

Welsh & Breder (1922); Breder & Clark (1947); Laroche & Davis (1973); Martin & Drewry (1978); Sibunka & Pacheco (1981); Able & Fahay (1998); Merriner & Laroche (1977)

EARLY LIFE HISTORY DESCRIPTION

EGGS:

Diameter: 0.85 – 0.91 mm

No. of Oil Globules: many in a foamy cluster

Oil Globule Diameter: 0.34 mm (mean diameter)

Yolk: clear

Shell: smooth, adhesive and irregular in outline

Hatch Size: 2.4 mm (live length)

LARVAE:

Length at Flexion: ca. 4-5 mm

Length at Transformation: by 7.4 mm

Sequence of Fin Development: P₁, D&A&C

Pigmentation: Preflexion- on anterior of yolk sac & trunk directly over yolk sac; ventrally & laterally on anterior half of tail; on snout, pectoral fin base, & dorsally on head & trunk by 2.6 mm. Flexion and postflexion- unknown

Diagnostic Characters: meristics & undetermined pigmentation; possibly prickle development pattern

JUVENILES:

Description based on two specimens, 7.4 and 9.7 mm

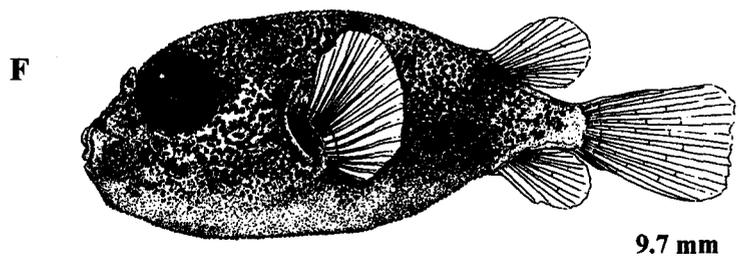
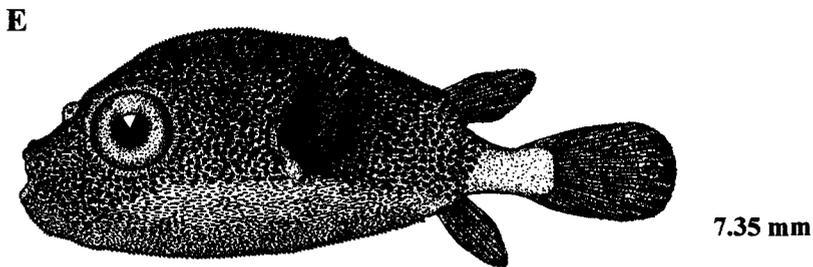
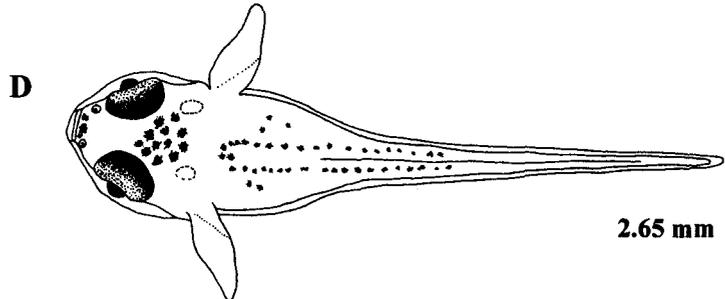
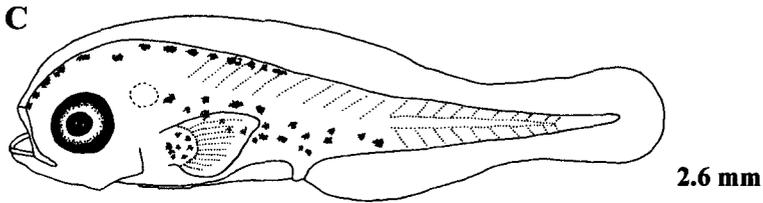
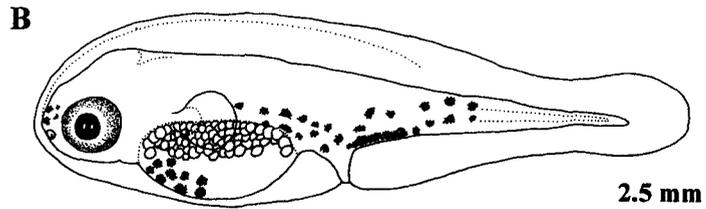
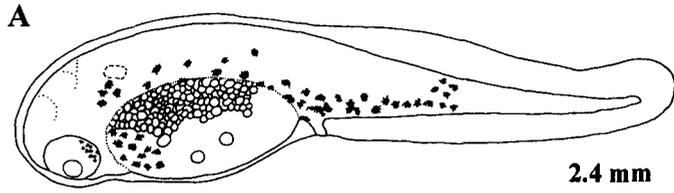
SL: at 7.4 mm pigment uniformly concentrated over upper two-thirds of body from snout to just posterior of D & A fin insertions; ventral one-third of body & caudal peduncle only sparsely pigmented; dermal prickles cover body from snout to about origin of D & A fins; by 9.7 mm pigment has increased in ventral region of body but dorsal two-thirds remains darker with 3 to 4 bands of pigment developing on trunk & tail.

ILLUSTRATIONS

A-E from Welsh and Breder (1922): A-D reared & measured while alive are redrawn here (by P. J. Bond) with only the melanophores depicted, E field collected & measured after preservation; F from Able & Fahay (1998)

TETRAODONTIDAE

Sphoeroides maculatus (Bloch and Schneider)



LITERATURE CITED

- Able, K.W. & M. P. Fahay. 1998. *Sphoeroides maculatus* (Bloch and Schneider) Northern Puffer, Pages 252-255 in *The First Year in the Life of Estuarine Fishes in the Middle Atlantic Bight*. Rutgers University Press, New Brunswick, New Jersey. 342 p.
- Arai, H. & S. Fujita. 1988. Spawning behavior and early life history of the sharpnose puffer, *Canthigaster rivulata*, in the aquarium. *Japan. J. Ichthyol.*, 35(2): 194-202.
- Breder, C.M. & E. Clark. 1947. A contribution to the visceral anatomy, development, and relationships of the Plectognathi. *Bull. Am. Mus. Nat. Hist.* 88(5): 291-319.
- Clark, E. 1950. Notes on the behavior and morphology of some West Indian plectognath fishes. *Zool. N. Y.* 35 (13): 159-168.
- Fujita, S. 1966. Egg development, larval stages and rearing of the puffer *Lagocephalus lunaris spadiceus* (Richardson). *Japan. J. Ichthyol.* 12 (4/6): 162-168.
- Gladstone, W. 1987. The eggs and larvae of the sharpnose pufferfish *Canthigaster valentini* (Pisces: Tetraodontidae) are unpalatable to other reef fishes. *Copeia*, 1987: 227-230.
- Laroche, J.L. & J. Davis. 1973. Age, growth and reproduction of the northern puffer, *Sphoeroides maculatus*. *Fish. Bull. U. S.*, 71: 955-963.
- Leis, J. M. 1984. Tetraodontoidei: Development. Pages 447-450 in *Ontogeny and systematics of fishes*. Moser, H.G. et al. (eds.). *Am. Soc. Ichthyol. Herpetol. Spec. Publ.* (1): 760 p.
- Martin, F. D. & E. C. Drewry. 1978. Development of fishes of the Mid-Atlantic Bight. An atlas of egg, larval and juvenile stages. *U.S. Fish Wildl. Serv., Biol. Serv. Program FWS/OBS-78/12.* 6: 416 p.
- Merriner, J. V. & J. L. Laroche. 1977. Fecundity of the northern puffer, *Sphoeroides maculatus*, from Chesapeake Bay. *Chesapeake Sci.* 18(1): 81-83.
- Moura, R. L., & R. M. C. Castro. 2002. Revision of Atlantic sharpnose pufferfishes (Tetraodontiformes: Tetraodontidae: *Canthigaster*), with description of three new species. *Proc. Biol. Soc. Wash.* 115(1): 32-50.
- Nelson, J. S. 1994. *Fishes of the World*. 3rd edition, John Wiley & Sons, Inc., Toronto, Canada. 600 p.
- Shipp, R.L. 1974. The pufferfishes (Tetraodontidae) of the Atlantic Ocean. *Publications of the Gulf Coast Research Laboratory Museum, Ocean Springs, Mississippi.* (4): 162 p.

- Sibunka, J. D. & A. L. Pacheco. 1981. Biological and fisheries data on northern puffer, *Sphoeroides maculatus* (Bloch and Schneider). NOAA/NMFS Sandy Hook Laboratory, Technical Series Report (26): 56 p.
- Sikkel, P. C. 1990. Social organization and spawning in the Atlantic sharpnose puffer, *Canthigaster rostrata* (Tetraodontidae). *Env. Biol. Fishes* 27: 243-254.
- Stroud, G. J., B. Goldman, & W. Gladstone. 1989. Larval development, growth and age determination in the sharpnose pufferfish *Canthigaster valentini* (Teleostei: Tetraodontidae). *Japan. J. Ichthyol.* 36(3): 327-337.
- Tyler, J. C. 1980. Osteology, Phylogeny, and Higher Classification of the Fishes of the Order Plectognathi (Tetraodontiformes). NOAA Tech. Rep. NMFS Circ. 434: 422 p.
- Watson, W. 1996bt. Tetraodontidae: Puffers. In. Moser, H.G. [ed.], *The early stages of fishes in the California Current region*. California Cooperative Oceanic Fisheries Investigations Atlas 33:1428-1437.
- Welsh, W. W. & C. M. Breder. 1922. A contribution to the life history of the puffer, *Spherooides maculatus* (Schneider). *Zool. N. Y.* 2(12): 260-276.