

NEW RECORDS OF HAGFISHES (MYXINI: MYXINIFORMES: MYXINIDAE) FROM THE PACIFIC COAST OF COSTA RICA

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Abstract. A specimen of the Pacific hagfish, *Eptatretus stoutii* (Lockington, 1878), 351 mm total length, and four specimens of the whiteface hagfish, *Myxine circifrons* Garman, 1899, 400–545 mm total length, were collected between 1987 and 2010 from off the Pacific coast of Costa Rica at depths ranging from 80 to 825 m. The specimen of *E. stoutii* represents the first record of the species in Costa Rican and Central American waters, as well as a southeast range extension of about 3500 km on the known distribution of the species; the specimens of *M. circifrons* represents the second documented record of this species in Costa Rican waters. In this paper these new records are reported and discussed; a brief description of the specimens as well as comparative morphometric and meristic data are provided.

Keywords: eastern Pacific, Central America, ichthyofauna, *Eptatretus stoutii*, *Myxine circifrons*

Hagfishes are a basal group of cartilaginous, eel-like, and jawless craniates (Wisner 1999, Fernholm and Mincarone 2010, Kuo et al. 2010) that are entirely marine and bottom dwelling (Wisner 1999). These fishes are characterized by having vestigial eyes, three paired sets of sensory barbels, two sets of laterally everting and biting-scraping keratinous cusps (or teeth) attached to a dental plate (in turn attached to the anterior end of the dental muscle), a series of slime pores located along the lower side of the body, and by lacking paired fins (Fernholm 1998, Nelson 2006).

Hagfishes are scavenger feeders, mostly eating the insides of dying or dead invertebrates and fishes (Fernholm 1998, Nelson 2006, Clark and Summers 2012), and they are the only craniates in which the body fluids are isosmotic with seawater (Nelson 2006). These fishes occur in all oceans at depths between 15 and 5000 m (Nelson 2006, Fernholm and Mincarone 2010, Fernholm et al. 2013).

The taxonomy of hagfishes is based mainly on the variation in the teeth and gill structures, as well as a limited set of meristic, morphological, and colour characteristics, with the latest review of the family by Fernholm (1998) and Fernholm et al. (2013). Currently, members of the family are divided into three subfamilies: Myxininae, Eptatretinae, and Rubicundinae (see Fernholm et al. 2013). Myxininae includes four genera (*Myxine* Linnaeus, 1758; *Nemamyxine* Richardson, 1958; *Neomyxine* Richardson, 1954; and *Notomyxine* Nani et Gneri, 1951) and about 27 valid species (Rubio et al. 2005, Kuo et al. 2010, Fernholm et al. 2013, Eschmeyer and Fong 2015). Eptatretinae and Rubicundinae are represented each one by a single genus (*Eptatretus* Cloquet, 1819; and *Rubicundus* Fernholm, Norén, Kullander, Quattrini, Zintzen, Roberts, Mok et Kuo, 2013, respectively) and a total combined of about 51 valid species (Eschmeyer and Fong 2015).

The genus *Myxine* is the most diverse within the subfamily Myxininae (see Fernholm 1998, Fernholm et al.

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2013) and is characterized by the following combination of characters:

- Efferent branchial ducts open by a common external aperture on each side (i.e., only one pair of external gill openings);
- Pharyngocutaneous duct (which exits the pharynx behind the gills) present only on the left side;
- 5–7 pairs of gill pouches; and
- A fin fold, usually well developed on ventral midline originating just behind gill opening (Fernholm 1998, Fernholm et al. 2013).

A preliminary review of this genus was presented by Wisner and McMillan (1995), who listed a total of 14 species from the Pacific and Atlantic coasts of the American continent. Currently, about 23 species of *Myxine* are recognized (Rubio et al. 2005, Eschmeyer and Fong 2015).

The genus *Eptatretus*, and the subfamily Eptatretinae consequently, is characterized by the following combination of characters:

- Efferent branchial ducts open separately to the exterior with 5–16 external gill openings;
- Nostril short, tubular; and
- Body color usually gray to light brown, never reddish (Nelson 2006, Fernholm et al. 2013).

This subfamily has been extensively revised within the last 25 years (e.g., Fernholm and Hubbs 1981, Kuo et al. 1994, McMillan and Wisner 2004), almost tripling the number of known species from about 16 in 1980 to 47 at present (Møller and Jones 2007, Eschmeyer and Fong 2015). Species within Eptatretinae are distributed in all major oceans (Eschmeyer and Fong 2015).

A total of 5 species of *Myxine* have been recorded from the eastern Pacific Ocean (EPO): *Myxine circifrons* Garman, 1899 (from southern California, USA, to Chile); *Myxine fernholmi* Wisner et McMillan, 1995 (south-central Chile); *Myxine hubbsi* Wisner et McMillan, 1995 (southern California, to Chile); *Myxine hubbsoides* Wisner et McMillan, 1995 (central Chile); and *Myxine pequenoi* Wisner et McMillan, 1995 (Valdivia, Chile). The number of *Eptatretus* species, recorded from the EPO is much higher, amounting to 13 (Table 1) (Møller and Jones 2007, Eschmeyer and Fong 2015). All these species are relatively common in temperate and sub-temperate waters but they are rare in the tropical portion of the EPO (Mincarone and McCosker 2004). To date none or only a few specimens of these genera are known from scientific collections made in the Pacific coast of Costa Rica or Central America (Wisner and McMillan 1995, Bussing and López 2009, 2011).

Between 1987 and 2010 five adult hagfishes measuring 351–545 mm in total length (TL) (Figs. 1 and 2) were captured from off the Pacific coast of Costa Rica (Figs. 3 and 4). These specimens were captured by commercial fishermen and were donated and deposited at the fish collection of the Museo de Zoología of the Universidad de Costa Rica (UCR), under the following catalog numbers: UCR 2008-003 (two specimens collected 22 km W from off Cabo Blanco, Costa Rica, 9°33'25"N, 85°22'0"W, at a depth of 770–825 m, on October 1987, by H. Araya), UCR 2290-002 (two specimens collected in front of Cabo

Blanco, Costa Rica, 9°30'0"N, 85°5'39"W, at a depth of 637–665 m, on September 1992, by W. Valdelomar), and UCR 2705-007 (one specimen collected 13 km SW from off Cabo Blanco, 9°29'49"N, 85°13'27"W, at a depth of 80–210 m, on October 2010, by H. Araya). Recently, these specimens were identified by us as *Myxine circifrons* (UCR 2008-003 and UCR 2290-002; Fig. 1) and *Eptatretus stoutii* (Lockington 1878) (UCR 2705-007; Fig. 2). In this paper these new records are reported and discussed.



Fig. 1. *Myxine circifrons*, 545 mm in total length (UCR 2008-003), caught off Costa Rica (9°33'25"N, 85°22'0"W); Above, entire specimen, lateroventral view; below, cups and basal plates in excised and spread condition, dorsal view



Fig. 2. *Eptatretus stoutii*, 351 in total length TL (UCR 2705-007), caught off Costa Rica (9°29'49.99"N, 85°13'27.54"W). Above, entire specimen, lateroventral view; below, cups and basal plates in excised and spread condition, dorsal view

Table 1

Morphometric and meristic data of *Epiplatretus stoutii* from Costa Rica (UCR 2705–007) compared with its other known eastern Pacific congeners

Measurement/count	Species													
	<i>E. stoutii</i> (this study)	<i>E. bischoffii</i>	<i>E. bobwisneri</i>	<i>E. deani</i>	<i>E. fritzi</i>	<i>E. grouseri</i>	<i>E. laurahubbsae</i>	<i>E. mcconnoughyi</i>	<i>E. mcco斯基</i>	<i>E. nanni</i>	<i>E. polytremma</i>	<i>E. sinus</i>	<i>E. stoutii</i>	<i>E. swickrothi</i>
Total length	351	210–680	328–360	130–523	207–592	142–380	240–375	147–470	283–320	446–664	289–460	129–481	179–468	314
Preocular length	4.8	4.0–6.6	—	4.2–8.9	4.8–8.2	—	4.4–5.9	4.5–7.4	—	4.0–6.1	4.4–6.7	4.1–8.2	4.0–7.7	—
Pre-branchial length	23.6	17.6–22.4	19.4–22.9	14.4–20.4	17.6–24.5	20–24	18.4–20.4	14.7–18.1	24–26	12.8–15.6	13.9–16.9	19.7–27.8	18.7–25.3	19.7
Branchial length	12.2	11.4–16.1	10.0–11.1	12.7–18.2	11.5–15.8	6.3–8.1	5.2–5.9	15.5–21.6	9.3–10.1	17.5–22	16.8–20.1	9.2–17.2	11.5–14.2	9.3
Trunk length	47.6	45–54	50.3–2.8	48.0–55.5	46.2–55.6	54–57	54.5–58.5	48.2–55.7	49–50	48–53	48–53	45.0–54.0	47.0–53.5	58.9
Tail length	14.5	14–21.8	16.7–17.1	12.6–19.2	13.2–18.1	14.6–17.5	18.1–21.3	12.2–16.1	15.6–17.7	15.2–17.3	12.7–17.9	10.2–17.4	10.4–17.8	12.1
Tail depth	6	5.6–8.3	7.6–7.8	5.2–10.3	5.8–9.2	6.3–7.9	8.2–9.9	6.0–8.8	8.7–10.2	6.2–9.2	5.7–8.6	4.8–9.0	4.5–8.3	2.4
Body depth with finfold	6.8	7.1–11.2	8.5–9.2	4.7–10.5	—	4.2–8.8	7.3–9.1	6.1–9.8	9.4–10.6	7.3–9.9	6.8–10.9	4.9–10.4	5.0–9.7	—
Body depth without finfold	6.3	—	—	4.5–10.5	5.3–10.2	—	—	5.5–9.0	—	—	—	4.6–10.1	4.1–9.0	2.9
Body depth at cloaca	4.3	—	—	3.8–8.5	4.5–7.2	—	—	4.7–7.1	—	—	—	3.9–8.6	3.8–7.9	2.6
Gill pouches	11	10–11	8	10–12	10–12	5–6	7–8	12–14	8	12–13	13–14	9–12	10–14	12
Multicuspid in anterior row	3	3	3	3	3	3	2	3	3	3	3	3	3	3
Multicuspid in posterior row	2	3	2	2	2	2	2	2	3	3	3	2	2	2
Unicuspid in anterior row	7	7–10	9	6–10	7–10	9	13–17	7–9	9–10	9–12	8–10	6–9	6–10	9
Unicuspid in posterior row	8	8–10	8	7–9	7–9	8	11–16	7–9	9–10	8–11	7–10	6–10	6–10	9
Total cusps	40	44–52	44	37–46	38–46	44	61–68	38–45	48–51	49–55	45–51	34–46	36–46	46
Prebranchial slime pores	15	10–15	9	4–10	10–15	12–13	14–17	6–11	14–15	8–12	6–9	10–17	10–16	18
Branchial slime pores	11	8–11	7	9–13	9–12	4–5	6–8	11–16	7	11–13	11–14	8–11	9–14	12
Trunk slime pores	46	40–46	46–47	39–49	40–49	44–46	60–67	39–50	40–42	38–47	39–45	36–49	39–51	70
Tail slime pores	12	12–16	13–14	9–15	8–15	14–15	14–16	8–13	10–12	11–15	12–17	7–14	8–14	19
Total slime pores	84	74–83	76	67–80	74–85	76–77	97–105	67–84	72–74	72–82	72–79	66–82	71–88	119

Based on data from McMillan and Wisner (1984), Wisner and McMillan (1988, 1990), McMillan (1999), and Møller and Jones (2007); Measurements expressed as percentages of the total length.

The identification of the specimens was carried out on the basis of the following combination of distinctive characters:

***Myxine circifrons*:**

- First three cusps fused at base in anterior set and first two fused in posterior set;
- 48–50 total cusps;
- Five gill pouches on each side;
- 21–23 slime pores on prebranchial area;
- 82–84 total slime pores;
- Tail length 10.0%–12.0% of TL;
- Ventral finfold well developed; and
- Body color blackish to dark, reddish-brown, with the head and barbels pale.

***Eptatretus stoutii*:**

- First three cusps fused at base in anterior set and first two fused in posterior set;
- 40 total cusps;
- Eyespots presents, small and with distinct margins;
- 11 gill pouches on each side;
- 84 total slime pores;
- Both, prebranchial and tail length greater than branchial length;
- Ventral finfold prominent; and
- Body color uniformly light brown.

All these characters, agree with diagnosis of the species, and match well with descriptions of specimens by

Garman (1899), Chirichigno (1978), Wisner and McMillan (1990), Barss (1993), Wisner and McMillan (1995), Rubio et al. (2005), and Nakaya (2009). Additional comparative information about the species and the meristic and morphometric data from the examined specimens are presented in Tables 1 and 2, respectively. The comparative information was obtained from Garman (1899), Chirichigno (1978), McMillan and Wisner (1984), Wisner and McMillan (1988, 1990), McMillan (1999), Rubio et al. (2005), and Møller and Jones (2007). Counts and measurements were taken on the left side of the specimens and in all cases follow the criteria of McMillan and Wisner (1984).

In the equatorial waters of the EPO only three species of *Myxine* have hitherto been listed: *Myxine circifrons*; *Myxine fernholmi*; and *Myxine hubbsi*. Also the genus *Eptatretus* has been previously represented in the EPO by three species: *Eptatretus bobwisneri* Fernholm, Norén, Kullander, Quattrini, Zintzen, Roberts, Mok et Kuo 2013; *Eptatretus grouseri* McMillan 1999; and *Eptatretus mc-coskeri* McMillan 1999 (see Mincarone and McCosker 2004, Eschmeyer and Fong 2015). The above-mentioned *Myxine* species tend to exhibit wide distributions within the EPO. In contrast, all these three species of *Eptatretus* represent very restricted distributions, being only known from the Galapagos Islands. Another species from the Galapagos Islands—*Eptatretus lakeside* Mincarone et

Table 2

Morphometric and meristic data of *Myxine circifrons* from Costa Rica (2008–003 and UCR 2290–002) and comparative material

Measurement/count	Costa Rica	Panama	Colombia	Peru	
	This study <i>N</i> = 4	Garman (1899) <i>N</i> = 1	Rubio et al. (2005) <i>N</i> = 2	Chirichigno (1978) <i>N</i> = 2	Nakaya (2009) <i>N</i> = 3
Total length [mm]	400–545	467	383–400	543–355	495–526
Body depth [mm]	22.0–26.0	25.7	18.4–19.9	21.0–26.1	—
Body depth [% TL]	4.8–5.5	5.5	4.6–5.1	4.8–5.9	—
Prebranchial length [mm]	125.0–165.0	145.7	113.7–114.8	107.9–154.7	—
Prebranchial length [% TL]	30.3–32.1	31.2	28.7–29.7	28.5–30.4	30.0–30.9
Trunk length [mm]	227.0–320.0	—	217.0–219.2	—	—
Trunk length [% TL]	56.7–58.7	—	—	—	57.5–58.2
Tail length [mm]	45.0–60.0	—	52.3–66.0	—	—
Tail length [% TL]	10.0–12.0	—	—	—	—
Dorsal finfold length [mm]	47.0–66.0	—	—	—	—
Dorsal finfold length [% TL]	9.7–14.7	—	—	—	—
Dorsal finfold height [mm]	7.0–11.0	—	8.0	8.0–12.0	—
Dorsal finfold height [% TL]	1.6–2.5	—	2.0–2.1	2.2	—
Prebranchial pores	21–23	23	23–24	22–26	17–22
Trunk pores	50–52	—	51–52	54–57	56–62
Caudal pores	10–11	11	10	10	8–10
Total pores	82–84	—	84–86	86–93	83–93
Multicusps anterior teeth	3	—	3	3	3
Multicusps posterior teeth	2	—	—	—	2
Unicusps anterior teeth	10–12	—	—	—	10–11
Unicusps posterior teeth	9	—	—	—	9
Total unicusps	48–50	—	—	—	48–49

N = number of specimens examined, TL = Total length.

McCosker 2004—was recently placed in the genus *Rubicundus* (see Fernholm et al. 2013).

Myxine circifrons has been previously recorded near San Francisco, California, United States of America, the coast of Baja California, and the Gulf of California, Mexico (Wisner and McMillan 1995, Hendrickx and Hastings 2007), Costa Rica (Wisner and McMillan 1995), the Gulf of Panama (Garman 1899), Colombia (Rubio et al. 2005), Ecuador, Peru (Chirichigno 1978, Wisner and McMillan 1995, Nakaya 2009), and Chile (Wisner and McMillan 1995, Pequeño 1997) (Fig. 3). The presently reported finding of *M. circifrons*, represents the second documented record of the whiteface hagfish in the Pacific coast of Costa Rica (after Wisner and McMillan 1995).

Eptatretus stoutii has been previously listed only from southeastern Alaska, United States of America, to Bahia San Pablo, central Baja California, Mexico (Wisner and McMillan 1990) (Fig. 4). The present report of *E. stoutii*—being the first finding of the species in equatorial waters—represents a southeast range extension of about 3500 km on the known distribution of the species, as well as the fourth species of the genus known to be present in the overall area. However, in this paper we do not assume that its occurrence represents a recent species expansion (see below).

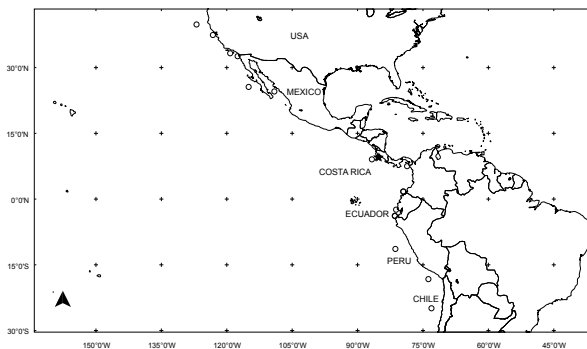


Fig. 3. Records of *Myxine circifrons* in the eastern Pacific Ocean, the star indicates the presently reported record, open circles indicate previous findings and museum records

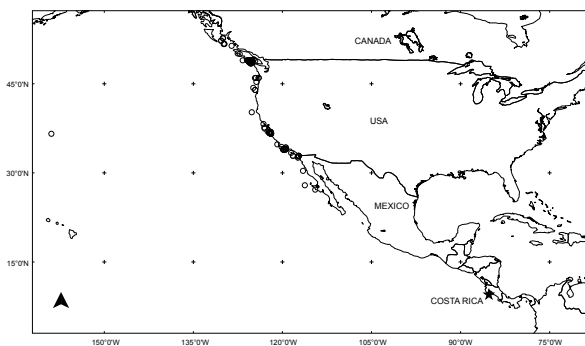


Fig. 4. Records of *Eptatretus stoutii* in the Eastern Pacific Ocean, the star indicates the presently reported record, open circles indicate previous findings and museum records

On the basis of Bussing and López (1994, 2005, 2009, 2011), both species, *Myxine circifrons* and *Eptatretus stoutii*, represent additions to the list of fish species known to be present on the Pacific coast of Costa Rica. In this regard, in last five years, an important number of fish species have been recorded for the “first time” from Costa Rican waters, precisely most of them on the Pacific coast (see Bussing and López 2011, Cortés et al. 2012, López-Garro et al. 2012, Starr et al. 2012, Angulo 2014a, 2014b, 2015, Angulo et al. 2014a, 2014b). A very similar case to the present record of *E. stoutii* was the species *Hydrolagus colliei* (Lay et Bennett, 1839) (Chimaeriformes, Chimaeridae), previously known only from southwestern Alaska to the Gulf of California, but now also known to be present in the Pacific coast of Costa Rica (Angulo et al. 2014a).

As noted by Angulo (2014a, 2014b, 2015) and Angulo et al. (2014a, 2014b) the majority of these new records correspond to species that are likely residents in this area that might have remained undetected due to intrinsic rarity or difficulty of access to their specific habitats (deep-water). The presence of these species suggests that the Costa Rican marine ichthyofauna is considerably richer than previously expected (Angulo 2014a, 2014b, 2015). Consequently, an estimation of number, composition and distribution of species in this area is still far from being obtained (Angulo 2014a, 2014b, 2015, Angulo et al. 2014b).

In this regard, the expansion of fisheries into deeper waters and the development of new fisheries for new deep-water target species in this area (see Wehrtmann and Nielsen-Muñoz 2009 for an overview), as noted by Angulo (2014a, 2014b, 2015) and Angulo et al. (2014b), will likely bring with them new captures of unexpected species. As a result of it, some species being currently considered as rare, such as those reported here, might be common or abundant at certain depths or habitats.

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