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In Situ Video Observations of Two Manefishes (Perciformes: Caristiidae) in the Mesopelagic Zone of the Northern Gulf of Mexico

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This paper describes direct video observations of two manefishes, likely *Paracaristius* sp., from the mesopelagic waters of the north-central Gulf of Mexico. One fish was observed with a remotely operated vehicle at a depth of 829 m by an industrial ROV as part of the SERPENT Project. The second was observed at 496 m from a manned submersible. Little is known about the behavior of manefishes because most records result from net-collected material. Our observation demonstrates that manefishes are capable of precise locomotory and posture control using extended, erect fins and that the pelvic fins of these fishes are extended in a parachute-like manner. Moreover, one of the specimens exhibited an unusual vertical, sinusoidal oscillation of its caudal fin. One of the observations took place in association with a physonect siphonophore. These observations may include the deepest published record for a manefish in the Gulf of Mexico.

MANEFISHES are characterized by a relatively short head, steep snout, large eyes, a deep, strongly compressed body, a very long, high dorsal fin that originates over the anterior portion of the head and recesses into a groove in the dorsum, and greatly elongated pelvic fins that also fold into a shallow groove. They generally are pinkish brown, brown, or nearly black with black fins, and grow to about 60 cm in length (Post, 1986; Paxton, 2001). They have a broad geographical distribution with species reported from all oceans (Paxton, 2001; Csepp and Stevenson, 2006). Larvae are epipelagic and juveniles occur from the epipelagic to the mesopelagic (Tolley et al., 1990). Adults are mesopelagic and bathypelagic, occurring at depths ranging from 100–2000 m, but usually between 300 and 800 m (Post, 1986; Paxton, 2001). They are reported to be associated with siphonophores (Janssen et al., 1989).

Two genera, *Caristius* with four to five species and *Platyberyx* with three species, have historically been recognized (Post, 1986; Nelson, 2006), while the most recent treatment of the family (Trunov et al., 2006) recognizes two genera: *Caristius* and *Paracaristius* with four and two species, respectively. Several authors (Hartel and Triant, 1998; Paxton, 2001; McEachran, 2005; Csepp and Stevenson, 2006; Trunov et al., 2006) stress that the family requires major revision.

Although several caristiid species have been reported from the eastern and western North Atlantic (Post, 1986, 1990; Scott and Scott, 1988; Paxton, 2001) and south Atlantic (Tweddle and Anderson, 2008), their presence in the Gulf of Mexico (hereafter GOM) had not been published until Tolley et al. (1990) reported three young (30.2–67.9 mm SL) caristiids: two from the GOM and a third from the northeast coast of Florida. After examination of the holotype of *Caristius maderensis* Maul, 1949, Tolley et al. (1990) identified their three specimens as *Caristius* sp. cf. *maderensis*. It now appears likely that the specimens that Tolley et al. (1990) described as belonging to the genus *Caristius* were in fact members of the genus *Paracaristius* based on Trunov et al.'s (2006) description of the genus *Paracaristius* that references a wide suborbital space and a relatively short upper jaw covered by suborbitalia.

This paper describes direct video observations of two manefishes, both presumed to belong to the genus *Paracaristius* from the mesopelagic waters of the north-central GOM. One of these observations was collected as part of the SERPENT Project (Scientific Environmental ROV Partnership using Existing INdustrial Technology), an industrial–academic collaboration that uses industry-owned, remotely operated vehicles (ROVs) to study marine life (Benfield, 2007). The other was observed from a manned submersible during investigations of *Lophelia pertusa* coral communities in the Viosca Knoll area.

MATERIALS AND METHODS

2007 observation.—On 27 May 2007 at 08:39 local time (GMT-5), an industrial ROV operated by Oceaneering Inc. was conducting routine work near a subsea riser 829 m beneath a drilling rig in the northern GOM (27.12106°N, 90.45575°W). The ROV crew observed the specimen suspended in the water column near the riser. The ROV slowly approached the fish and recorded 5 min 45 s of video, during which time the ROV was able to maneuver to within less than a meter of the fish (Fig. 1), which afforded collection of good-quality video. The video was forwarded to Louisiana State University as part of the SERPENT Project.

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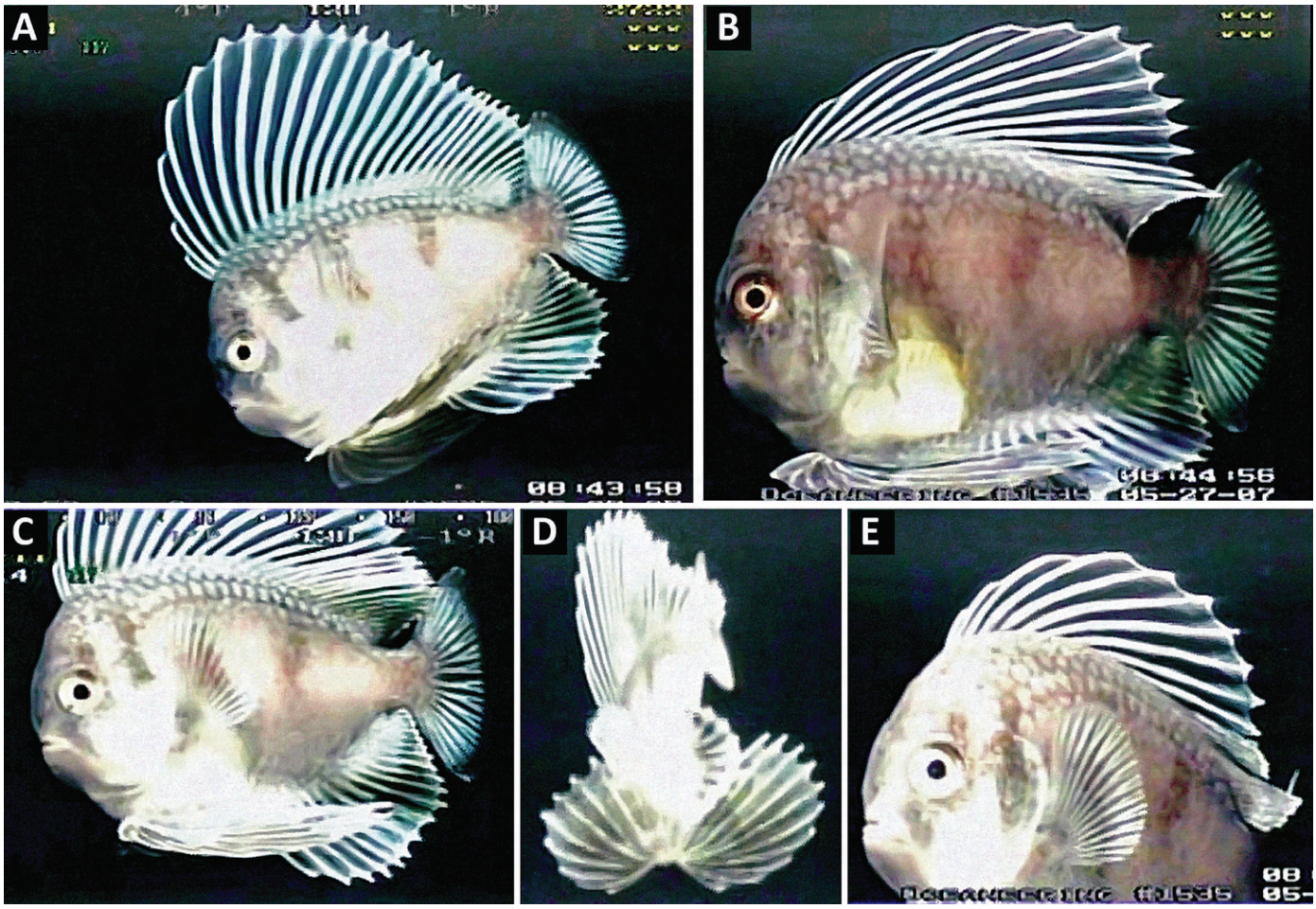

Fig. 1. Representative close-up images of the manefish observed in 2007 by SERPENT illustrating the posture of its fins, general anatomy, and coloration with detail on the: (A) dorsal fin; (B) caudal fin; (C) anal fin; (D) pelvic fins; and (E) pectoral fin.

2004 observation.—This specimen was observed on 1 Aug 2004 at 16:21:02 local time (GMT-5), while the Johnson-Sea-Link manned submersible (JSL) was conducting a dive as part of a study to characterize *Lophelia pertusa* coral communities at a site on Viosca Knoll (29.15662°N, 88.01859°W). A single manefish (Fig. 2) was observed at 496 m next to a damaged physonect siphonophore (family Apolemiidae). The encounter was recorded for 40 sec during which time the fish was within the field of view for 27 sec.

Still images showing representative features of these fish (Figs. 1, 2) were extracted from the video using Topaz Moment software (Topaz Labs LLC). The 2007 observation contained sufficient detail to visually enumerate fin-ray counts visually. Still images that showed fin rays on the 2004 fish were imported into Matlab (Mathworks, 2008) and counts were estimated using the 'improfile' function. A digital copy of the original 2007 video was archived at the SERPENT Project website (http://archive.serpentproject.com/1232/). The 2004 observation is archived at http://fl.biology.usgs.gov/files/CARISTIUS_4749.mpg. Both videos are also available from the authors by request. We also examined available museum collection databases for other records of Caristiidae from the GOM. Museum abbreviations follow Leviton et al. (1985).

RESULTS

Both specimens likely belong to the genus *Paracaristius*. Identification of the 2007 fish was based on general morphology and counts of fin rays. The body was laterally compressed with a long dorsal fin that originated on the head at the level of the posterior margin of the eye (Fig. 1) and consisted of 29 elements. The suborbital space was wide and the upper jaw was short, extending just posteriorly of the anterior edge of the eye. Fin-ray counts appeared to be as follows: pectoral, 15–16 (13 branched); pelvic, 15–16; anal, 18; caudal, 17 (15 branched; Fig. 1). Overall the body color was a pale beige color with a darker gray dorsum and three approximately equidistant narrow, brown, vertical bands approximately centered below the 6th, 12th, and 17th dorsal-fin rays (Fig. 1). We estimated the fish to be 15–20 cm (TL).

The quality of the video of the 2004 specimen did not permit accurate visual estimations of fin-ray counts for all fins. Its morphology was generally similar to the 2007 fish, with a large dorsal fin originating near the posterior margin of the eye, large fan-like pelvic fins that were splayed outward when the fish was stationary, and an overall light brown coloration (Fig. 2). The presence of vertical banding patterns could not be assessed because the fish was overexposed when broadside to the camera. Image analysis of brightness levels along fins (Matlab) provided the following estimates of fin-ray counts: dorsal, >30; anal, 17–18. It was not possible to estimate the length of the fish in the absence of any scaling information.

When first observed, the 2007 manefish was motionless, facing away from the ROV. Its dorsal, pelvic, and anal fins were extended, and it used its pectoral fins for minor

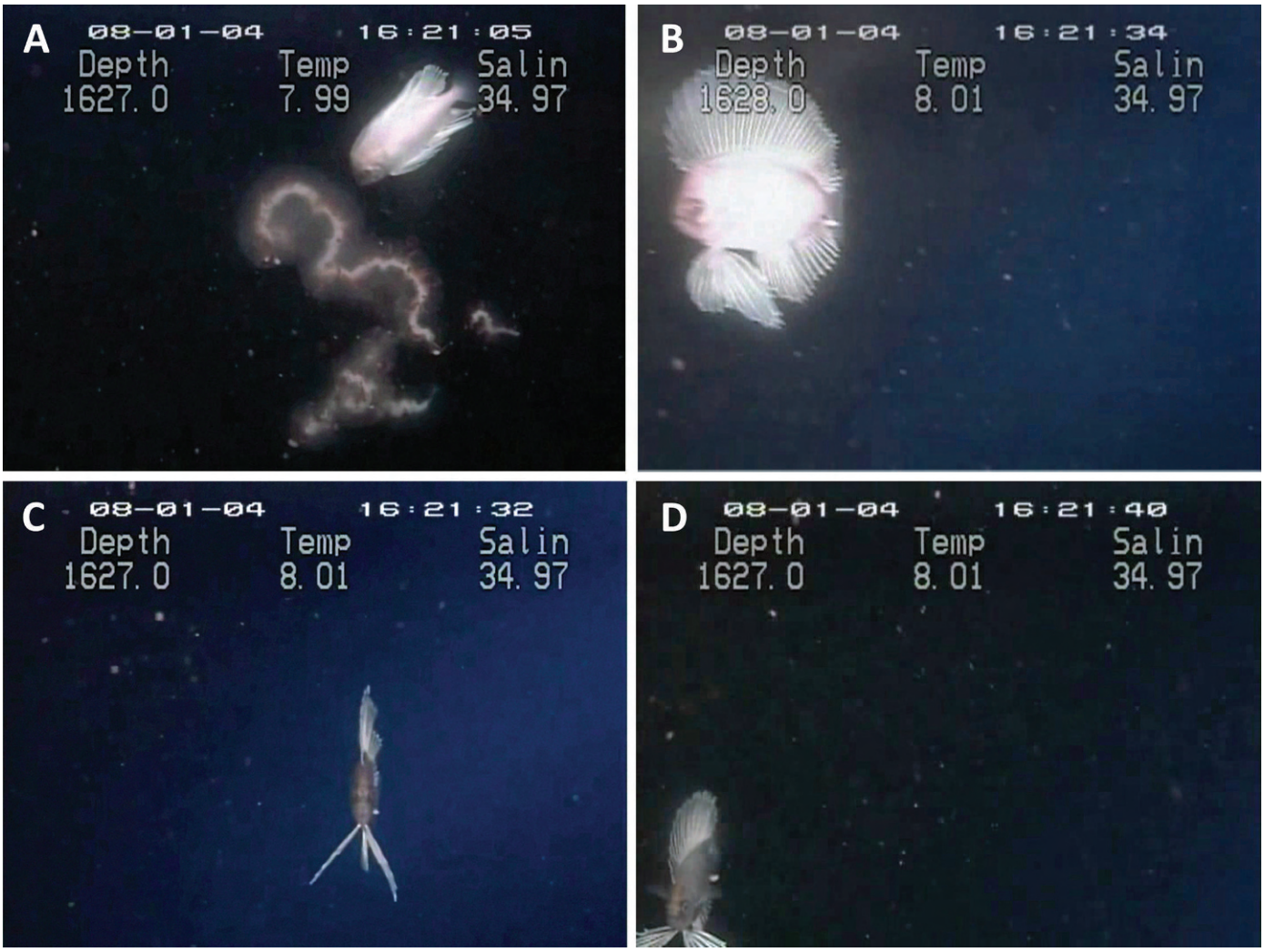

Fig. 2. Representative images of the manefish observed in 2004 by USGS. (A) Fish initially observed in close proximity to siphonophore; (B) lateral view of fish; (C–D) frontal views of fish showing orientations of pelvic fins.

postural adjustments by beating them in alternating left and right contralateral cycles. The pelvic fins were spread outward ventrolaterally, to form a large horizontal surface that resembled a parachute. As the ROV approached, the specimen slowly turned to face the vehicle, using paddle-like motions of the pectoral fins and some slight, sinusoidal movements of the caudal fin. It did not attempt to avoid the ROV, but remained in a posture that allowed it to observe the ROV. The bright (six 250W) lights of the ROV did not appear to affect the behavior of the fish. The water temperature measured during the observation was 9.3°C.

The 2004 fish exhibited more movement than the 2007 individual during the brief encounter. During the 2004 observation, the fish was initially stationary facing the siphonophore (Fig. 2A). It then turned toward the JSL and swam offscreen. When the fish was re-acquired by the video, it faced the JSL directly with the pelvic fins tilted downward at 61° from horizontal (Fig. 2C), then turned and briefly presented a broadside aspect (Fig. 2B) before again facing the camera with pelvic fins extended more horizontally (Fig. 2D) as the video ended. The temperature and salinity during the encounter were 8.0°C and 34.97 psu, respectively.

Museum collections contained records of 13 Caristiidae from the Gulf of Mexico, Florida Straits and Atlantic Ocean off Florida (Fig. 3). Collection specimens (reported identity, number of individuals, collection depth, and length [mm]) were: MCZ 66466 (Caristiidae, n = 1, 226–267 m, SL = unknown), MCZ 40514 (Caristiidae, n = 1, 411 m, SL = unknown), MCZ 41098 (Caristiidae, n = 1, 768 m, SL = unknown), MCZ 41101 (Caristiidae, n = 1, 183–229 m, SL = unknown), MCZ 66436 (*Caristius* sp., n = 2, 100–200 m, SL = 15 and 22), UF 213863 (*Caristius japonicus*, n = 1, 418–820 m, SL = 91.1), UF 171870 (Caristiidae, n = 1, 329 m, SL = 46.4), UF 149776 (n = 2, 293–379 m, SL = 11.2 and 12.8), FSBC 17905 (*C.* sp. cf. *madierensis*, n = 1, 0–900 m, SL = 67.9), FSBC 17906 (*C.* sp. cf. *madierensis*, n = 1, 0–600 m, SL = 65.3), and GCRL 17426 (*C.* sp. cf. *madierensis*, n = 1, 226 m, SL = 30.2).

DISCUSSION

Adult manefishes inhabit mesopelagic and bathypelagic waters (Marcus, 2004). Although five to six species are recognized worldwide, the taxonomy of this family is uncertain and in need of revision (Csepp and Stevenson, 2006; Trunov et al., 2006; Tweddle and Anderson, 2008). One of the challenges associated with *in situ* video data is the difficulty in determining the species present. In the absence of a physical specimen, there are frequently limits to the degree to which observational data can be used for precise

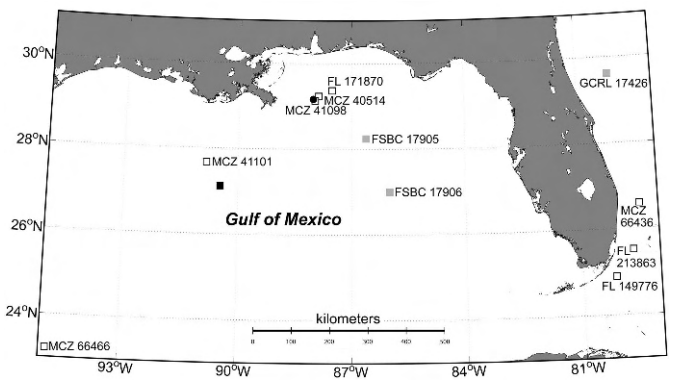

Fig. 3. Locations of prior records of juvenile specimens by Tolley et al. (1990; ■), museum collection specimens (□), SERPENT observation (■), and the USGS observation (●). Where collection locations specified the locations of the start and end of the tow, we have plotted the arithmetic mean of the latitude and longitude coordinates. Due to the map projection, distances are accurate at 25°N and approximate at other latitudes.

taxonomic determination. We were fortunate that the video record was of high quality and the fish was not frightened by the presence of the ROV; however, higher resolution imaging could provide additional taxonomic details that would permit identification to species.

We estimate the length of the 2007 specimen to be approximately 15–20 cm based on the dimensions of the nearby riser (132 cm diameter); however, this length must be regarded as an approximation at best because laser scaling information was not available. The size of the 2004 specimen could not be estimated. Adult manefishes are not large. Marcus (2004) estimated the size of adults at approximately 26.5 cm SL and larger. We initially classified our fish as an adult; however, the largest specimen of *Paracaristius* that has been observed with a vertical banding pattern was 7.43 cm SL (Karsten Hartel, Harvard University, pers. comm., 24 October 2008). Such banding was evident on our specimen, which raises two possibilities: we have overestimated its true length and that it was, in fact, a juvenile; or that banding occurs in individuals larger than 7.43 cm SL.

These are the first reports of the *in situ* behavior and orientation of live manefishes in the world ocean, following upon submersible video documentation of the taxon (herein re-identified as *Paracaristius*) in the GOM (Sulak et al., 2007, 2008), as well as their apparent association with siphonophores (Janssen et al., 1989; Lindsay et al., 2001). Tolley et al. (1990) reported two juveniles from stations in the eastern GOM and a third juvenile from a station off eastern Florida (Fig. 3). Our 2007 observation was considerably further west than the Tolley et al. (1990) specimens and with 72 km of the MCZ 41101 record; however, the MCZ 66466 specimen represents the most westerly record from the GOM (Fig. 3). The 2004 observation was from a region that has previously yielded three other manefishes (Fig. 3).

Museum collections contain records of manefishes, which have been collected from net tows extending to 900 m. Precise capture depths are usually not known when net tows span broad depth ranges. A search of fish collection databases (AMNH, BMNH, CAS, Fish Base, FMNH, MNHN, TU, USNM, UW) indicated only the MCZ, UF, and FSBC have GOM or Florida Straits specimens. Moreover, the information on fish lengths from the majority of specimens documented in the MCZ collection, and therefore, their developmental stages, is incomplete because some specimens were lost. Manefishes are reported to occupy progressively deeper waters as they mature. Whatever their developmental stages may have been, our observations appear to be among the deepest recorded collections of manefishes from the GOM.

One particularly interesting behavior observed during this encounter was the sinusoidal movement pattern of the caudal fin. This movement was manifested as a series of sinusoidal vertical undulations during a 7 s period from 08:43:51–08:43:58 on the video. Attempts to quantify this movement using Matlab were unsuccessful. Sinusoidal undulation of fins has been summarized by Sfakiotakis et al. (1999). Actinopterygian fishes that employ sinusoidal undulation include Tetraodontiformes (dorsal, anal, and pectoral fins), Amiiformes (dorsal fins), and Gymnotiformes (anal fins). Vertical sinusoidal undulations of the caudal fin have only recently been documented in Perciformes by Ting and Yang (2008). Their investigation of this behavior, which they term caudal fin-wave propagation, in a hybrid of two species of *Cichlasoma*, suggests that it is adaptive in providing stabilization during head-down postures. This interpretation is consistent with our 2007 observation as the manefish was tilted head-down when it undulated the caudal fin.

Manefishes of the genus *Caristius* have been observed in association with siphonophores (Janssen et al., 1989; Lindsay et al., 2001). Janssen et al. (1989) documented such an association with the siphonophore *Bathyphysa conifera* at 168 m during a night dive by a manned submersible in the Atlantic approximately 150 km SSW of Nantucket, Massachusetts. In that case, the manefish was close enough to the siphonophore to physically contact the colony. Based on the behavior of the manefish in relation to the siphonophore, and stomach contents of the specimen, they suggested that species of *Caristius* may steal food from, and consume portions of the siphonophore directly. Lindsay et al. (2001) observed an unidentified species of manefish in association with the prayid calycophoran siphonophore *Praya* sp. That manefish was also observed positioned ''flush'' with the siphonostome of the siphonophore. The 2004 observation was in close proximity to a damaged physonect siphonophore (family Apolemiidae), which raises the possibility that the damage was inflicted by the manefish. We did not observe any siphonophores during the 2007 encounter with the manefish; however, a large apolemiid siphonophore was observed 20 min after the manefish at a depth of 1082 m next to the riser. Both prayid calycophoran and apolemiid physonect siphonophores were also observed at this site within the depth range 764–911 m over a 40-day period spanning the manefish observation.

Another notable aspect of the morphology and behavior of these specimens was how broadly expanded the pelvic fins were. While these fins have been described as being folded or enclosed in a shallow groove, both our 2007 *in situ* observation and Janssen et al.'s (1989) juvenile specimen indicate that these fins are broadly expanded in a parachute-like orientation. The 2004 specimen also displayed a similar posture, although its pelvic fins were not extended as horizontally (61° relative to horizontal) as was manifested in the 2007 observation. In all three cases, the generally splayed orientation of all the fins suggests a level of stability that may be important when swimming in close proximity to siphonophores.

While a pair of observations of individual manefishes does not provide a basis for estimating how abundant this fish is

in the GOM, we note that this observation is the only time that we have observed this taxon during over 100 hours of mesopelagic and bathypelagic ROV video surveys. Consequently, we speculate that they are present in very low densities. As additional ROVs provide SERPENT Project observations from the GOM, we would not be surprised to learn more about these little-known fishes.

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