

BRIEF COMMUNICATION**Seeking the sun in deep, dark places: mesopelagic sightings of ocean sunfishes (Molidae)**

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Evidence is presented from publicly available remotely operated vehicle (ROV) footage that suggests deep-water ranging in ocean sunfishes (family Molidae) is more common than typically thought, including a new maximum depth recorded for the southern sunfish *Mola ramsayi*.

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The family Molidae, or the ocean sunfishes, is currently believed to comprise four widely distributed species: the ocean sunfish *Mola mola*, (L. 1758), sharptail sunfish *Masturus lanceolatus* (Liénard 1840), southern sunfish *Mola ramsayi* (Giglioli 1883) and slender sunfish *Ranzania laevis* (Pennant 1776), although the taxonomy remains uncertain, with the possible existence of several currently undescribed species (Bass *et al.*, 2005; Pope *et al.*, 2010). Often seen basking at the surface, there was a long held perception that these species were rare, inactive drifters feeding solely on gelatinous zooplankton (Pope *et al.*, 2010). An increasing number of recent studies, however, have shown these notions to be far from accurate, with evidence of long-distance migrants travelling $c. 27 \text{ km day}^{-1}$ (Cartamil & Lowe, 2004), displaying deep diving behaviours (Hays *et al.*, 2009; Sims *et al.*, 2009) and consuming a mixed diet (Sivänta *et al.*, 2012; Nakamura & Sato, 2014). More specifically, there is now strong evidence of cryptic benthivory in these typically pelagic fishes (Harrod *et al.*, 2013) and records of deep-water forays to feed on colonial gelata such as siphonophores (Nakamura & Sato, 2014; Nakamura *et al.*, 2015). Taken together, a picture of an active migrant feeding broadly within marine food webs has emerged, but observational data to validate

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behavioural studies remain difficult to come by (Houghton *et al.*, 2000). Serendipitous sightings of three sunfish species are presented here, sourced from industrial and research submersibles, providing further evidence of the deep ranging capabilities of the Molidae. More broadly, these records taken together with previous remotely operated vehicle (ROV) sightings of a hammerhead shark *Sphyrna lewini* (Griffith & Smith 1834) (Moore & Gates, 2015) add weight to the idea that mesopelagic environments may be of greater importance than thought previously for taxa often considered as epipelagic.

Sighting data were sourced primarily from the scientific and environmental ROV partnership using existing industrial technology (SERPENT) project (Jones *et al.*, 2009). As direct observations of marine life in the deep sea are often prohibitively expensive, this collaboration enables scientists to browse video footage shot by industrial ROVs, providing rare access to life in the open ocean and sightings of much understudied species *e.g.* oarfish *Regalecus glesne* Ascanius 1772 (Benfield *et al.*, 2013) and deep sea squid *Grimalditeuthis bonplandi* (Hoving *et al.*, 2013). Other data were sourced from ROV footage available online or through personal communications (see Fig. 1 and Table I).

A total of 13 anecdotal sightings of Molidae were obtained at depths of up to 550 m (Table I). Eleven animals were recorded from depths of >160 m, with eight of these individuals exceeding 200 m. Aside from the general pattern of mid-water ranging, the Australian sighting of a *M. ramsayi* at 483 m probably constitutes the deepest record for this species to date. The only previous record of depth use for this species came from the Sea of Oman (Sea & Bejgan, 2014) where an individual was caught in a trawl at 85 m. For context, the maximum depths previously recorded from sunfishes were 844 m for *M. mola* (Potter & Howell, 2011) and 670 m for *M. lanceolatus* (Harbison & Janssen, 1987), which suggests that 483 m is unlikely to represent a maximum for *M. ramsayi* given the gross morphological similarities between these species.

Previous studies have intimated that such movements of Molidae into deeper water may be a means of locating deep or vertically migrating zooplankton prey (Cartamil & Lowe, 2004; Sims *et al.*, 2009; Dewar *et al.*, 2010; Nakamura *et al.*, 2015). Typically, such forays to depth constitute daytime bouts of V-shaped dives punctuated by periods at the surface (Cartamil & Lowe, 2004; Dewar *et al.*, 2010). Recently, Nakamura *et al.* (2015) verified that the main function of surfacing is the recovery of body temperature, with the fish increasing heat gain from the warm surface water by physiological regulation (Hays, 2015). The data presented here may be aligned with such behaviour given that the greatest depths of sunfishes recorded from the ROV footage (Table I) occurred during the day (0600 to 1800 hours) but with some diving activity at night (with maximum depth of 306 m recorded at 0130 hours). Such daytime excursions to mesopelagic depths (albeit rarely) have also been documented in leatherback turtles *Dermochelys coriacea*, with the overall assertion that individuals were speculating for vertically ascending gelatinous zooplankton, rather than feeding at depth (Houghton *et al.*, 2008). From the ROV footage (Fig. 1), no comment can be made on whether these observations constituted brief (*i.e.* speculative), or prolonged (*i.e.* feeding) excursions to depth or the behaviour prior to or following such events. These data, however, can provide visual observations over a broad geographical range to support the notion that ocean sunfishes routinely dive below the epipelagic zone.

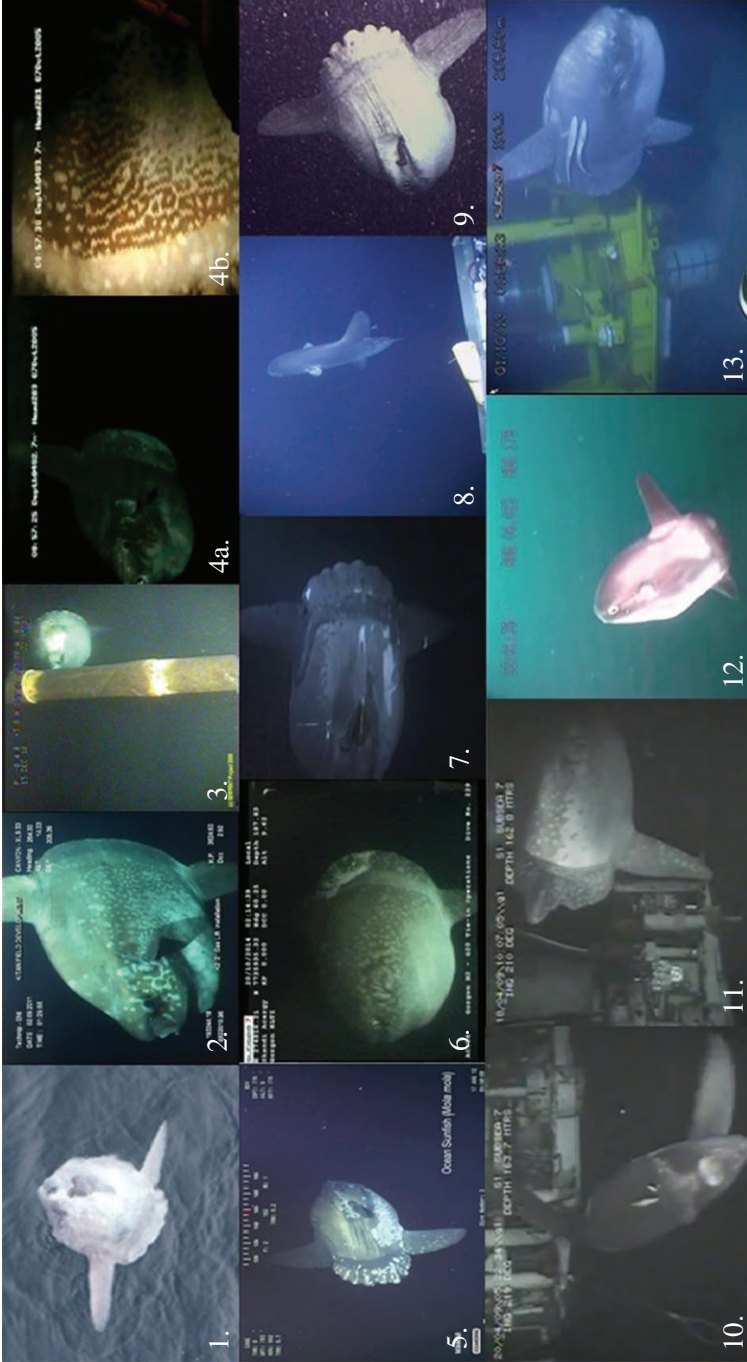


FIG. 1. Incidental sightings of ocean sunfishes; photographs and stills from remotely operated vehicle (ROV) video footage. The number on figures refers to individuals in Table I (see Table I for location and depth data also). The footage of individuals was clear enough for reliable identification of species. For example, the image of individual 11 clearly shows the distinctive sharp tail that is diagnostic of *Masturus lanceolatus*, whilst images 4(a) and 4(b) show the increased band of denticles with closely situated ossicles that are indicative of *Mola ramsayi*. Interesting behaviours were also identified from these brief encounters such as for individual 10 which can be clearly seen in the video footage scratching itself against the rig structure.

TABLE I. Observation records of ocean sunfishes. Full co-ordinates are given, where known, otherwise general location is stated

Observation number	Date	Local time (hours)	Location: geographical co-ordinates	Species	Depth (m)	Reference
1	10 September 2004	–	North Sea, west of Shetland, U.K. 60° 20' 03" N; 4° 05' 56" W	<i>Mola mola</i>	0	SERPENT Archives (Jones <i>et al.</i> , 2009)
2	2 September 2011	0129	Indian Ocean, Timor, Western Australia 10° 38' 37" S; 126° 11' 50" E	<i>Mola mola</i>	305	SERPENT Archives (Jones <i>et al.</i> , 2009)
3	15 December 2010	2215	South Atlantic, Congo, West Africa 20° 28' 53.2" S; 114° 24' 37.6" E	<i>Mola mola</i>	110	SERPENT Archives (Jones <i>et al.</i> , 2009)
4	7 December 2005	0857	Indian Ocean, Australia 18° 30' 00" S; 115° 30' 00" E	<i>Mola ramsayi</i>	483	SERPENT Archives (Jones <i>et al.</i> , 2009)
5	17 August 2012	0558	North Atlantic, Gulf of Mexico	<i>Mola mola</i>	242	SERPENT Archives (Jones <i>et al.</i> , 2009)
6	20 October 2014	0213	Indian Ocean, Australia 20° 28' 53.2" S; 114° 24' 37.6" E	<i>Mola mola</i>	193	SERPENT Archives (Jones <i>et al.</i> , 2009)
7	10 November 2002	0922	North Atlantic, Florida 27° 44' 8" N; 91° 13' 3" W	<i>Mola mola</i>	401	2002 R.V. <i>Seward Johnson II</i> Fall Cruise (Cordes, 2009)
8	19 May 2007	1417	North Atlantic, Gulf of Cadiz 35° 17' 914" N; 6° 38' 709" W	<i>Masturus lanceolatus</i>	348	Tyler (pers. comm.) JC10 R.V. <i>James Cook</i> cruise 2009
9	1 July 2001	–	North Atlantic, Dry Tortugas, Florida Keys 24° 43' N; 82° 52' W	<i>Mola mola</i>	550	Thys (pers. comm.) 2001 Islands in the Stream Expedition S. A. Earle/Sustainable Seas Expedition
10	20 April 2009	1008	Location unknown	<i>Masturus lanceolatus</i>	167	SERPENT Archives (Jones <i>et al.</i> , 2009; Subsea, 2009b)

TABLE I. Continued

Observation number	Date	Local time (hours)	Location: geographical co-ordinates	Species	Depth (m)	Reference
11	18 April 2009	0849	Location unknown	<i>Masturus lanceolatus</i>	164	SERPENT Archives (Jones <i>et al.</i> , 2009; Subsea, 2009b)
12	17 October 2008	2201	Location unknown	<i>Mola mola</i>	50	Californian District Fisheries and Wildlife Archives (CDFW, 2008)
13	1 October 2013	0158	Location unknown	<i>Mola mola</i>	206	SERPENT Archives (Jones <i>et al.</i> , 2009)

With respect to prey acquisition at depth, low levels of mesopelagic light suggest that the Molidae possess adequate visual acuity at depth to hunt mobile prey, potentially in combination with other senses such as olfaction, (Hara, 1994). Visual acuity, determined from immature *M. mola*, was calculated at 3.5–4.3 cycles per degree (Kino *et al.*, 2009), similar to values recorded from some adult sharks [e.g. 3.8: *Galeus melastomus* Rafinesque 1810 and 2.8: *Etmopterus spinax* (L. 1758); Bozzano & Collin, 2000] and higher than those from adult cetaceans (e.g. 2.7: *Lagenorhynchus obliquidens* and 2.6: *Delphinapterus leucas*; Murayama & Somiya, 1998). As visual acuity typically increases over the lifetime of an individual (Fritsches & Marshall, 2003), this value is likely to increase for mature sunfishes. Eye size usually reflects the importance of vision to a species (Walls, 1942) and the large eyes of the Molidae support the suggestion by Hays *et al.* (2003) that ambient light levels at prey field depths may be important in determining foraging success in marine predators. Ocean sunfish eyeball diameter data have only been published from juveniles (total length, L_T , <1 m), with maximum eye diameter of 38 mm (Cleland, 1862). This is comparatively large when considering other pelagic predators [*Carcharodon carcharias* (L. 1758) 37.1 mm and *S. lewini* 25.5 mm; Lisney & Collin, 2007] with the overall inference that Molidae are well adapted to foraging at depth. Moreover, as gelatinous zooplankton may be difficult to locate while looking down through the water column, diving to depth may allow such species to be silhouetted against down-welling light during re-ascent.

Alternatively, prey densities at depth may simply be sufficient to warrant exploration in low-light conditions, although the mechanisms for detection are not yet fully understood. Davenport (1988) and Davenport & Balazs (1991) suggested that the Molidae and leatherback turtles may use luminescence to help in their search for deep prey (e.g. pyrosomes); however, as such behaviour was not observed here, it is not possible to comment further. The potential for the ROV lights themselves to attract sunfishes must also be acknowledged, given that baited remote underwater video systems (BRUVS) routinely employ illumination to entice animals closer to the camera (Harvey *et al.*, 2012; Fitzpatrick *et al.*, 2013; De Vos *et al.*, 2014). This matter aside, gelata are certainly present at depth in open water and can constitute 50–80% of the integrated standing crop by volume (Angel & Pugh, 2000; Houghton *et al.*, 2008). Qualitatively, there is evidence of putative prey in the Gulf of Mexico from the SERPENT archives (corresponding geographically to the 2012 *M. mola* sighting; Table I) including the scyphomedusa *Stygiomedusa gigantea* (Benfield & Graham, 2010), *Aurelia aurita*, narcomedusae (*Solmissus* spp.), salps and ctenophores, suggesting deep-water feeding behaviour warrants further investigation.

Within this collection of mesopelagic encounters, there was one sighting of specific interest where an *M. lanceolatus* was filmed interacting with the physical structure of the rig itself. Given that the Molidae can be highly parasitized (Fraser-Brunner, 1951) and have been observed undertaking many behaviours suggested to reduce parasite loads (e.g. attracting sea birds; Abe *et al.*, 2012, aggregating at reef cleaning stations and breaching; Konow *et al.*, 2006), the rig structure may offer a hard surface to rub against. In the relatively featureless open ocean, such opportunities are lacking which may explain the behaviour of the 2009 *M. lanceolatus* sighting at 167 m (see Table I; Subsea, 2009a). The video footage here clearly shows the *M. lanceolatus* using the platform's framework to scratch itself, suggesting that such structures might provide a service for sunfishes throughout the water column.

Another sighting of specific interest was recorded in 2004 to the west of Shetland (Table I). This record was not collected from great depth, but in surface waters, where an *M. mola* was observed at 60° N, close to the reported northerly limit of the *M. mola* range, where they are sighted rarely. This northerly boundary may be temperature constrained as *M. mola* in the north-east Atlantic Ocean have been recorded spending 99% of the time in water temperatures between 10 and 19° C (Sims *et al.*, 2009). Despite its northerly location, this individual was sighted in September when the average sea surface temperature off Shetland is 12.7° C (World Sea Temperatures, 2015), well within the stated *M. mola* temperature range. Consequently, it is unlikely that the scarcity of *M. mola* sightings in this area reflects thermal tolerances alone.

In conclusion, this paper provides repeated evidence of mid-water ranging in the Molidae using anecdotal sightings from publicly available ROV footage. These data suggest that sunfishes are more common in the mesopelagic zone than previously thought, in line with deep-water forays of other typically epipelagic species. A new depth record is also presented for the *M. ramsayi* sighted at 483 m and a rare observation of an *M. mola* north of 60° N. These data show the importance of collaborations between commercial enterprises and academics, providing access to anecdotal sightings that have the potential to significantly increase the understanding of rarely encountered fish species. Such evidence also serves to highlight the increasing realization that the Molidae are far more complex in their ecology than previously thought.

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