



NATURAL HISTORY REPORT

The devil in the deep: expanding the known habitat of a rare and protected fish

Lachlan C. Fetterplace^{1,2}, John W. Turnbull³, Nathan A. Knott⁴, Natasha A. Hardy⁵

¹School of Biological Sciences, University of Wollongong, NSW, Australia.

Corresponding author, E-mail: fishthinkers@gmail.com

²Fish Thinkers Research Group, 11 Riverleigh Avenue, Gerroa, NSW 2534, Australia.

³School of Biological, Earth and Environmental Science, University of New South Wales, NSW 2052 Australia

⁴Fisheries Research, New South Wales Department of Primary Industries, 4 Woollamia Road, Huskisson, NSW, Australia

⁵School of Life and Environmental Sciences, University of Sydney, NSW 2006 Australia

ABSTRACT

The accepted geographic range of a species is related to both opportunity and effort in sampling that range. In deepwater ecosystems where human access is limited, the geographic ranges of many marine species are likely to be underestimated. A chance recording from baited cameras deployed on deep uncharted reef revealed an eastern blue devil fish (*Paraplesiops bleekeri*) at a depth of 51 m and more than 2 km further down the continental shelf slope than previously observed. This is the first verifiable observation of eastern blue devil fish, a protected and endemic southeastern Australian temperate reef species, at depths greater than the typically accepted depth range of 30 m. Knowledge on the ecology of this and many other reef species is indeed often limited to shallow coastal reefs, which are easily accessible by divers and researchers. Suitable habitat for many reef species appears to exist on deeper offshore reefs but is likely being overlooked due to the logistics of conducting research on these often uncharted habitats. On the basis of our observation at a depth of 51 m and observations by recreational fishers catching eastern blue devil fishes on deep offshore reefs, we suggest that the current depth range of eastern blue devil fish is being underestimated at 30 m. We also observed several common reef species well outside of their accepted depth range. Notably, immaculate damsel (*Mecaenichthys immaculatus*), red morwong (*Cheilodactylus fuscus*), mado (*Atypichthys strigatus*), white-ear (*Parma microlepis*) and silver sweep (*Scorpius lineolata*) were abundant and recorded in a number of locations at up to a depth of at least 55 m. This underestimation of depth potentially represents a large area of deep offshore reefs and micro-habitats out on the continental shelf that could contribute to the resilience of eastern blue devil fish to extinction risk and contribute to the resilience of many reef species to climate change.

KEYWORDS

Natural history, Biogeography, Range expansion, Eastern blue devil fish, BRUV, SCUBA, Recreational fishing, Temperate reef, Depth range, Patch reef

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INTRODUCTION

In October 2013, we were two months into undertaking video sampling of fish communities on poorly studied marine soft-sediment environments, off the southeast coast of Australia. We sampled around 3 km offshore using baited remote underwater video stations (BRUVS; Fig. 1) in relatively deep water (50–60 m), beyond the ability to effectively sample using SCUBA. We dropped cameras on what we thought to be sand, but that turned out to be uncharted low-profile patch reef, full of overhangs and crevices.

For our purposes, samples on non-target habitat (reefs) are considered ‘failed’, typically stored on hard drives and left to gather dust at the back of a laboratory. This time though, perhaps because the seascape was so interesting, we went through the entire hour-long video sample from a deep offshore reef. And there it was, the unmistakable electric blue colouring, white stripes and shy emergence of an eastern blue

devil fish (*Paraplesiops bleekeri*) from a crevice to investigate a baited camera. This observation occurred at nearly triple their previously recorded depth (at 51 m) and more than 2 km further down the continental shelf slope than previously observed (video [here](#)).

Eastern blue devil fish are protected off the coast of eastern Australia under the *Fisheries Management Act 1994*. They are rare and endemic to eastern Australian coastal reefs and considered vulnerable to extraction for the aquarium industry (NSW DPI 2006). Despite this, little is known about them beyond taxonomic and descriptive information. In particular, little is known about the full extent of their geographic and depth range, information that is important to understanding the extinction risk, critical habitat and management needs of vulnerable and endemic species (Purcell et al. 2004).

The observation of eastern blue devil fish, a demersal (bottom dwelling) coastal reef species, on deep offshore reefs

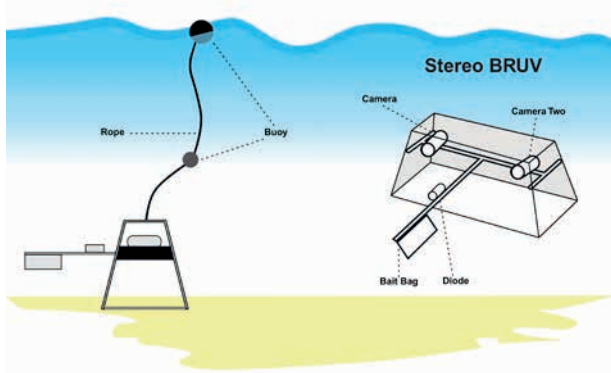


Figure 1: Baited remote under water video stations (BRUVS) are often used to sample fish communities (taken from Fetterplace and Rees 2017, CC BY 4.0). BRUVS are lowered to the sea floor (or to the desired depth if sampling pelagic fishes e.g. Rees et al. 2015 for an interesting example) and left to record visiting species without the need for an operator to be continuously present. This allows a number of samples to be taken simultaneously by deploying numerous BRUVS at the same time over a number of sites. Other advantages of BRUVS include that it avoids potential behavioural changes fish may have in the presence of divers, provides a permanent record, is non-extractive, and can survey at depths, times and in weather conditions that are dangerous for divers. The use of newer paired camera stereo BRUVS also allows the accurate measurement of fish size (for a detailed review of BRUVS methodology see Whitmarsh et al. 2017).

was unusual, primarily because of the observed depth and distance from the coast. Eastern blue devil fish are charismatic yet shy (Fig. 2) cryptic fish previously recorded in shallow coastal waters and on inshore rocky reefs of 1–17 m (Edgar and Stuart-Smith 2018) where they are found in caves, crevices and under ledges (Kuitert 2000, NSW DPI 2006). Eastern blue devil fish are listed as having a possible range down to 30 m (e.g. Kuitert 2000, NSW DPI 2006, Gomon et al. 2008); however, there are no records on Reef Life Survey (RLS), a global database for reef biota, at depths below 17.2 m. In fact, most RLS records are from much shallower depths, with an average depth recorded on the RLS database of 9.1 m (Edgar and Stuart-Smith 2014, Edgar and Stuart-Smith 2018).

We know of no historical records in Australian museums or databases of eastern blue devil fish from deeper than 30 m either. Owing to a combination of their protected status and the complex terrain they inhabit, commercial fishers are unlikely to come across them, as trawling is avoided on these areas because of the risk of damage to nets. The vast majority of sightings and records of eastern blue devil fish are reported from divers and researchers. The accepted depth range of eastern blue devil fish and many coastal reef fish coincides with the recreational dive limits of ~30 m, despite the fact that



Figure 2: The eastern blue devil (*Paraplesiops bleekeri*) is a temperate cave-associated species that would not look out of place on a tropical reef. Brightly coloured and a prize sighting for divers; they are protected in New South Wales (Australia) waters because of their natural rarity and low abundance. (Photographer: John Turnbull: CC BY-NC-SA 2.0).

Box 1: Extending our knowledge of deep reef assemblages

The eastern blue devil fish was not the only species that we recorded outside its known depth range. After the initial unexpected observation of the eastern blue devil fish, we identified the species present on another 17 additional 'failed' reef BRUVS samples collected across an approximately 75 km stretch of coastline from Jervis Bay to Bawley Point, NSW, Australia (data available at Fetterplace and Knott 2018). It soon became clear that a number of more common species were also captured on camera outside their previously recorded depth range (Fig. 3, Table 1). Notably, several common reef species, such as immaculate damsel, red morwong, mado, white-ear and silver sweep, are all listed as occurring down to 30 m, yet were present on 50–89% of deepwater reef samples (Fig. 3, Table 1). Other species were observed <15 m outside their accepted depth range, including crimson-banded wrasse (*Notolabrus gymnogenis*) on 17% of samples (Fig. 3, Table 1). We also found evidence that the depth range of one species, redbanded grubfish (*Parapercis binivirgata*), includes much 'shallower' areas than listed in the scientific literature. This species is listed as occurring in waters deeper than 86 m, however, was present at a depth of 50 m on 39% of reef samples (Table 1). These observations further support our hypothesis that the depth range of many other coastal reef species is likely underestimated.

Once off the reef edge, the fish communities found on the surrounding sandy areas begin to change and are very different to those on the reef (Schultz et al. 2012). Our study area is no exception; the patch reefs at a depth of 50 m tend to be dominated by a range of more colourful or conspicuous species, whilst the surrounding sand habitats sampled in Fetterplace (2018) are dominated by flatheads (Platycephalidae), which use camouflage and burial in the sand to ambush prey. In contrast to the reef samples, none of the species encountered in comprehensive sampling on soft sediments at a depth of 50–60 m was outside its depth range (Table 1). Species that occur on sand are much more likely to have been caught in scientific or commercial trawling and the capture depths then included in the scientific records.



Figure 3: Five species (photos from top to second from the bottom are red morwong, immaculate damsel, mado, white-ear and silver sweep) that are common on shallow reefs and previously had an accepted depth range of <30 m were observed regularly on deeper reefs in this study (>50 m). Crimson-banded wrasse (bottom photo) was also observed outside their depth range on a small number of samples. (Photographer: John Turnbull: CC BY-NC-SA 2.0).

Table 1: The list of species that were recorded on BRUVS samples with each species habitat association, percentage of reef (n=18) and sand (n=56) samples that each species was recorded on, depth range listed in the scientific literature (depth range based on Kuitert 2000, Gomon et al. 2008, Froese and Pauly 2017, Bray 2018, McGrouther 2018) and maximum depth recorded in our study if greater than listed in the literature. Species that were recorded >10 m deeper than in the literature are highlighted in bold.

Family	Species	Common Name	Habitat Association	Reef Samples (%)	Soft sediments (%)	Depth Range in Scientific Literature (m)	Max Depth Recorded Current Study (m)
Araucanidae	<i>Anoplocapros inermis</i>	Eastern Boxfish	Demersal	-	2*	2–300	
Aulopiformes	<i>Latropiscis purpurissatus</i>	Sergeant Baker	Reef associated	44	-	15–250	
Berycidae	<i>Centroberyx affinis</i>	Nannygai	Reef associated	94	-	10–450	
Callanthiidae	<i>Callanthias australis</i>	Splendid Perch	Reef associated	22	-	10–365	
Canthigaster	<i>Canthigaster callisterna</i>	Clown Toby	Reef associated	11	-	10–250	
	<i>Pseudocaranx georgianus</i>	Silver Trevally	Benthopelagic	56	27	0–200	
Carangidae	<i>Seriola hippos</i>	Samsonfish	Pelagic	6*	-	1–100	
	<i>Seriola lalandi</i>	Yellowtail Kingfish	Pelagic	6*	2*	0–825	
	<i>Trachurus novaezelandiae</i>	Yellowtail Scad	Pelagic	-	23	0–500	
Chaetodontidae	<i>Chelmonops truncatus</i>	Eastern Tailma	Reef associated	6	-	5–70	
	<i>Cheilodactylus fuscus</i>	Red Morwong	Reef associated	56	-	0–30	55
Cheilodactylidae	<i>Nemadactylus douglasii</i>	Grey Morwong	Reef associated	89	5	0–200	
	<i>Nemadactylus macropterus</i>	Jackass Morwong	Reef associated	6*	-	0–450	
Clupeidae	<i>Sardinops sagax</i>	Australian Sardine	Pelagic	-	2	0–200	
Congridae	<i>Gorgasia</i> spp.	Garden Eels	Soft sediments	-	2	NA	
Dinolestidae	<i>Dinolestes lewini</i>	Longfin Pike	Benthopelagic	44	-	1–65	
Enoplosidae	<i>Enoplosus armatus</i>	Old Wife	Reef associated	22	-	0–90	
Gemplidae	<i>Thyrsites atun</i>	Barracouta	Benthopelagic	-	16	0–550	
Heterodontidae	<i>Heterodontus portusjacksoni</i>	Port Jackson Shark	Reef/oceanodromous	22	16	1–275	
	<i>Achoerodus viridis</i>	Eastern Blue Groper	Reef associated	50	-	0–60	
	<i>Bodianus frenchii</i>	Foxfish	Reef associated	6*	-	10–80	
Labridae	<i>Bodianus unimaculatus</i>	Eastern Pigfish	Reef associated	89	-	0–60	
	<i>Coris sandeyeri</i>	Eastern King Wrasse	Reef associated	6*	-	0–60	
	<i>Notolabrus gymnogenis</i>	Crimson Banded Wrasse	Reef associated	17	-	4–40	53
	<i>Ophthalmolepis lineolata</i>	Southern Maori Wrasse	Reef associated	78	-	1–60	

Table 1 continued: The list of species that were recorded on BRUVS samples with each species habitat association, percentage of reef (n=18) and sand (n=56) samples that each species was recorded on, depth range listed in the scientific literature (depth range based on Kuitert 2000, Gomon et al. 2008, Froese and Pauly 2017, Bray 2018, McGrouther 2018) and maximum depth recorded in our study if greater than listed in the literature. Species that were recorded >10 m deeper than in the literature are highlighted in bold.

Family	Species	Common Name	Habitat Association	Reef Samples (%)	Soft sediments (%)	Depth Range in Scientific Literature (m)	Max Depth Recorded Current Study (m)
Latrididae	<i>Latridopsis forsteri</i>	Bastard Trumpeter	Reef associated	33	-	2–160	
Microcanthidae	<i>Atypichthys strigatus</i>	Mado	Reef associated	89	-	0–30	55
	<i>Eubalichthys bucephalus</i>	Black Reef Leatherjacket	Reef associated	22	5	0–250	
	<i>Eubalichthys mosaicus</i>	Mosaic Leatherjacket	Reef associated	17	-	6–150	
	<i>Meuschenia flavolineata</i>	Yellowstriped Leatherjacket	Reef associated	11	2*	1–50	52
Monacanthidae	<i>Meuschenia freycineti</i>	Sixspine Leatherjacket	Reef associated	72	38	1–100	
	<i>Meuschenia scaber</i>	Velvet Leatherjacket	Reef associated	94	30	5–200	
	<i>Meuschenia venusta</i>	Stars & stripes Leatherjacket	Reef associated	6*	-	5–100	
	<i>Nelusetta ayraudi</i>	Ocean Jacket	Demersal	50	63	0–360	
Mullidae	<i>Upeneichthys sp. †</i>	Goatfish	Demersal	39	2*	5–200	
Muraenidae	<i>Gymnothorax prasinus</i>	Australian Green Moray	Reef associated	6*	-	0–40	46
Myliobatidae	<i>Myliobatis tenuicaudatus</i>	Southern Eagle Ray	Soft seds/ seagrass	6*	5	0–240	
Odontaspidae	<i>Carcharias taurus</i>	Grey nurse Shark	Reef/oceanodromous	-	2*	0–190 [#]	
Orectolobidae	<i>Orectolobus sp. ‡</i>	Wobbegong	Reef associated	6*	-	0–280	
Paralichthyidae	<i>Pseudorhombus jenynsii</i>	Smalltooth Flounder	Soft sediments	-	4	?–150	
Parascylliidae	<i>Parascyllium collare</i>	Collar Carpetshark	Reef associated	6*	-	20–230	
Pempheridae	<i>Pempheris multiradiata</i>	Bigscale Bullseye	Reef associated	6*	-	2–70	
Pinguipedidae	<i>Parapercis binivirgata</i>	Redbanded Grubfish	Demersal	39	-	86–404	50
	<i>Platycephalus caeruleopunctatus</i>	Bluespotted Flathead	Soft sediments	-	73	5–100	
Platycephalidae	<i>Platycephalus grandispinis</i>	Longspine Flathead	Soft sediments	-	88	3–75	
	<i>Platycephalus richardsoni</i>	Tiger Flathead	Soft sediments	-	32	10–430	
Plesiopidae	<i>Paraplesiops bleekeri</i>	Eastern Blue Devil	Reef associated	6*	-	3–30	51
	<i>Mecaeichthys immaculatus</i>	Immaculate Damsel	Reef associated	56	-	0–30	55
Pomacentridae	<i>Parma microlepis</i>	White-ear	Reef associated	83	-	1–30	55

Table 1 continued: The list of species that were recorded on BRUVS samples with each species habitat association, percentage of reef (n=18) and sand (n=56) samples that each species was recorded on, depth range listed in the scientific literature (depth range based on Kuter 2000, Gomon et al. 2008, Froese and Pauly 2017, Bray 2018, McGrouther 2018) and maximum depth recorded in our study if greater than listed in the literature. Species that were recorded >10 m deeper than in the literature are highlighted in bold.

Family	Species	Common Name	Habitat Association	Reef Samples (%)	Soft sediments (%)	Depth Range in Scientific Literature (m)	Max Depth Recorded Current Study (m)
Pristiophoridae	<i>Pristiophorus cirratus</i>	Common Sawshark	Soft sediments	-	2*	37–630	
	<i>Pristiophorus nudipinnis</i>	Southern Sawshark	Soft sediments	-	5	5–165	
Rhinobatidae	<i>Aptychotrema rostrata</i>	Shovelnose Ray	Soft seds/Seagrass	-	13	0–220	
	<i>Trygonorrhina fasciata</i>	Fiddler Ray	Demersal	6*	50	0–180	
Scombridae	<i>Sarda australis</i>	Australian Bonito	Pelagic	6*	-	NA	
	<i>Scomber australasicus</i>	Slimey Mackerel	Pelagic	-	4	1–200	
Scorpaenidae	<i>Scorpaena jacksoniensis</i>	Eastern Red Scorpionfish	Reef associated	6*	-	0–73	
Scorpididae	<i>Scorpis lineolata</i> [§]	Silver Sweep	Reef associated	50	-	1–30	53
Scyliorhinidae	<i>Asymbolus rubiginosus</i>	Orange Spotted Catshark	Demersal	6*	-	25–540	
	<i>Caesioperca lepidoptera</i>	Butterfly Perch	Reef associated	94	-	4–100	
Serranidae	<i>Hypoplectrodes annulatus</i>	Blackbanded Seaperch	Reef associated	17	-	0–100	
	<i>Hypoplectrodes maccullochi</i>	Halfbanded Seaperch	Reef associated	61	-	1–50	55
Sillaginidae	<i>Sillago flindersi</i>	School Whiting	Soft sediments	-	25	1–180	
	<i>Chrysophrys auratus</i>	Pink Snapper	Reef associated	44	4	0–200	
Sparidae	<i>Rhabdosargus sarba</i>	Tarwhine	Reef associated	6	-	0–60	
Triakidae	<i>Mustelus antarcticus</i>	Gummy Shark	Demersal	11	7	0–350	
Trigidae	<i>Chelidonichthys kumu</i>	Red Gurnard	Soft sediments	-	16	1–200	
Urolophidae spp.	spp.††	Stingaree	Demersal	-	5	NA	
Total Number of Species				50	31		

* Single individual observed.

† Either *U. lineatus* or *U. vlamingi* (both 5–200 m), however it is difficult to differentiate between these species with certainty on camera in low light.

‡ Either *O. halei* (0–195 m) or *O. maculatus* (0–280 m), however only a single distant individual was observed.

§ Almost certainly *S. lineolata*, however without ray counts, the rarer *S. violacea* (also 0–30 m) cannot be entirely eliminated as a potential ID.

†† Most likely *Trygonoptera testacea* but may include *Urolophus sufflavus*, *U. kapalensis* and *U. cruciatus*.

Single specimen trawled at 600 to 1000 m.

suitable habitat likely exists on deeper offshore reefs (Purcell et al. 2014). Indeed, we also observed common reef species, including immaculate damsel (*Mecaenichthys immaculatus*), red morwong (*Cheilodactylus fuscus*), mado (*Atypichthys strigatus*), white-ear (*Parma microlepis*) and silver sweep (*Scorpiis lineolata*) on reefs at a depth of 53–55 m, well outside their reported depth range (Box 1). These observations further support our hypothesis that the depth range of eastern blue devil fish and also other coastal reef species is likely being underestimated.

Our observation, using baited cameras, may be the only verifiable video footage ever taken of eastern blue devils at this depth. However, a confirmed capture from 48 m on a charter fishing boat of an eastern blue devil fish occurred off the coast of Sydney in February 2018 (see Appendix 1). Recreational fishers also report accidentally catching eastern blue devil fishes on lines on patch reefs that we know to be in waters deeper than 40 m. Often the fishermen did not know what they were and posted a description or photos for identification on online fishing forums (L. Fetterplace, pers. obs.). On investigation, we were able to confirm that a number of these photos were of eastern blue devil fish. However, recreational fishers can distrust scientists, are often not consulted, and are guarded about the locations of their fishing spots. Despite this, their knowledge is potentially significant in corroborating scientific observations and increasing sampling effort of rare species. Here, a report from a charter fishing operator and anecdotal observations by recreational fishers of eastern blue devil fishes on deep reefs further suggest that the geographic and depth range of this protected species are currently being underestimated.

The observation of eastern blue devil fish, a coastal reef species, on deep reefs out on the continental shelf raises several questions regarding how it came to be there. We know these fish are site-attached, cryptic predators inhabiting coastal rocky reefs, they are nocturnal demersal predators and do not move into the upper water column (Kuitert 2000). The particular reef on which the eastern blue devil fish was sighted is surrounded by large areas of exposed sandy seafloor and the gradient in this area means that this fish would have had to move horizontally roughly 2 km from the nearest reefs in their current accepted depth range. Adults of many demersal reef-attached species do not move across large areas of sand (Chapman and Kramer 2000, Turgeon et al. 2010), and for these species, sandy areas can effectively form barriers to adult movement. We know of no examples of adult eastern blue devil fish ever being recorded moving across soft sediments (or any non-reef habitats). All these constraints on movement suggest that the observed adult eastern blue devil fish settled during its larval stage and grew to adulthood on the deep offshore reef sampled in this study.

On the basis of our report and corroborating evidence from recreational fishers, a broader interdisciplinary effort to research the range of eastern blue devil fish as well as many other coastal reef species is warranted. Deeper water research will greatly benefit from collaborating with fishers and citizen

science programmes (e.g. Redmap and Australasian fishes project). Extending the range of eastern blue devil fish from a thin strip along the coast to 2–5 km offshore opens up a vast area of potential habitat sites that have not been investigated. If the range of the eastern blue devil fish can be further corroborated down to at least 50 m and potentially well beyond, this would significantly expand the known habitat of a rare and protected fish. This knowledge can help give conservation measures for this species the greatest chance of success, whilst also benefiting the management of deeper offshore reefs.

How commonly eastern blue devil fish occur on deeper reefs is unknown, as is the relative importance of deep reefs to eastern blue devil fish and many other reef species. The implications are exciting. Have these fish always been on deep complex reefs (>40 m) and we simply have not detected them? Could deep reef habitats act as cooler water refugia (Hoegh-Guldberg et al. 2017, Kavousi and Keppel 2018), increasing the resilience of a rare and protected temperate reef species against climate change? Numerous climate-driven range shifts have been documented globally (Figueira and Booth 2010, Poloczanska et al. 2013, Pecl et al. 2017), and it is feasible that eastern blue devil fishes and other reef fishes may be shifting their range both in latitude and depth. Without further sampling of deeper reefs on the continental shelf, we will not know the extent and range of the deeper populations of eastern blue devil fish, and how they and other reef fishes are being affected by climatic changes in an ocean warming hotspot (Sunday et al. 2015).

These sightings remind us yet again how little we know of the deeper oceans, and the dangers of restricting conservation and management efforts to well-studied shallow, coastal and relatively ‘accessible’ environments. Indeed, we show that eastern blue devil fish and a number of more common species are using deep reefs well outside their commonly accepted depth range. Many other reef fish species most probably occur on deeper reefs in Australia and in coastal waters globally (Purcell et al. 2014), and we are simply not yet looking deep enough.

1. DATA AVAILABILITY

The site specific species presence or absence for each deep reef BRUVS sample (summarised in Table 1) and the accepted depth ranges for each species from all reference sources consulted, is available under a CC BY 4.0 licence as a dataset: [Offshore Reef Fishes of South Coast NSW](#) (Fetterplace and Knott 2018).

Ethical Note: The sampling methods in this study were approved by the New South Wales Department of Primary Industries (Fisheries) animal care and ethics committee, ACEF Ref: 10/09.

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APPENDIX 1. CHARTER BOAT CAPTURE OF EASTERN BLUE DEVIL FISH

On the 17 February 2018, a Sydney-based charter boat 'Fish-Finder' caught an adult eastern blue devil fish in 48 m of water outside of Sydney Harbour in the vicinity of South Head. The fish appeared to be showing signs of barotrauma; however, it was released and reportedly swam away strongly. At the time of publication, a photo is available on the charter boats social media pages [here](#).