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First North Pacific records of the pointy nosed blue chimaera, *Hydrolagus* cf. *trolli* (Chondrichthyes: Chimaeriformes: Chimaeridae)

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Abstract

The occurrence of *Hydrolagus* cf. *trolli* is reported for the first time from the central and eastern North Pacific Ocean. This is a geographic range extension for this species, as it was previously only known to occur in the southern Pacific Ocean off of Australia, New Zealand, and New Caledonia.

Keywords: *Hydrolagus trolli*, Northern Hemisphere, Range extension

Introduction

Currently there are 38 recognized species of short-nosed chimaeras (family Chimaeridae), making it the most species rich family in the order Chimaeriformes (Kemper et al. 2015). The family has two recognized genera that are separated by the presence (*Chimaera*) or absence (*Hydrolagus*) of an anal fin. The genus *Hydrolagus* is the more diverse of the two genera with 22 species (Didier et al., 2012). Fifteen of these species are recognized as occurring in the Pacific Ocean, but only five species are known in the eastern Pacific (James et al. 2009). These five *Hydrolagus* species are geographically dispersed around the Galapagos Island, the southeastern Pacific along the coasts of Chile and Peru, and lastly in the northeastern Pacific (James et al. 2009). Until recently *Hydrolagus colliei* (Lay and Bennett, 1839) and *Hydrolagus melanophasma* (James, Ebert, Long, and Didier, 2009) were the only species confirmed to occur in the northeastern Pacific. *Hydrolagus colliei* is found from Alaska to Costa Rica, while *H. melanophasma* occurs off southern California, USA to northern Chile (Angulo et al., 2014; Aguirre-Villaseñor et al. 2013). However, a third species of *Hydrolagus*, first noted but not identified by Ebert (2003), had been observed by remotely operated vehicle (ROV) at Davidson Seamount off central California at a depth greater than 2000 m. Lundsten et al. 2009 identify *Hydrolagus trolli* from the Davidson Seamount, however provide no descriptive information. Central North Pacific records of chimaeras are few, with only the purple chimaera, *Hydrolagus purpurescens* (Gilbert 1905), being reported from the Hawaiian Islands.

The pointy nosed blue chimaera, *Hydrolagus trolli* (Didier and Séret 2002), was described from 23 specimens. The holotype is a male specimen measuring 1030 mm (TL) that was captured by bottom trawl off New Caledonia (20°44.90'S, 167°43.10'E) at a bottom depth of 1246 m. *Hydrolagus trolli* is a little known chimaera species usually found at depths ranging 610–2000 m (Last and Stevens 2009). To date, this species has only been confirmed from the southwestern Pacific, off Australia, New Zealand, New Caledonia, the Lord Howe Rise and Norfolk Ridge (Last and Stevens 2009). This species, or a similar looking species, is known to occur over a much broader geographical range in the Southern Hemisphere, e.g. South Africa (Ebert and van Hees, 2015), but to date there are no descriptions of this species from the Northern Hemisphere. A specimen of *H.* cf. *trolli* was recorded off Chile (as *H. pallidus* in Andrade & Pequeño, 2006), (Bustamante et al. 2012). A potential specimen of *H. trolli* was collected off St. Paul Island in the Southern Indian Ocean but identification could not be confirmed due to poor condition (Didier and Séret 2002).

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During a series of remotely operated vehicle (ROV) deep-sea surveys off the California coast and west of the Hawaiian Islands conducted by the Monterey Bay Aquarium Research Institute (MBARI), a large, bluish, short-nosed *Hydrolagus* species was observed on several occasions. Here we report on the occurrence of these *Hydrolagus* specimens that we have identified as *Hydrolagus* cf. *trolli*.

Materials and methods

Observations of *Hydrolagus* cf. *trolli* were videotaped in situ using either a Panasonic WVE550 3-chip standard definition or Ikegami HDL-40 high definition video camera during deep-water surveys using the ROV *Tiburon* off the coast of California and Hawaii. Using MBARI's Video Annotation and Reference System database (VARS, Schlining et al. 2006), videotaped observations were entered into a searchable database and merged with ancillary data so that latitude, longitude, depth, and CTD information is known for every observation. We queried VARS for observations identified as potentially being these species based on macroscopic characters. Due to inconsistencies in the calibrated laser system which is used for estimating organism size, we were unable to obtain lengths of our specimens.

During the surveys off central California (T0142-06, T1075-02, T1102-04, T0215-01), southern California (T0664-10), and west of the Hawaiian Islands, (T0296-12), unidentified *Hydrolagus* specimens were repeatedly observed (Fig. 1, Table 1). These records are of a large, bluish, short-nosed chimaera that had never before been observed previously in the central or eastern North Pacific. Surveys T0664-10, T0215-01, and, T0296-12 from the San Juan Seamount, Monterey Submarine Canyon, and from off the Hawaiian islands, respectively, were initially identified as *H.* cf. *trolli* by one of us (D.A. Ebert), and D.A. Didier (Millersville University) and L.A.K. Barnett (University California, Davis).

Results and discussion

Observations

Hydrolagus cf. *trolli* from dive T-0142 (Fig. 2a) was the first observation of these unknown bluish *Hydrolagus* specimens in the Northern Hemisphere, and the first of four observations from Monterey Bay, California. Specimen from trawl T-0142 was first reported by Lundsten et al. 2009, and recorded off the coast of central California at the Davidson Seamount on 9 May 2000 at approximately 2064 m. A similar specimen was observed near the same location on dive T-1102 (Fig. 2b) at the Davidson Seamount, on 20 June 2007, at approximately 1641 m. Both specimens from dives T-0142 and T-1102 have striking similarities including: a short, pointed snout, with preopercular and oral canals that share a common branch from the infraorbital canal, bluish-grey body coloration, a concave first dorsal fin with keeled spine, large, triangular pectoral fins, and broad pelvic fins. Additionally, the dorsal, pectoral, and pelvic fins of these specimens all have a pale blue margin on the distal edge.

The third observation of this *Hydrolagus* species from Monterey Bay, CA was identified from dive T-0215 in the Monterey Canyon, on 5 October 2000, at approximately 1679 m (Fig. 2c). A fourth specimen was observed on dive T-1075 (Fig. 2d), also in the Monterey Canyon on 24 January 2007 at approximately 1658 m. Specimens from dives T-1075 and T-0215 had similar morphological features to the Davidson Seamount specimens. The specimen observed on dive T-1075 had preopercular and oral canals sharing a common branch from the infraorbital canal on the left hand side, while these canals branched separately on the right side of the head. This could not be observed in the specimen from dive T-0215 as the majority of the photos were from a dorsal view.

During a subsequent survey of seamounts off southern California, another large, bluish *Hydrolagus* specimen was observed. This specimen, also identified as *H.* cf. *trolli*, from dive T-0664 was recorded on 2 May 2004 on the San Juan Seamount at approximately 1629 m (Fig. 2e). The *Hydrolagus* specimen from this dive had a short pointed snout, large, triangular pectoral fins, and a bluish-grey coloration, consistent with those specimens observed on the Davidson Seamount.

A sixth observation of a *H.* cf. *trolli* specimen was during surveys off the western coast of the Hawaiian Islands. This was the first observation of *H.* cf. *trolli* from the central North Pacific. *Hydrolagus* cf. *trolli* from dive T-0296 was recorded on 16 April 2001 at approximately 1641 m (Fig. 2f). Although this *Hydrolagus* specimen was identified as *H.* cf. *trolli* it had several subtle differences from specimens T-0142 and T-0215 such as a short, blunt snout, and larger eyes. However, this specimen exhibited a few similar features to specimen T-0664. These similarities include: a keeled dorsal spine, longer than the height of the primary dorsal, and a short caudal filament.

Observations from all surveys show *H.* cf. *trolli* occurring over rocky substrates, sometimes over high relief outcrops. These observations suggest individuals typically occur over hard-bottom habitats or rocky, and mixed substrate patches with vertical relief. These observed substrate associations are in contrast to *Hydrolagus melanophasma*, which usually associates with soft bottom habitats (James et al. 2009). However, some eastern Pacific *Hydrolagus* species such as *Hydrolagus mccoskeri*, are known to associate with high relief habitats (James et al. 2009; Barnett et al. 2006).

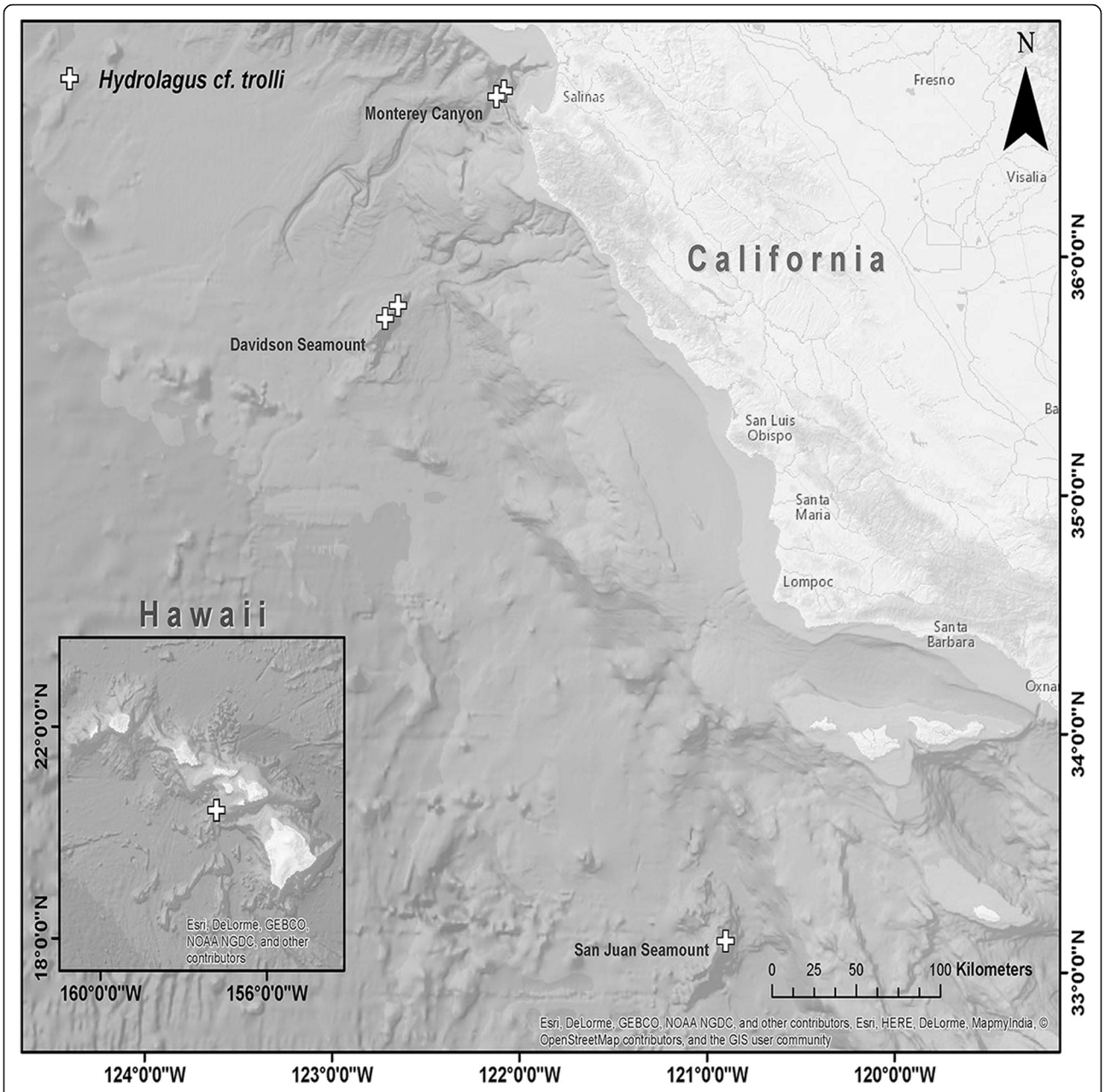

Fig. 1 GPS locations of *Hydrolagus* cf *trolli* observations. Map courtesy of Lonny Lundsten, MBARI

Description

Hydrolagus trolli is a highly distinctive chimaera species, often identified by a combination of the following characteristics: an even blue-gray to pale blue color, a pointed snout, a dark margin around the orbit with dark shadows along edges of the lateral line, and preopercular canal and oral canals usually sharing a common branch (Didier and Séret 2002; Compagno and Dagit 2006). *Hydrolagus trolli* is a large, although slender bodied species with a narrow head that evenly tapers to a whip-like tail. A caudal filament is present, although short and blunt. The pectoral fins of *H. trolli* are large and triangular, usually tapering to a point on the distal edge. The pelvic fins are broad, and square along distal edge. The first dorsal fin is triangular, with a concave distal edge (Didier and Séret 2002). The dorsal fin spine is curved anteriorly, with two small rows of serrations on the distal 1/3 of the posterior surface. The fin spine is usually just shorter than the height of dorsal fin in juveniles, and slightly longer in adults. The second dorsal fin is elongate, sloping, relatively even in height, and is connected to the dorsal caudal fin by a narrow piece of skin.

Table 1 CTD, GPS coordinates, and additional comments for observed *Hydrolagus* cf. *trolli* specimens

Specimen	Conductivity (psu)	Temperature (C)	Depth (m)	Latitude/Longitude	Location	Comments
T0142-06	34.49	2.01	2063.2	35.797391/−122.650021	Davidson Seamount	POP and O lateral line appear to share a common branch. No claspers observed.
T1102-04	34.37	2.45	1641.7	35.742034/−122.71744	Davidson Seamount	POP and O lateral line canal share a common branch. No claspers observed.
T0215-01	34.46	2.47	1679.6	36.671808/−122.122993	Monterey Submarine Canyon	Coloration appears blue-purple. Short caudal filament. No claspers observed.
T1075-02	34.374	2.47	1658.3	36.695932/−122.08455	Monterey Submarine Canyon	POP and O lateral line canal branch separately on right side of head only. No claspers observed.
T0664-10	34.49	2.58	1629.4	33.133464/−120.90126	San Juan Seamount	Coloration appears blue-purple. Short caudal filament. No claspers observed.
T0296-12	34.57	2.77	1640.8	20.426773/−157.223329	Hawaii	Snout more compressed, similar to *H. purpurescens*. No claspers observed.

The caudal fin is rounded with dorsal and ventral lobes nearly equal in height, though ventral lobe is slightly longer (Didier and Séret 2002). Males have a deeply curved frontal tenaculum, which is distally upturned with spines along the dorsal edge; and pelvic claspers that have fleshy, pale, distal lobes, divided for 1/3 their length, with tips usually extending beyond distal edge of pelvic fin (Didier and Séret 2002).

Comparisons

Hydrolagus cf. *trolli* is the third species of *Hydrolagus* observed in the eastern North Pacific, and is the second species observed from the central North Pacific. *Hydrolagus* cf. *trolli* is morphologically distinct from the other two eastern North Pacific *Hydrolagus* species, *Hydrolagus colliei* and *Hydrolagus melanophasma,* in coloration. The overall brownish-red color and white spots of *H.*

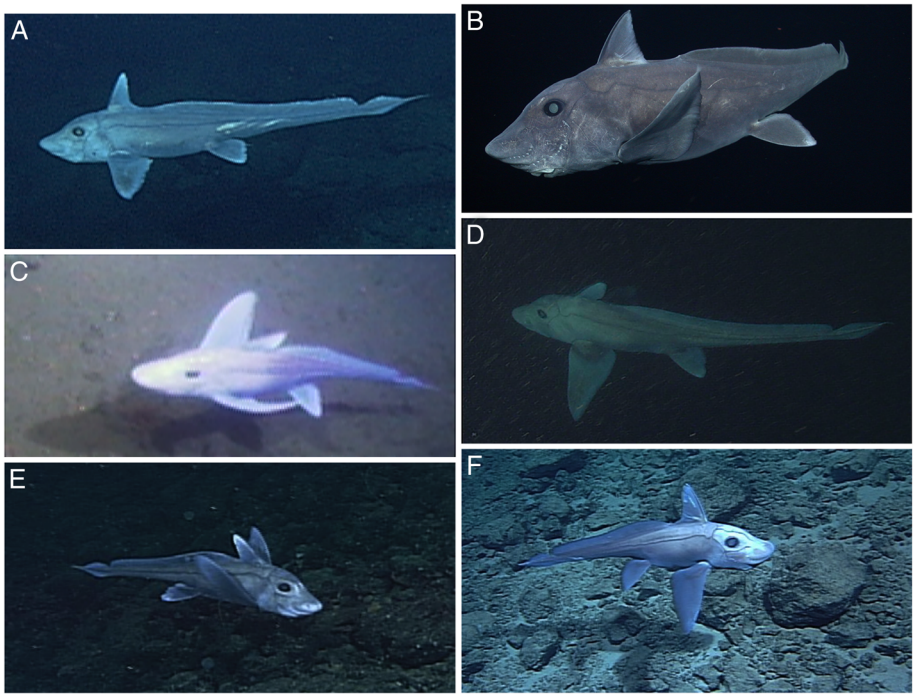

Fig. 2 **a** *Hydrolagus* cf *trolli* specimen T-0142 full-length lateral view. **b** *Hydrolagus* cf *trolli* specimen T-1102 lateral view, close up. **c** *Hydrolagus* cf *trolli* specimen T-0215 dorsal view. **d** *Hydrolagus* cf *trolli* li specimen T-1075 lateral view. **e** *Hydrolagus* cf *trolli* specimen T-0664 full-length lateral view. **f** *Hydrolagus* cf *trolli* specimen T-0296 lateral view, over rocky substrate

colliei, and overall dark, black coloration of *H. melanophasma* are easily distinguished from the even blue color of *H.* cf. *trolli* (Ebert 2003).

The only *Hydrolagus* species currently known from the central North Pacific is *Hydrolagus purpurescens* (Gilbert 1905) that was described from Hawaiian waters. It closely resembles *H.* cf. *trolli* specimens, but differs from it in body coloration, pectoral fin shape, and dorsal spine length and shape. *Hydrolagus purpurescens* is thought to be more widespread throughout the central and western North Pacific, though similar bottom depth ~1130 m. Despite possible overlapping geographically with *H.* cf. *trolli* these two species are morphologically different in several aspects. The head of *H. purpurescens* is robust and deeply compressed, with a snout that is high and compressed, while the observed specimens had pointy snouts (Gilbert 1905; Garman 1911). The pectoral fins of *H. purpurescens* are large, and broad (Gilbert 1905; Garman 1911), while our specimens had pectoral fins more pointed, and triangular. *Hydrolagus purpurescens* has a straight dorsal spine that is longer than the height of the first dorsal fin, with no serrations (Gilbert 1905; Garman 1911). Dorsal fin spines of our *H.* cf. *trolli* specimens were keeled, except for the specimens observed on dives T-0142, and T-0215 where the fin spines could not be observed in detail. Finally, the even black-purple to purplish-plum coloration of *H. purpurescens* is distinct from the grey and blue coloration of our *H.* cf. *trolli* specimens. All the observed *H.* cf. *trolli* specimens have characteristics that more closely resemble *H. trolli* than *H. purpurescens*.

Remarks

The presence of *Hydrolagus* cf. *trolli* increases the number of known *Hydrolagus* species to three off California, and to two species off the Hawaiian Islands. Our specimens cannot yet be confirmed as *Hydrolagus trolli* until morphometric data and or DNA samples from preserved specimen have been collected and analyzed. However, these observations by ROVs suggest that even in relatively well-known areas much remains to be elucidated on the Chondrichthyan fauna from these regions.

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Authors' contributions
All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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