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Short Note

Sightings and Strandings of Beaked Whales from the Mexican Central Pacific

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Beaked whales from the family Ziphiidae are some of the least frequently observed animals on the planet (Dalebout et al., 1998). These cetaceans are deep divers with remarkable physiological and behavioral capabilities, allowing them to access ecological niches at depths exceeding 1,000 m, where they endure radical changes in pressure, temperature, and light (Fedak & Thompson, 1993; Tyack et al., 2006).

Published data describing beaked whale diving behavior indicate that the principal aim of long dives is to explore the deep oceanic niche in order to feed (Fedak & Thompson, 1993; Tyack et al., 2006; Lusher et al., 2015). Beaked whales' stomach contents show that their main prey are deep water squid, crustaceans, and fishes (Lusher et al., 2015; Hernandez-Milian et al., 2017). The surfacing behavior of beaked whales is usually inconspicuous, and most sightings are very brief; therefore, they are very difficult to study, and the limited ecological knowledge that exists has come mostly from stranded individuals (MacLeod et al., 2003; Lusher et al., 2015; Reyes & Van Waerebeek, 2018; Aguilar de Soto et al., 2020).

Fatal stranding events involving several beaked whale species have been associated with Navy mid-frequency active sonar use (Fernández et al., 2005; D'Amico et al., 2009; Simonis et al., 2019). These events have been of public interest, prompting management actions, litigation, and research during recent decades (Southall et al., 2018). Stranding events of single individuals, however, are the most common (McLeod et al., 2003; Arbelo et al., 2010, 2013; Félix et al., 2011; West et al., 2013; Centelleghe et al., 2017; Bachara et al., 2018, 2020; Aguilar de Soto et al., 2020), and they may be associated with natural factors (i.e., lifespan, sickness, and predation) or anthropogenic activities (i.e., fishery interactions, ship collisions, and marine debris ingestion) (Allen et al., 2012; Arbelo et al., 2013). Any stranding event (mass or single individual) represents an opportunity to collect biological information about these oceanic species; therefore, strandings are considered a main resource for information, especially when the carcass condition is fresh. Recently, a new beaked whale species, *Berardius minimus*, was described in the North Pacific by identifying morphological characteristics, such as the short body size of mature individuals, short beak, and dark body color, based on four individuals stranded on Japanese coasts (Yamada et al., 2019).

Scientific information about the biology and ecology of cetaceans in the Mexican Central Pacific (MCP) is limited. Therefore, a monitoring program was started in 2010 by the University of Colima, whose activities include maritime surveys to register cetacean sightings and attendance at reported cetacean strandings on beaches of the region. The aim of this short note is to report sightings and strandings of beaked whales during the monitoring period of 2010 to 2019 in the MCP (south of Jalisco, Colima, and north of the Michoacán states; Figure 1). This constitutes the first scientific document about ecological

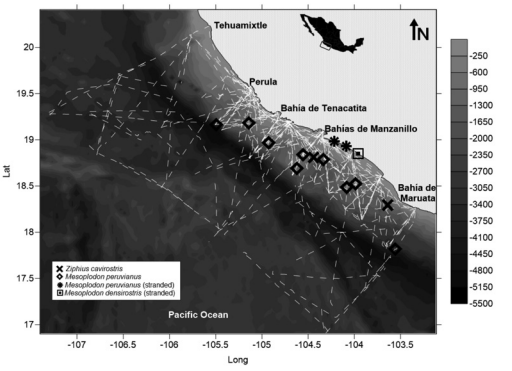

Figure 1. Geographic position of beaked whale sightings during the 2010-2015 study period and stranding events (2017 and 2019) at beaches of the Mexican Central Pacific (MCP). Dashed lines represent observation effort. Bathymetry scale bar is in meters.

parameters for these species reported from this region.

A medium-sized research vessel (15 m) was used to conduct 16 surveys during the 2010-2015 study period, completing one survey per season in the winter, spring, and autumn of 2010; winter and autumn of 2011; winter, spring, summer, and autumn of 2012; winter, summer, and autumn of 2013; winter and autumn of 2014; and winter and autumn of 2015. During these surveys, ~16,376 km from coastal to oceanic waters were navigated. Additionally, using a small boat (8 m), surveys covering only coastal waters of Colima and south of Jalisco were conducted monthly from 2010 to 2015, and then only during the winter-spring months of 2016 to 2019 (based on the resulting seasonality of sightings; see below), which represented ~22,118 km surveyed. Thus, a total research effort of ~38,494 km was achieved, covering a wide region that led to reliable results (Figure 1).

Each survey was a set of nonsystematic transects conducted at an average speed of 10 to 12 kts (18 to 22 km/h). Cetacean observations were made during daylight hours (0700 to 1900 h) with pre-set rotations for a maximum observation time of 40 min, with 40 min of rest per person to avoid bias due to fatigue. Three observers, one located at the front of the boat and two others placed on each side of the highest ship deck observed a 180° wide area ahead using Fujinon 7 × 50 binoculars. Active observations were carried out only when conditions on the Beaufort scale were between 0 and 3 because beaked whale detections are strongly limited by sea state. For every beaked whale sighting, the geographic position and the course of the ship were recorded with the global positioning system Garmin GPSmap 76cs. Additional information concerning the observed beaked whales was registered on a sighting sheet, including date, time, sighting number, estimated group size, and animal's activities. Species identification was based on a visual examination of the whale's (1) approximated total length (average estimate of the three observers), (2) morphological features such as the forepart of the body and dorsal fin (position and size), and (3) color patterns (dark, grey, or brown) of the body's dorsal section (Carwardine, 2002; Ellis & Mead, 2017). Photographs were taken using a Canon digital camera EOS60D to analyze in detail any morphological features and to corroborate the species by consulting a key identification of beaked whales from the Smithsonian website (https://collections.nmnh.si.edu/search/mammals/?irn=7511113).

Cetacean stranding records from the MCP region were indirectly monitored through announcements, brochures, talks with regional fishermen, and tour operators. Likewise, the general public, civil associations, and environmental authorities provided stranding reports to which our research group responded. During each opportunistic stranding event, our research team recorded the following data: date, time, site, animal decomposition state (i.e., alive, fresh, early decomposition, advanced decomposition, or mummified), species, size class (i.e., calf/juvenile or adult), sex, morphometric measurements, and evidence of human interactions (i.e., net marks, wounds from ship strikes, knife cuts, and gunshot wounds) (see ACCOBAMS [2018] guidelines for cetacean stranding monitoring: www.accobams.org/guidelines).

During the monitoring program, 11 beaked whale sightings were registered. Ten of them were observed during the coastal–oceanic surveys, whereas the 11th sighting was seen during one coastal survey (Table 1). Most of these beaked whale sightings (90%) were registered on the continental slope and near a submarine trench in the region at a mean depth of 2,200 m (range: 1,103 to 4,626 m) and a mean distance of 42.9 km (range: 14.7 to 58.9 km) to the coast but principally in the waters south of Jalisco, Colima, and north of Michoacán. During offshore surveys, beaked whale sightings were absent in 2,000 to 3,000 m deep waters beyond the submarine trench (Figure 1). The aggregated distribution over the continental slope and submarine trench of the MCP could be related to ecological activity (e.g., feeding habits). It is known that regional oceanographic features, such as the Thermocline Cabo Corrientes Dome, can have optimal features for biomass production (e.g., temperature and nutrients concentration; Gómez-Valdivia et al., 2015), which, in turn, would favor the presence of these

Table 1. Sightings of beaked whales, presumed *Mesoplodon peruvianus* (Mp) and *Ziphius cavirostris* (Zc), in the Mexican Central Pacific during surveys from 2010 to 2019

No.	Date (d/mo/y)	Presumed species	Geographic position		Distance to coast (km)	Depth (m)	Group size
			Latitude	Longitude			
1	7/1/2012	Mp	19° 10.97' N	105° 08.62' W	24.7	1,281	2
2	1/3/2012	Zc	18° 17.74' N	103° 38.42' W	14.7	1,512	1
3	4/10/2012	Mp	18° 47.22' N	104° 20.08' W	26.2	1,771	7-8
4	6/12/2012	Mp	17° 49.10' N	103° 33.63' W	54.6	4,109	2
5	6/11/2013	Mp	19° 09.80' N	105° 29.80' W	58.9	4,626	7-8
6	7/11/2013	Mp	18° 58.16' N	104° 55.61' W	32.7	1,502	4-5
7	9/11/2013	Mp	18° 29.27' N	104° 05.08' W	41.7	1,495	6-10
8	23/11/2014	Mp	18° 50.30' N	104° 33.24' W	29.9	1,103	3
9	24/3/2015	Mp	18° 31.43' N	103° 59.32' W	31.9	1,275	2-3
10	26/3/2015	Mp	18° 41.47' N	104° 37.19' W	48.4	1,411	2
11	2/5/2015	Zc	18° 46.82' N	104° 26.37' W	26.5	1,669	1

species in the area for feeding (Cárdenas-Hinojosa et al., 2015; Jefferson et al., 2015; Lanfredi et al., 2016; Reyes & Van Waerebeek, 2018). Beaked whale sightings in the MCP region predominated during the autumn (55%) and winter (36%) seasons, with only one occurring during the spring (9%). There were no records of sightings during the only two summers surveyed, which was a consequence of the difficulty to navigate during these seasons due to the occurrence of tropical storms and hurricanes in the region. Currently, there is a lack of knowledge regarding seasonal distributions for most beaked whale species (e.g., McSweeney et al., 2007; Revelli et al., 2008). While these results are still uncertain, they may begin to provide some insight into a seasonal pattern.

One ziphiid species, presumed to be the lesser beaked whale (*Mesoplodon peruvianus*; Van Waerebeek et al., 2018), was the most frequently observed (82%) in the waters of the MCP, with a variable group size of two to ten individuals. Identification of this species at sea was based on typical morphological features such as dark gray color at the top of the body and lighter color below, mainly in the forepart of the body, and the distinct pale "chevron" pattern on the back of males, a falcate dorsal fin, and total length of around 4 m (Figure 2). Despite a light similar morphological appearance with Perrin's beaked whale (*Mesoplodon perrini*), the likelihood of these sightings being the latter species was discarded because its distribution has only been reported along the central coasts of California, north of the MCP region, and it is likely that this species is endemic to the North Pacific Ocean (Jefferson et al., 2015). Two sightings of single individuals during oceanic surveys were identified as presumed Cuvier's beaked whales (*Ziphius cavirostris*) (Table 1) by their apparently larger size relative to the other beaked whale sightings and light brown coloration mainly in the forepart of the body (Allen et al., 2012; Ellis & Mead, 2017).

Two stranding events of beaked whales occurred during this study. The first occurred on 11 August 2017 at Cuyutlán beach, Armería (Colima, México). This stranding included two individuals: a 340-cm-length female and presumably its female calf, a smaller individual with 160-cm total length (Table 2). The distance between these carcasses was approximately 15 km at the same beach (Figure 1). Both individuals showed some deep wounds ($n < 10$) at the ventral region of the body, probably caused postmortem by some scavenger organisms. These wounds were similar to those reported in another beaked whale mother and calf stranded in Ecuador (Félix et al., 2011). Both beaked whales in this case showed an advanced state of decomposition (Figures 3 & 5); however, considering its total size, body pattern coloration, and mainly the shape of its rostrum, the calf was identified by one of the authors (WB) as a lesser beaked whale. Additionally, its skull was collected, and the condylobasal length was about 30 cm. Only a single 25-cm mandible was recovered (Figure 4); other skull measurements were not carried out because it was fragile, and it broke during its recovery. Reyes et al. (1991) reported a calf with

Figure 2. Sequence images of presumed lesser beaked whale (*Mesoplodon peruvianus*) sightings on 9 November 2013 in the MCP

Table 2. Beaked whales, *Mesoplodon peruvianus* (Mp) and *Mesoplodon densirostris* (Md), stranded at beaches of Colima, México

No.	Date (d/mo/y)	Species	Geographic position		Sex	Total length (cm)	Carcass decomposition state
			Latitude	Longitude			
1	11/8/2017	Mp	18° 55.71' N	104° 05.39' W	Female	340	Advanced
2	11/8/2017	Mp	18° 59.1' N	104° 13.04' W	Female	160 (calf)	Advanced
3	8/4/2019	Md	18° 51.06' N	103° 57.44' W	Female	320	Fresh

a similar size caught offshore of Perú, but skull morphometric analysis was not cited. This is probably for the same reasons mentioned herein.

The adult female's skull was also collected, and skull measurements considered useful for species diagnosis of the lesser beaked whale (Reyes et al., 1991) were taken: (1) condylobasal length, (2) length from tip rostrum to posterior extension maxillary plate, (3) length from tip rostrum to anterior margin superior nares, (4) zygomatic width, and (5) absence of maxillary ridges (Figure 6).

The skull measurements for this adult female were slightly smaller than the values given by Reyes et al. (1991), but they were similar to the sizes measured by Reyes & Van Waerebeek (2018) for lesser beaked whales from Peruvian waters (Table 3). Likewise, the zygomatic width was coincident with rank reported for this species, being the narrowest adult skull of beaked whales (Reyes et al., 1991). In addition, this individual did not show maxillary ridges. The mandibles were 35 cm in length, but their tips were missing (Figure 6). Since mandibles are usually not available for many *Mesoplodon* individuals, cranial characteristics are considered the principal tool to distinguish species from its congeners (Reyes et al., 1991). Thereby, the adult female was identified as a lesser beaked whale.

This adult female showed an external pattern coloration that was darker in the forepart of the body, similar to a large hematoma. By carefully

Figure 3. A lesser beaked whale calf stranded on 11 August 2017 at Cuyutlán beach, Armería (Colima, México)

Table 3. Skull morphometry for the adult female beaked whale stranded on 11 August 2017 on Cuyutlán beach, Armería (Colima, México). These skull diagnostic characteristics are considered the most important to distinguish lesser beaked whale (Reyes et al., 1991). Data for specimens from Peruvian waters are included for comparison. See Figure 6 as reference for measurements (in cm).

	This study	Reyes et al. (1991)	Reyes & Van Waerebeek (2018)
1 Condylobasal length	45.0	47.8-62.1	37.7-59.8
2 Length from tip rostrum to posterior extension maxillary plate	42.0	41.7-56.6	32.4-55.0
3 Length from tip rostrum to anterior margin superior nares	28.8	31.3-43.9	23.7-41.3
4 Zygomatic width	26.0	24.3-28.0	--
5 Absence of maxillary ridges	Yes	Yes	Yes

Figure 4. Skull (top) and mandible (bottom) of the lesser beaked whale calf stranded on 11 August 2017 at Cuyutlán beach, Armería (Colima, México). Measurement #1 = condylobasal length. Ruler scale = 5 cm.

analyzing images of the body's external surface, we observed rake marks at the ventral part, which were in addition to the deep wounds, potentially caused by predator teeth (Figure 5). It has been suggested recently that killer whales (*Orcinus orca*) are the main predator of beaked whales and that they can even cause massive mortality events (Aguilar de Soto et al., 2020). Killer whales have been reported in the MCP region, and it seems that they represent a distinctive ecotype with mostly generalist feeding habits (Vargas-Bravo et al., 2020). Thus, a predatory interaction could have been the cause of death for this adult female lesser beaked whale. Nevertheless, since there was not a necropsy performed, it cannot be ruled out that the observed teeth marks were caused postmortem by any marine animal (e.g., sharks) and that the animals died of a different cause. By carefully analyzing the skull and mandibles of this individual, a small fracture between the coronoid process and the condyle of the left side was observed (Figure 6). This could point towards a trauma, with mandibular fractures known to occur following a range of traumatic events that affect cetaceans, including bycatch and ship strike. There is no information on this type of anthropogenic interaction with beaked whales for the MCP region, so this event could be the first.

The second stranding event occurred on 8 April 2019 at Pascuales beach, Tecomán (Colima,

Figure 5. An adult female lesser beaked whale stranded on 11 August 2017 at Cuyutlán beach, Armería (Colima, México). Zoom image shows rake marks in the ventral part, which were potentially caused by predator teeth.

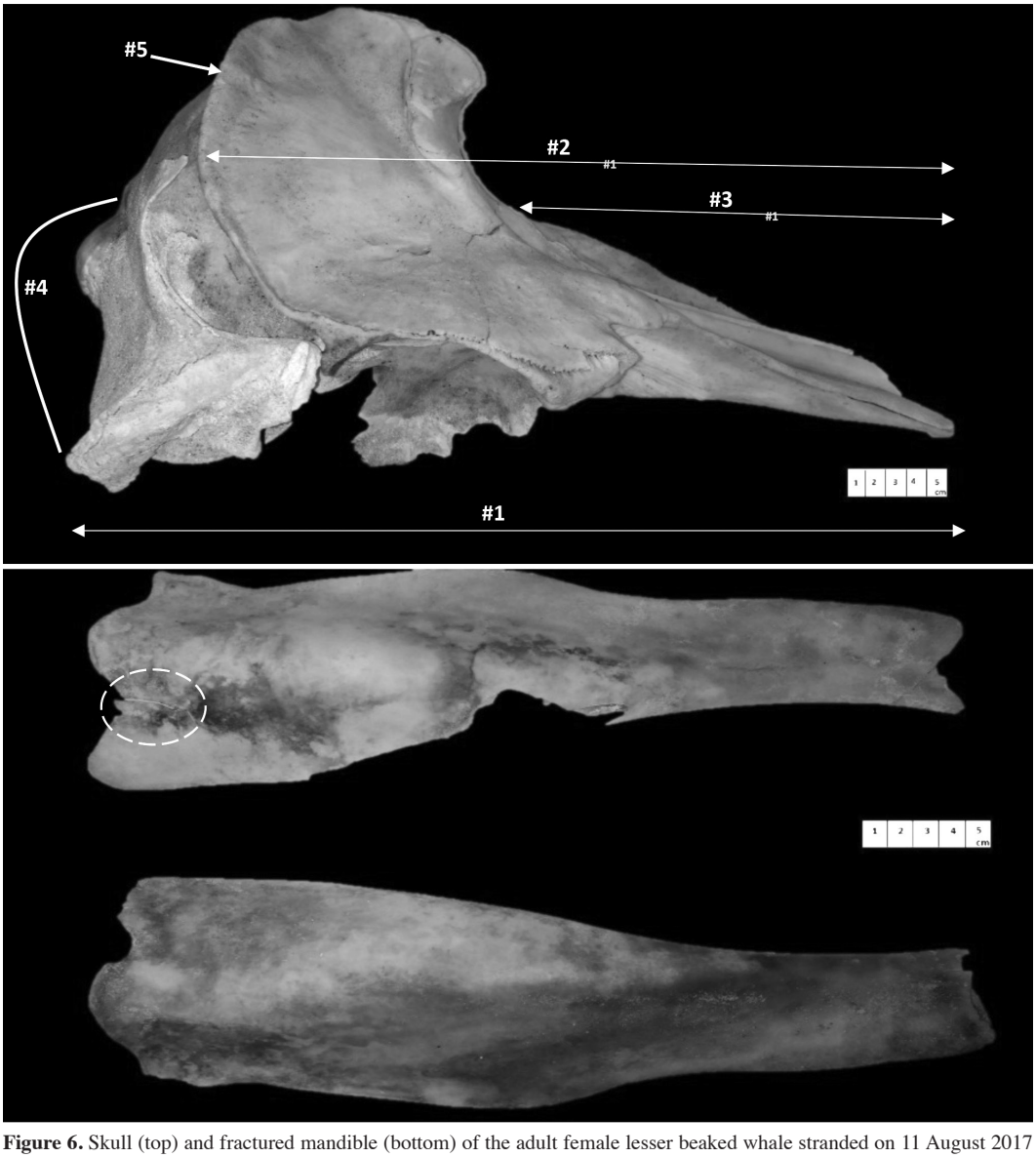

Figure 6. Skull (top) and fractured mandible (bottom) of the adult female lesser beaked whale stranded on 11 August 2017 at Cuyutlán beach, Armería (Colima, México). Skull measurement #1 = condylobasal length, #2 = length from tip rostrum to posterior extension maxillary plate, #3 = length from tip rostrum to anterior margin superior nares, #4 = zygomatic width, and #5 = absence of maxillary ridges. Dotted circle indicates a small fracture between the coronoid process and the condyle of the left mandible. Ruler scale = 5 cm.

México), 16.5 km south of the previously described adult female lesser beaked whale stranding (Table 2). It was identified through external morphology as a juvenile female Blainville's beaked whale (*Mesoplodon densirostris*; Mead, 1989) by one of the authors (WB). It measured 320 cm total length, and the carcass condition was fresh (Figure 7). The external examination did not reveal signs of potential human interactions, but healed whitish oval scars were observed along the ventral region of the body (Figure 7). These types of scars are usually attributed to cookiecutter sharks (*Isistius* spp.; Jones, 1971). An on-site dissection was carried out to collect the skull and samples of skin, blubber, muscle, and liver for future studies. In addition, the stomach

Figure 7. A juvenile female Blainville's beaked whale (*Mesoplodon densirostris*) stranded on 8 April 2019 at Pacuales beach, Tecomán (Colima, México)

was examined to investigate feeding occurrence and potential prey; only a parasite was observed, presumably an anisakid nematode (Iglesias et al., 2008; Luis Jorge García-Márquez, pers. comm., July 2020), with a length around 3 cm, pale yellow coloration, and located in the lumen of the forestomach. This is the second documented stranding event for Blainville's beaked whale in Mexican waters and the first one along the Pacific coast. Only one other Blainville's beaked whale was found stranded in 2016 in La Paz Bay, inside the Gulf of California (Urbán et al., in press).

A total of 36 stranding events of lesser beaked whales have been summarized by Reyes & Van Waerebeek (2018). In 41% of the events, the cause of death was found to be related to net entanglement, while cause of death for the rest was unknown. Most recently, Bachara et al. (2020) reported beaked whale strandings in waters of El Salvador, which were predominantly comprised of the lesser beaked whale. Specifically, along the coasts of the Mexican Pacific, 15 lesser beaked whale strandings occurred between 1980 and 2016 (Reyes & Van Waerebeek, 2018). In addition, two stranding records of this species have occurred recently in Oaxaca, Mexico: (1) an adult male in March 2016 (García-Grajales et al., 2017) and (2) a male calf in July 2019 (Francisco Villegas-Zurita, pers. comm., October 2019). All these reports of lesser beaked whales suggest that it is the species that strands most frequently on the Mexican Pacific beaches, which coincides with our result that this beaked whale was the most observed in MCP waters (Table 1).

The main anthropogenic threat identified affecting oceanic cetaceans has been Navy mid-frequency active sonar (Fernández et al., 2005; D'Amico et al., 2009; Simonis et al., 2019). However, there are other human actions affecting beaked whales (Arbelo et al., 2013; Puig-Lozano et al., 2018). For example, Cuvier's beaked whales have been found stranded in the Philippines, Scotland, Croatia, and Norway due to gastric impactions or with plastic bags found in their stomachs (Gomerčić et al., 2006; Bråte et al., 2017; Vaughan, 2019). Subsequent research should consider additional disturbances, such as marine debris, chemical pollution, and fisheries interactions, which generally occur in coastal regions but probably even affect the marine species found in deep-oceanic habitats (Arbelo et al., 2013; Puig-Lozano et al., 2018).

Natural factors can also be the cause of death in some cases (Tajima et al., 2015). García-Grajales et al. (2017) reported that an adult male lesser beaked whale, found along the Oaxaca (México) coast in March 2016, suffered a pneumothorax. Arbelo et al. (2013) cited four mortality events of Blainville's beaked whales in the Canary Islands (Spain) associated with loss of nutritional status and neonatal-perinatal pathology. Centelleghe et al. (2017) published a report of a Cuvier's beaked whale calf stranded on the southern Italian coastline with mild pathological findings suggestive of morbillivirus infection. Bondoc et al. (2017) reported an adult male Blainville's beaked whale stranded in the Philippines affected with membranous glomerulopathy and endoparasitism-associated pneumonia. Thus, it is assumed that a similar natural factor could have caused the death of the Blainville's beaked whale reported herein since the *in situ* examination did not show evidence of anthropogenic interaction (e.g., external injuries or marine debris ingestion). However, further analyses of the concentrations of PCBs and heavy metal in different tissues sampled (mentioned above) will help to corroborate a potentially natural cause of death.

We are not able to conclude the causes of death for these three beaked whale specimens that stranded on beaches of the MCP region through this short note; therefore, only some hypotheses were raised. We encourage subsequent research to conduct formal necropsy procedures on available fresh carcasses. Nevertheless, these records, in addition to the sightings at sea of the third species, presumed to be a Cuvier's beaked whale (all of which have a conservation status catalogued as "Data Deficient" by the International Union of Conservation of Nature [IUCN]), suggest that the MCP region may be an ecological habitat for several beaked whale species. The MCP also serves as a habitat for other oceanic species—for example, rough-toothed dolphins (*Steno bredanensis*) and false killer whales (*Pseudorca crassidens*)—that feed within this region (Ortega-Ortiz et al., 2014a, 2014b). Additionally, the MCP is considered a region of ecological importance for more coastal cetacean species such as humpback whales (*Megaptera novaeangliae*) and spotted dolphins (*Stenella attenuata*) (Kono-Martínez et al., 2017). Therefore, it is important to continue broad-scale, regional cetacean monitoring efforts, including sightings at sea and postmortem examinations of stranded individuals, to generate more knowledge on the ecology of cetacean species using the MCP region such as these beaked whales.

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