



Occurrence of Cuvier's beaked whales (*Ziphius cavirostris*) at Guadalupe Island, Mexico, from 2006 through 2009

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ARTICLE INFO

| Manuscript type | Note |
|----------------------------|--|
| Article history | |
| Received | 29 June 2012 |
| Received in revised form | 22 August 2013 |
| Accepted | 22 August 2013 |
| Available online | 17 August 2015 |
| Responsible Editor: | Maritza Sepúlveda |
| Citation: | Cárdenas-Hinojosa, G., Hoyos-Padilla, M. and Rojas-Bracho, L. (2015) Occurrence of Cuvier's beaked whales (<i>Ziphius cavirostris</i>) at Guadalupe Island, Mexico, from 2006 through 2009. <i>Latin American Journal of Aquatic Mammals</i> 10(1): 38-47. http://dx.doi.org/10.5597/lajam00192 |

Cuvier's beaked whale (*Ziphius cavirostris*) is the most widely distributed species of beaked whale, with a cosmopolitan distribution throughout almost all temperate, subtropical and tropical waters of the world as well as sub-polar and even polar waters in some areas (Heyning, 1989; MacLeod and D'Amico, 2006). Globally, it may also be the most abundant species of beaked whale within the family Ziphiidae (Heyning, 1989). However, there is little information on local distribution in many areas around the world.

Guadalupe Island is an oceanic island located in the Pacific Ocean, 260km west of Baja California, Mexico at 29°00'N, 118°26'W (Figure 1). The deep waters around this island are a potential habitat for beaked whales, since the continental shelf is extremely narrow, and depths of 3600m are found close to shore (Pierson, 1987). Furthermore, there is a series of deep canyons along different parts of the east coast, such as Primer Cañón and Cañones Gemelos, which are both located in a large bay (Bahía Norte) off the northeastern coast of the island. There are also other canyons in the middle part of the island, in Campo Lima, and in the southeast in the Corrales area (Gallo-Reynoso and Figueroa-Carranza, 2005).

Before 2009, no dedicated research on beaked whales occurred in Guadalupe Island; previous reports of the presence of several species of beaked whales have been opportunistic by researchers working on other species, such as white sharks (*Carcharodon carcharias*) (Hoyos-Padilla, 2009) and Guadalupe fur seals (*Arctocephalus townsendi*) (Gallo-Reynoso and Figueroa-Carranza, 1995; 1998; 2005). The first report on the presence of beaked whales in Guadalupe Island was

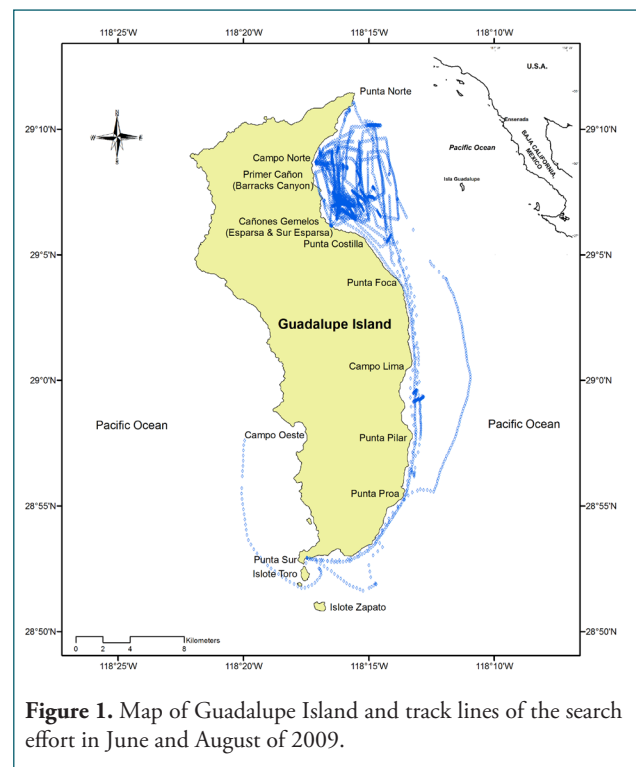


Figure 1. Map of Guadalupe Island and track lines of the search effort in June and August of 2009.

a note published by Gallo-Reynoso and Figueroa-Carranza (1995). These authors reported three sightings of a bottlenose whale (*Hyperoodon* sp.) observed in July 1992 and 1993, close to the southeastern coast of Guadalupe Island. However, the identification of the beaked whales was mistakenly attributed to a whale of the genus *Hyperoodon*. According to analyses of size, scarring patterns, and distribution of sightings

(Pitman *et al.*, 1999), and to genetic studies and appearance (Dalebout *et al.*, 2003) the sightings previously reported as bottlenose whales in the tropical Indo-Pacific may have been of Longman's beaked whales (*Indopacetus pacificus*).

Gallo-Reynoso and Figueroa-Carranza (1998) reported 16 sightings of beaked whales in Guadalupe Island. Their study periods were in winter (February 1991-1992), spring (June 1983-1991), summer (July-August 1991, 1992 and 1993), and autumn (November-December 1991-1992). Baird's beaked whale (*Berardius bairdii*) represented 50% of all beaked whale sightings. Longman's beaked whales (according to Pitman *et al.*, 1999) represented 31.2%, followed by Cuvier's beaked whales (12.5%) and unidentified beaked whales (6.25%). All records were in summer (June and July) close to the coast, excepting the one of Baird's beaked whale, which occurred in November.

Gallo-Reynoso and Figueroa-Carranza (2005) compiled all their beaked whale sightings in a book about Guadalupe Island. They added 41 days of observations, mainly from the east coast during winter and spring of 2000 and winter and summer of 2003. In total, they reported nine sightings of beaked whales, seven of Cuvier's, one of Hubb's beaked whales, and one of an unidentified ziphiid. These animals were found mainly in summer in Corralitos, Campo Lima and Bahía Norte, areas characterized by the presence of submarine canyons.

In this note, we report opportunistic sightings of Cuvier's beaked whales recorded during a white shark research project from 2006 through 2008, and the results obtained in 2009 during a pilot study focused on the beaked whales of Guadalupe Island.

Tracking expeditions for white sharks in the east of Guadalupe Island were conducted from a variety of 6-7m outboard-powered fiberglass skiffs (known as *pangas*) from October to December of 2006, 2007, and 2008 by one of us (MHP). Only naked eye opportunistic sightings of beaked whales were made during these expeditions. Groups of animals were approached to determine location using Garmin GPS Map76 (only 2008 and 2009) and group size, and to obtain photographs and underwater videos for species identification. The categorization of the individuals followed criteria by McSweeney *et al.* (2007). Unfortunately, survey effort was not recorded. In summer and autumn 2009, the Coordinación de Investigación y Conservación de Mamíferos Marinos from the Instituto Nacional de Ecología y Cambio Climático started the first beaked whale pilot project in Guadalupe Island (in collaboration with the white shark project) with the stated goal of analyzing the potential population of Cuvier's beaked whales in Guadalupe Island for long-term studies, and to determine the logistics feasibility of the island for such studies. The beaked whale search effort was conducted from pangas and from a shore-based site (15.5m above mean sea level) with a SOKKIA DT510A theodolite and West Marine binoculars (7x50). The depth and sea surface temperature

were determined with a Color Dual-Frequency Sonar /GPS Deep-sounding 50/200kHz sonar to 2500 feet and precision GPS+WAAS chart recorder with super-sharp 480x480 pixel display and unique Lowrance LMS-337C DF memory card versatility. Data on sea surface temperature (SST) for all months was collected in 2009 only. A total of 336km was covered during 46.2 hours of panga transects during June and August of 2009 (Figure 1). The shore-based search effort was conducted for 26.4 hours on four different days during June and August 2009, with an average of 6.6 hours of search effort per day. In September and October of 2009, search effort was not recorded and was conducted only using pangas.

A total of 67 sightings of Cuvier's beaked whales were recorded from 2006 through 2009 at Guadalupe Island (Table 1). Forty six underwater footages and 240 photographs were obtained from 24 and 11 sightings of Cuvier's beaked whales, respectively. Five (7.46 %) of the total sightings were recorded during nighttime while tracking for white sharks were carried out. These encounters are unusual, and the first ones reported on the scientific literature to our knowledge. We sighted the animals as they approached closely (less than 10 meters approximately) to the drifting small boat. Two of the five nocturnal sightings were evidenced by footages. The animals showed the head when surfacing, and the rostrum was seen clearly (illuminated by a hand lamp), and identified as Cuvier's beaked whales based on shape of the head and rostrum, body size, and pigmentation patterns. In the period between 2006 to 2008, previous to the pilot study, only 24 opportunistic sightings of Cuvier's beaked whales were recorded, and 43 dedicated sightings were registered in 2009 (Table 1 and Figure 2). The greater number of Cuvier's beaked

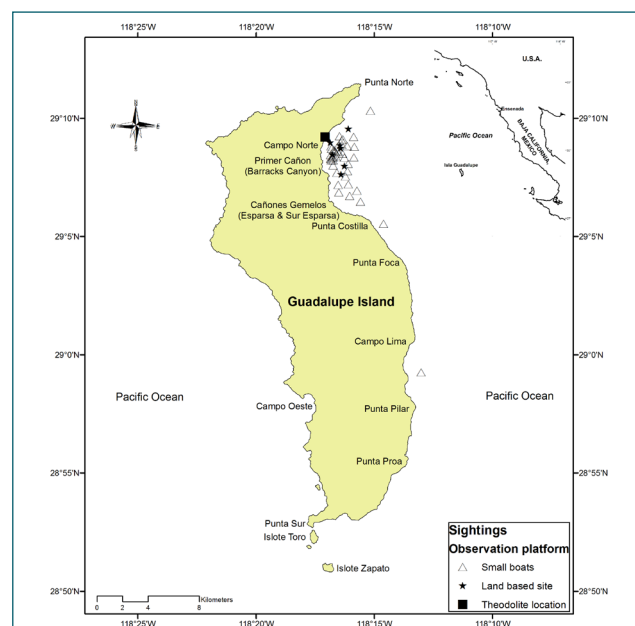


Figure 2. Opportunistic sightings of Cuvier's beaked whales (*Ziphius cavirostris*) from 2006 to 2008 and sightings recorded on pilot study during summer and autumn of 2009. Only eight geographic positions were recorded between 2006 and 2008.



Figure 3. Different images representing some of the sighting characteristics of the Cuvier's beaked whales (*Ziphius cavirostris*) in Guadalupe Island. a. Mauricio Hoyos recording an underwater footage of an adult male from the panga; b. sighting number 33 at 0.97km from shore; c. adult male; besides features such as white oval scars from cookie-cutter sharks and linear scars from intraspecific interactions, some individuals (males and females) had a white pigmentation on the belly; and d. mother and calf pair.

whales sightings in 2009 in comparison to 2006 to 2008 is likely a result of search effort focused on this species. Because most of the search effort was not systematic during the study period, we were only able to compare the sighting rates with other studies on Cuvier's beaked whales with the results from June and August of 2009. During this period with boat-based field effort we had an encounter rate of 0.17 group/hour. Furthermore, we compared the total number of sightings reported at Guadalupe Island during 2006 through 2009 with other studies where Cuvier's beaked whale was reported. The total number of sightings (67) or the encounter rate reported here (0.17) are higher than the totals reported for other areas where survey effort was much higher [including the Southern Gulf of California (21 sightings, Barlow *et al.*, 1997), Mediterranean Sea (33 and 11 sightings, Cañadas *et al.*, 2002; Gannier and Epinat, 2008 respectively), Great Abaco, Bahamas (6 sightings and 0.02 group/hour, MacLeod *et al.*, 2004), Hawaii (17 sightings and 0.01 group/hour, Baird *et al.*, 2006; 40 sightings, McSweeney *et al.*, 2007), Bay of Biscay (60 sightings, Kiszka *et al.*, 2007), southwest Gulf of California (31 sightings and 0.06 group/hour, Cárdenas-

Hinojosa, 2008) and San Clemente Island (37 sightings and 0.04 group/hour, Falcone *et al.*, 2009)].

In contrast to previous reports from Guadalupe Island (Gallo-Reynoso and Figueroa-Carranza, 1995; 2005), Cuvier's beaked whale was the only species of beaked whale seen during our surveys. Almost all encounters from 2006 through 2009 (with the exception of one encounter in Campo Lima) occurred in Bahía Norte between Punta Costilla and Punta Norte, largely associated with Primer Cañón and Cañones Gemelos (Figure 2), where our survey effort has been concentrated (Figure 1). We encountered Cuvier's beaked whales between 0.46 and 2.18km (mean = 1.05; SD = 0.41; $n = 49$) from shore in water depths from 42 to 580m (mean = 269.2; SD = 138.2; $n = 35$). The mean depth of Cuvier's beaked whales recorded here is much lower than results reported in the literature (*e.g.* MacLeod *et al.*, 2004; Baird *et al.*, 2006; Cárdenas-Hinojosa, 2008; Falcone *et al.*, 2009). The encounters of Cuvier's beaked whales occurred from 19 to 28°C of SST (Table 1), with a mean of 22.1°C (SD = 2.23; $n = 53$) (Table 2). Similar results were reported by Gallo-Reynoso and Figueroa-Carranza in 1995, who

Table 1. Sightings of Cuvier's beaked whales recorded from 2006 through 2009 at Guadalupe Island, Mexico.

| Sighting number | Observation platform | Date | Time | Group size | Depth (m) | Sea surface temperature (°C) | Distance from shore (km) |
|-----------------|----------------------|-------------|----------|------------|-----------|------------------------------|--------------------------|
| 1 | Panga | 16 Nov 2006 | 23:24:00 | 3 | 42 | 20 | |
| 2 | Panga | 22 Nov 2006 | 14:31:00 | 1 | | | |
| 3 | Panga | 23 Nov 2006 | 1:42:00 | 1 | 74.2 | 20 | |
| 4 | Panga | 02 Dec 2006 | 17:05:00 | 4 | 48.5 | 19 | |
| 5 | Panga | 04 Dec 2006 | 13:34:00 | 2 | 98 | 20.5 | |
| 6 | Panga | 05 Dec 2006 | 15:30:00 | 4 | 70 | 20 | |
| 7 | Panga | 05 Dec 2006 | 21:11:00 | 4 | | | |
| 8 | Panga | 06 Dec 2006 | 9:15:00 | 3 | 92 | 19.7 | |
| 9 | Panga | 08 Dec 2006 | 11:00:00 | 7 | | | |
| 10 | Panga | 08 Dec 2006 | 12:17:00 | 2 | | 20 | |
| 11 | Panga | 07 Oct 2007 | 0:10:00 | 1 | 330 | 20.9 | |
| 12 | Panga | 24 Oct 2007 | 15:29:00 | 5 | 315 | 20.9 | |
| 13 | Panga | 25 Oct 2007 | 16:39:00 | 4 | 321 | 20.9 | |
| 14 | Panga | 13 Nov 2007 | 17:13:00 | 3 | 245 | 20.8 | |
| 15 | Panga | 16 Nov 2007 | 7:21:00 | 5 | | | |
| 16 | Panga | 26 Sep 2008 | 12:15:00 | 4 | | 21 | |
| 17 | Panga | 28 Sep 2008 | 16:03:00 | 4 | | 21 | 1.49 |
| 18 | Panga | 15 Oct 2008 | 13:37:00 | 4 | | | |
| 19 | Panga | 16 Oct 2008 | 9:18:00 | 4 | 135 | 20.4 | 0.75 |
| 20 | Panga | 22 Oct 2008 | 12:50:00 | 7 | 248 | 25.5 | 0.68 |
| 21 | Panga | 29 Oct 2008 | 12:35:00 | 1 | 385 | 22.3 | 0.90 |
| 22 | Panga | 29 Oct 2008 | 3:30:00 | 2 | 331 | 23.3 | 0.69 |
| 23 | Panga | 30 Oct 2008 | 15:55:00 | 3 | 346 | 21.4 | 0.88 |
| 24 | Panga | 31 Oct 2008 | 6:35:00 | 2 | | | 1.13 |
| 25 | Panga | 18 Jun 2009 | 12:51:55 | 1 | | 19.7 | 1.26 |
| 26 | Shore-based site | 19 Jun 2009 | 14:10:00 | 6 | | 19.72 | 0.67 |
| 27 | Shore-based site | 20 Jun 2009 | 14:48:00 | 1 | | 19.75 | 0.78 |
| 28 | Shore-based site | 20 Jun 2009 | 16:25:00 | 1 | | 19.7 | 1.17 |
| 29 | Shore-based site | 20 Jun 2009 | 10:15:00 | 1 | | 19.8 | 1.29 |
| 30 | Shore-based site | 20 Jun 2009 | 13:25:00 | 2 | | | |
| 31 | Shore-based site | 20 Jun 2009 | 11:15:00 | 3 | | 19.8 | 0.47 |
| 32 | Panga | 24 Jun 2009 | 10:59:52 | 1 | | 19.5 | 1.33 |

| | | | | | | | |
|----|------------------|-------------|----------|---|-----|------|------|
| 33 | Panga | 24 Jun 2009 | 2:43:32 | 3 | | 19.5 | 0.97 |
| 34 | Panga | 18 Aug 2009 | 9:05:37 | 2 | 120 | 21 | 0.62 |
| 35 | Panga | 18 Aug 2009 | 9:33:37 | 2 | | 20.9 | 0.99 |
| 36 | Panga | 18 Aug 2009 | 4:57:23 | 4 | 444 | 21.8 | 0.97 |
| 37 | Panga | 22 Aug 2009 | 10:05:56 | 2 | | 24.5 | 1.70 |
| 38 | Panga | 22 Aug 2009 | 15:29:00 | 3 | | 23.9 | 1.30 |
| 39 | Shore-based site | 23 Aug 2009 | 17:32:55 | 2 | | 22 | 1.26 |
| 40 | Shore-based site | 24 Aug 2009 | 12:12:23 | 2 | | 21.5 | 0.84 |
| 41 | Panga | 30 Aug 2009 | 06:35 | 3 | 465 | 25.5 | 1.19 |
| 42 | Panga | 03 Sep 2009 | 10:33 | 3 | | 23.5 | 2.17 |
| 43 | Panga | 04 Sep 2009 | 13:42 | 3 | 466 | 24.4 | 1.26 |
| 44 | Panga | 11 Sep 2009 | 11:05 | 3 | 137 | 28 | 0.58 |
| 45 | Panga | 18 Sep 2009 | 14:15 | 2 | 212 | 24 | 0.55 |
| 46 | Panga | 18 Sep 2009 | 16:15 | 2 | 220 | 24.4 | 0.58 |
| 47 | Panga | 25 Sep 2009 | 11:05 | 2 | 222 | | 0.70 |
| 48 | Panga | 25 Sep 2009 | 15:20 | 4 | 314 | 26.8 | 1.88 |
| 49 | Panga | 26 Sep 2009 | 17:25 | 7 | 213 | | 0.70 |
| 50 | Panga | 27 Sep 2009 | 11:20 | 2 | 580 | | 1.61 |
| 51 | Panga | 28 Sep 2009 | 13:30 | 6 | 280 | 25.3 | 1.06 |
| 52 | Panga | 28 Sep 2009 | 17:20 | 2 | 209 | | 0.67 |
| 53 | Panga | 01 Oct 2009 | 17:54 | 3 | | 25.3 | 1.04 |
| 54 | Panga | 02 Oct 2009 | 16:15 | 4 | | 25.6 | 2.18 |
| 55 | Panga | 07 Oct 2009 | 12:11 | 4 | 244 | 24.4 | 0.87 |
| 56 | Panga | 12 Oct 2009 | 07:45 | 4 | 278 | | 0.76 |
| 57 | Panga | 13 Oct 2009 | 18:09 | 2 | 415 | 25 | 0.98 |
| 58 | Panga | 13 Oct 2009 | 10:20 | 4 | | 24.8 | 1.54 |
| 59 | Panga | 14 Oct 2009 | 07:34 | 4 | 322 | | 0.74 |
| 60 | Panga | 16 Oct 2009 | 12:15 | 2 | 371 | 21.3 | 1.06 |
| 61 | Panga | 16 Oct 2009 | 15:35 | 3 | 310 | 21.3 | 0.78 |
| 62 | Panga | 17 Oct 2009 | 13:35 | 2 | | | 0.60 |
| 63 | Panga | 22 Oct 2009 | 14:16 | 5 | | 22.3 | 1.13 |
| 64 | Panga | 23 Oct 2009 | 09:10 | 3 | | 21.5 | 1.22 |
| 65 | Panga | 24 Oct 2009 | 08:53 | 1 | | 21.9 | 0.62 |
| 66 | Panga | 26 Oct 2009 | 11:12 | 4 | | 22.2 | 1.58 |
| 67 | Panga | 26 Oct 2009 | 11:56 | 1 | 520 | 22.7 | 1.32 |

recorded beaked whale sightings in summer at a mean SST of 22°C (SD = 1.2; $n = 45$) in 1992, and 21°C (SD = 0.9; $n = 45$) in 1993 around Guadalupe Island. In 2009, despite recording different means of SST from June to October (Table 2), including a 5.52°C difference between the coldest (19.7°C) and warmest (25.2°C) months (June and September), we encountered Cuvier's beaked every month of the year.

The 22.3% of the sightings from 2006 through 2009 were mother and calf pairs, and virtually all calves were recorded in 2009. Calves were defined as individuals of approximately one-third of the total length to the female adult (see Figure 3). In total, 32 individuals of Cuvier's beaked whales were identified (including poor quality video and photographs), and two individuals were re-sighted on two occasions with lapses of one and 22 days, respectively. Despite 46 high definition underwater footages with high proportion of the body visible, the quality of the images edited to allow individual identification was very poor (mainly low image resolution). For this reason, only 14 individuals of the Cuvier's beaked whale catalog have good quality photographs or footages. We classified 20 individuals as adults, nine as unknown class age, and three as hifen. Of the adults, 12 were identified as males and eight as females. Due to poor quality of images, sex could not be assigned to the nine individuals of unknown age class. The non-adult individuals were considered as males because they had few single or paired linear scars on the back. It is important to note the presence of a white pigmentation on adult individuals on the posterior part of the belly, caused by bites of cookie-cutter sharks (Figure 3). The presence of this species of shark (*Isistius brasiliensis*) has been documented in Guadalupe Island (Reyes-Bonilla *et al.*, 2010).

Cuvier's beaked whale group size off Guadalupe Island ranged from one to seven individuals with a mean of three (SD = 1.5; $n = 67$). In the review by MacLeod and D'Amico (2006) on beaked whale behavior and ecology, they mentioned that the mean group size for *Z. cavirostris* was 2.3 individuals (SD

= 1.7; $n = 189$). Similar results were recorded by McSweeney *et al.* (2007) off the Island of Hawaii (mean = 2.5; SD = 1.2; $n = 28$) and by Cárdenas-Hinojosa (2008) for the southwest Gulf of California (mean = 2.4; SD = 0.9; $n = 23$). It should then be noted that the mean group size reported here is larger than previous reports for this species, but smaller than off San Clemente Island (mean = 3.8; SD = 2.4; $n = 37$) (Falcone *et al.*, 2009).

An opportunistic surface feeding event was recorded during the night of 7 October, 2007. A mature female (visually estimated at 6m long) was seen very close to shore, in the vicinity of Primer Cañon, swimming slowly at the surface with the mouth open to feed on a concentration of squid identified as *Leachia dislocata* (Family Cranchiidae; Figure 4). Some squid were dead and floating on the surface so likely the Cuvier's beaked whale individual took most of the squid by scavenging. The female approached the boat as near as one meter away and after a near inspection it moved to the north slowly. According to MacLeod *et al.* (2003), this family of squid was one of the most frequently reported on dietary data available for 38 specimens of Cuvier's beaked whales from throughout the range of the species. This squid has also been reported as prey of the Laysan albatross (*Phoebastria immutabilis*) at Guadalupe Island (Pitman *et al.*, 2004). This seabird is a daytime sea surface scavenger of spawned adult squid (Pitman *et al.*, 2004). *L. dislocata* are available to albatrosses because, as in many squid species, females die after spawning and float to the surface (Nesis *et al.*, 1988). Furthermore, some of the families of squid reported as prey of the Laysan albatross at Guadalupe Island (Pitman *et al.*, 2004), as Histioteuthidae, Gonatidae, Chiroteuthidae, Octopoteuthidae, Onychoteuthidae, and Ommastrephidae (specifically, *Dosidicus gigas*, reported by Domeier, 2009) were some of the most frequently reported cephalopods on the diet of Cuvier's beaked whales (MacLeod *et al.*, 2003), indicating a potential availability of different prey sources at Guadalupe Island.

Table 2. Sea surface temperature (SST) recorded during the sightings of Cuvier's beaked whales 2006-2009 at Guadalupe Island, Mexico.

| | Mean | Min | Max | SD | N |
|-----------|-------|------|------|------|----|
| All years | 22.09 | 19 | 28 | 2.23 | 53 |
| 2006 | 19.88 | 19 | 20.5 | 0.45 | 7 |
| 2007 | 20.87 | 20.8 | 20.9 | 0.05 | 4 |
| 2008 | 22.12 | 20.4 | 25.5 | 1.77 | 7 |
| 2009 | 22.66 | 19.5 | 28 | 2.35 | 35 |
| Jun 2009 | 19.68 | 19.5 | 19.8 | 0.11 | 8 |
| Aug 2009 | 22.63 | 20.9 | 25.5 | 1.74 | 8 |
| Sep 2009 | 25.2 | 23.5 | 28 | 1.63 | 7 |
| Oct 2009 | 23.19 | 21.3 | 25.6 | 1.68 | 12 |

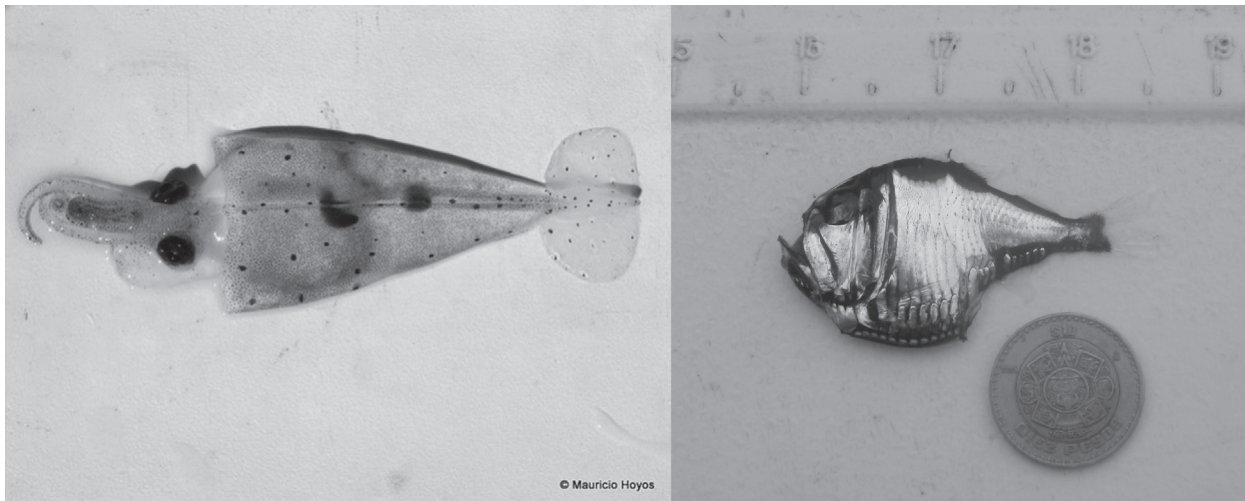


Figure 4. Prey items reported for the Cuvier's beaked whale (*Ziphius cavirostris*) off Guadalupe Island. Left: *Leachia dislocata*. Right: *Argyropelecus affinis*. The scale of the ruler is in inches.

Evidence of a second foraging display was observed on 14 October, 2009 when a group of Cuvier's beaked whales was sighted in the northeastern area of Cañones Gemelos in 322m depth heading north. After 29 minutes, we resighted the group in approximately the same area, but in deeper waters (366m). We found several mesopelagic silver hatch fish *Argyropelecus affinis* (Family Sternoptychidae; Figure 4) in the vicinity of the whales. These fish, which were alive and floating on the sea surface, had their swim bladders distended from their mouth, a sign of decompression (St John, 2003). This is an oceanic and mesopelagic species found at 300-600m at daylight (Badcock, 1984). As that sighting was recorded during the day, we suggest that the beaked whales were foraging on schools of these fishes in deep waters, and the fishes may have fled to escape the whales, resulting in decompression (Figure 4).

These two foraging displays are the first records on the diet of Cuvier's beaked whale at Guadalupe Island. Despite the fact that neither of these two species (*L. dislocata* and *A. affinis*) have previously been reported as prey items for Cuvier's beaked whale, this new report is not surprising because the high diversity of prey found elsewhere in stomachs of Cuvier's beaked whales suggests that they may be opportunistic in their feeding habits (Heyning, 2002). Furthermore, the visual observation of surface feeding on squid, as far as we know, is the first direct evidence reported of predator-prey interactions for this species.

Several features of habitat preferences of beaked whales are found at Guadalupe Island. It is an oceanic island exhibiting steep slope features such as submarine canyons and deep waters close to shore (Pierson, 1987), where most of the sightings were recorded. Similar to another species of beaked whales, the presence of *Z. cavirostris* has been correlated to habitats like oceanic islands (MacLeod and Zuur, 2005; Baird *et al.*,

2006). In addition, the frequent use of submarine canyons has been documented for northern bottlenose whales in the Gully region off the Nova Scotia shelf (Hooker *et al.*, 1999; 2002), for Blainville's beaked whales in the Bahamas (MacLeod and Zurr, 2005), and for Cuvier's beaked whales in the southwest Gulf of California (Cárdenas-Hinojosa, 2008) and in the Ligurian Sea (D'Amico *et al.*, 2003). The deep-water habits and diving behaviors are directly related to foraging for squid and other benthic and deep water organisms (Mead, 1989; Davis *et al.*, 1998; Waring *et al.*, 2001; Cañadas *et al.*, 2002; MacLeod *et al.*, 2003; MacLeod and D'Amico, 2006).

Therefore, we suggest that the occurrence of Cuvier's beaked whale in Guadalupe Island is related to the presence and availability of prey resources, particularly in the areas of submarine canyons. This is supported by the two foraging displays observed and reported in this note. The high sighting rate of Cuvier's beaked whales reported here could be because Guadalupe Island is far away from the mainland with scarce maritime activities (*e.g.* sustainable fisheries on abalone and lobster, Aguirre-Muñoz *et al.*, 2005) resulting in a habitat where the animals can conduct vital activities with low anthropogenic disturbance. Also, we suggest that the high sighting rate and presence of mother and calf pairs is because Guadalupe Island could be a refuge from killer whales (*Orcinus orca*). In the photographs or footages, we did not observe a scar potentially caused by orcas. There is only a visual encounter of a group of killer whales reported by fishermen on the island and the possible presence of this species inferred by the sound of slapping of flukes and behavior of fur seals (Gallo-Reynoso and Figueroa-Carranza, 1998). Furthermore, despite the potential threat of the temporal presence of white sharks from July to December around the Guadalupe Island (Domeier and Nasby-Lucas, 2007) and the space overlapping with Cuvier's beaked whales in Bahía Norte, there are no

reports of attacks of white sharks on this cetacean. Another probable reason of the high sighting rate are the deep waters close to the coast caused by the narrow continental shelf in the island, allowing us to encounter the beaked whales very close to shore (Table 1, Figures 2 and 3) and observe the groups of animals at naked eye from the shore-based site (specially adult males). It is important to mention that during surveys the local fishermen (boat operators) were able to sight beaked whales and differentiate them from bottlenose dolphins. They reported that these animals or *krikas* are common inhabitants of the island.

Thus, due to the bathymetric characteristics of the island and all the sighting records in the literature (including the ones reported here), the multi-year presence of Cuvier's beaked whale off Guadalupe Island suggests that this is an important area for the occurrence of Cuvier's beaked whales in Mexico. Furthermore, the presence of mother and calf pairs and the observation of two foraging displays may indicate that Guadalupe Island is a breeding/feeding area for this species. However, it is necessary to conduct systematic research with greater space-temporal search effort to study site-fidelity, habitat use, and potential residency of Cuvier's beaked whales to Guadalupe Island, as has been demonstrated in other island-associated populations of beaked whales (e.g. McSweeney *et al.*, 2007).

Acknowledgments

This research was funded by the Guadalupe Island Conservation Fund, Pflieger Institute of Environmental Research, Iemanya Oceanica, Shark Trust, Aquarium of the Pacific, Vallartech diving, Chedraui, SEMARNAT, and the Monterrey Bay Aquarium. Field work was facilitated through courtesies extended to Mauricio Hoyos by personnel of the Mexican Navy, local fishermen of Guadalupe Island, Horizon charters, Islander charters, Nautilus Explorer and *M/V Andrea Lynn*.

This research was conducted under scientific research permits from SEMARNAT (SGPA/DGVS/04053/07 and SGPA/DGVS/05828/08), and SEGOB (DICOPPU/211/1827/07 and DICOPPU/211/1023/09) and under a 'no objection' permit from CONANP (F00.RNO.RBIG-154/07, F00.RNO.RBIG.-166/07 and F00.RPBCPN.RBIG.-096/09). We thank Jay Barlow and Armando Jaramillo for their helpful editorial suggestions. We also thank the two anonymous reviewers and the editor for their useful comments that greatly improved the manuscript. Given the unusual encounters (nocturnal and underwater footages) of Cuvier's beaked whales reported here, a copy of the evidence can be requested to the author.

References

- Aguirre-Muñoz, A., Ezcurra, E., Enkerlin, H.E., Soberon, M.J., Salas, F.L.M., Santos de Prado, K., Peters, E., Luna-Mendoza, L., Tershy, B., Keitt, B., Garcia, G.C. and Aguirre, B.I. (2005) La construcción social de la conservación y el desarrollo sustentable de Isla Guadalupe. Pages 239-253 in Santos del Prado, K. and Peters, E. (Eds) *Isla Guadalupe, restauración y conservación*. SEMARNAT-INE, CICESE, GECI, SEMAR, México.
- Badcock, J. (1984) Gonostomatidae. Pages 284-301 in Whitehead, P.J.P., Bauchot, M.L., Hureau, J.C., Nielsen J. and Tortonese, E. (Eds) *Fishes of the north-eastern Atlantic and the Mediterranean*. Vol. 1. UNESCO, Paris, France.
- Baird, R.W., Webster, D.L., McSweeney, D.J., Ligon, A.D., Schorr, G.S. and Barlow, J. (2006) Diving behavior and ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawai'i. *Canadian Journal of Zoology* 84: 1120-1128. <http://dx.doi.org/10.1139/z06-095>
- Barlow, J., Forney, K., Von Sauner, A. and Urbán-Ramírez, J. (1997) A report of cetacean acoustic detection and dive interval studies (CADDIS) conducted in the Southern Gulf of California, 1995. *National Oceanic and Atmospheric Administration Technical Memorandum, NOAA-TM-NMFS-SWFSC-250*. La Jolla, CA, USA. 48 pp.
- Cañadas, A., Sagarminaga, R. and García-Tiscar, S. (2002) Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep Sea Research I* 49: 2053-2073. [http://dx.doi.org/10.1016/S0967-0637\(02\)00123-1](http://dx.doi.org/10.1016/S0967-0637(02)00123-1)
- Cárdenas-Hinojosa, G. (2008) *Distribución y hábitat de zífidos en la costa sudoccidental del Golfo de California* (Cetacea: Ziphiidae). M.Sc. Thesis. Universidad Autónoma de Baja California Sur. La Paz, México. 74 pp.
- Dalebout, M.L., Ross, G.J.B., Baker, C.S., Anderson, R.C., Best, P.B., Cockcroft, V.G., Hinsz, H.L., Peddemors, V. and Pitman, R.L. (2003) Appearance, distribution and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*. *Marine Mammal Science* 19: 421-461. <http://dx.doi.org/10.1111/j.1748-7692.2003.tb01314.x>
- D'Amico, A., Bergamasco, A., Zanasca, P., Carniel, S., Nacini, E., Portunato, N., Teloni, V., Mori, C. and Barbanti, R. (2003) Qualitative correlation of marine mammals with physical and biological parameters in the Ligurian Sea. *Institute of Electrical and Electronics Engineers Journal of Oceanic Engineering* 28: 29-43.
- Davis, R.W., Fargion, G.S., May, N., Leming, T.D., Baumgartner, M., Evans, W.E., Hansen, L.J. and Mullin, K. (1998) Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. *Marine Mammal Science* 14(3): 490-507. <http://dx.doi.org/10.1111/j.1748-7692.1998.tb00738.x>

- Domeier, M.L. (2009) Experimental scavenging preference for the adult white shark, *Carcharodon carcharias*. *California Fish and Game* 95(3): 140-145.
- Domeier, M.L. and Nasby-Lucas, N. (2007) Annual resightings of photographically identified white sharks (*Carcharodon carcharias*) at an eastern Pacific aggregation site (Guadalupe Island, Mexico). *Marine Biology* 150: 970-984. <http://dx.doi.org/10.1007/s00227-006-0380-7>
- Falcone, E.A., Schorr, G.S., Douglas, A.B., Calambokidis, J., Henderson, E., McKenna, M.F., Hildebrand, J. and Moretti, D. (2009) Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius cavirostris*) near San Clemente Island, California: a key area for beaked whales and the military? *Marine Biology* 156: 2631-2640. <http://dx.doi.org/10.1007/s00227-009-1289-8>
- Gallo-Reynoso, J.P. and Figueroa-Carranza, A.L. (1995) Occurrence of bottlenose whales in the waters of Guadalupe Island, Mexico. *Marine Mammal Science* 11(4): 573-575. <http://dx.doi.org/10.1111/j.1748-7692.1995.tb00680.x>
- Gallo-Reynoso, J.P. and Figueroa-Carranza, A.L. (1998) Cetaceans of Guadalupe Island, Baja California, México. *Bulletin of the Southern California Academy of Sciences* 97(1): 33-38.
- Gallo-Reynoso, J.P. and Figueroa-Carranza, A.L. (2005) Los cetáceos de Isla Guadalupe. Pages 203-217 in Santos del Prado, K. and Peters, E. (Eds) *Isla Guadalupe, restauración y conservación*. Secretaría de Medio Ambiente y Recursos Naturales-Instituto Nacional de Ecología, SEMARNAT-INE, Centro de Investigación Científica y de Educación Superior de Ensenada CICESE, Conservación de Islas GECEI, Secretaría de Marina-Armada de Mexico SEMAR, Mexico.
- Gannier, A. and Epinat, J. (2008) Cuvier's beaked whale distribution in the Mediterranean Sea: results from small boat surveys 1996–2007. *Journal of the Marine Biological Association of the United Kingdom* 88(6): 1245–1251. <http://dx.doi.org/10.1017/S0025315408000428>
- Heyning, J.E. (1989) Cuvier's beaked whale *Ziphius cavirostris* G Cuvier, 1823. Pages 289-308 in Ridgway, S.H. and Harrison, R. (Eds) *Handbook of marine mammals*, Vol. 4. Academic Press, London, UK.
- Heyning J.E. (2002) Cuvier's beaked whale - *Ziphius cavirostris*. Pages 305-307 in Perrin, W.F., Würsig, B. and Thewissen, J.G.M. (Eds) *Encyclopedia of marine mammals*. Academic Press, San Diego, USA.
- Hooker, S.K., Whitehead, H. and Gowans, S. (1999) Marine protected area design and the spatial and temporal distribution of cetaceans in a canyon submarine. *Conservation Biology* 3: 592-602. <http://dx.doi.org/10.1046/j.1523-1739.1999.98099.x>
- Hooker, S.K., Whitehead, H., Gowans, S. and Baird, R.W. (2002) Fluctuations in distribution and patterns of individual range use of northern bottlenose whales. *Marine Ecology Progress Series* 225: 287-297. <http://dx.doi.org/10.3354/meps225287>
- Hoyos-Padilla, E.M. (2009) *Patrones de movimiento del tiburón blanco (Carcharodon carcharias) en Isla Guadalupe, México*. Ph.D. Thesis. Centro Interdisciplinario de Ciencias Marinas. La Paz, Baja California Sur, México. 147 pp.
- Kiszka, J., Macleod, K., Van Canneyt, O., Walker, D. and Ridoux, V. (2007) Distribution, encounter rates, and habitat characteristics of toothed cetaceans in the Bay of Biscay and adjacent waters from platform-of-opportunity data. *ICES of Marine Science* 64: 1-11. <http://dx.doi.org/10.1093/icesjms/fsm067>
- MacLeod, C.D. and D'Amico, A. (2006) A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *Journal of Cetacean Research and Management* 7(3): 211-221.
- MacLeod, C.D., Santos, M.B. and Pierce, G.J. (2003) Review of data on diets of beaked whales: evidence of niche separation and geographic segregation. *Journal of the Marine Biological Association of the United Kingdom* 83: 651-665. <http://dx.doi.org/10.1017/S0025315403007616h>
- MacLeod, C.D., Hauser, N. and Peckham, H. (2004) Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. *Journal of the Marine Biological Assessment* 84: 469-474. <http://dx.doi.org/10.1017/S0025315404009476h>
- MacLeod, C.D. and Zuur, A.F. (2005) Habitat utilization by Blainville's beaked whales off Great Abaco, northern Bahamas, in relation to seabed topography. *Marine Biology* 147: 1-11. <http://dx.doi.org/10.1007/s00227-004-1546-9>
- McSweeney D.J., Baird, R.W. and Mahaffy, S.D. (2007) Site fidelity, associations, and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the isles Hawaii. *Marine Mammal Science* 23(3): 666-687. <http://dx.doi.org/10.1111/j.1748-7692.2007.00135.x>
- Mead, J.G. (1989) Beaked whales of the genus *Mesoplodon*. Pages 349-430 in Ridgway, S.H. and Harrison, R. (Eds) *Handbook of marine mammals*, Vol 4. Academic Press, London, UK.
- Nesis, K.N., Nigmatullin, Ch.M. and Nikitina, I.V. (1998) Spent females of deepwater squid *Galiteuthis glacialis* under the ice at the surface of the Weddell Sea (Antarctic). *Journal of Zoology* 244: 185-200. <http://dx.doi.org/10.1111/j.1469-7998.1998.tb00024.x>
- Pierson, M.O. (1987) Breeding behavior of the Guadalupe fur seal, *Arctocephalus townsendi*. Pages 83-94 in Croxall, J.P. and Gentry, R.L. (Eds) *Status, biology, and ecology of fur seals*. NOAA Technical Report, National Marine Fisheries Service, USA.

- Pitman, R.L., Palacios, D.M., Brennan, P.L.R., Brennan, B.J., Balcomb, K.C. and Miyashita, T. (1999) Sightings and possible identity of a bottlenose whale in the tropical Indo-Pacific: *Indopacetus pacificus*? *Marine Mammal Science* 15: 531–549. <http://dx.doi.org/10.1111/j.1748-7692.1999.tb00818.x>
- Pitman, R.L., Walker, W.A., Everett, W.T. and Gallo-Reynoso, J.P. (2004) Population status, foods and foraging of Laysan albatross *Phoebastria immutabilis* nesting on Guadalupe Island, Mexico. *Marine Ornithology* 32: 159-165.
- Reyes-Bonilla, H., Ayala, B.A., González, R.S., Sánchez, A.I., Walther, M.M., Bedolla G.Y., Ramírez, V.A., Calderón, A.L. and Olivares-Bañuelos, N.C. (2010) Checklist and biogeography of fishes from Guadalupe Island, Western México. *CalCOFI California Cooperative Oceanic Fisheries Investigations Reports* 51: 195-209.
- St John, J. (2003) Is your fish “bent” and will it survive? Pages 31-35 in *SPC Live Reef Fish Information Bulletin # 11*. Secretariat of the Pacific Community, New Caledonia.
- Waring, G.T., Hamazaki, T., Sheehan, D., Wood, G. and Baker, S. (2001) Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast US. *Marine Mammal Science* 17:703-717. <http://dx.doi.org/10.1111/j.1748-7692.2001.tb01294.x>