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STOMACH CONTENTS OF A CUVIER'S BEAKED WHALE (*ZIPHIUS CAVIROSTRIS*) STRANDED IN MONTEREY BAY, CALIFORNIA

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From 1942 to 2010 there were 23 reported strandings of Cuvier's Beaked Whale, *Ziphius cavirostris* (Odontoceti: Ziphiidae), in the Pacific Northwest (Oregon and Washington), and 25 reported strandings in California between 1982 and 2010 (Moore and Barlow 2013). Although *Z. cavirostris* appears to be the most cosmopolitan of the beaked whales, occurring in all oceans except in high polar regions (Leatherwood and Reeves 1983; Heyning 1989), global phylogenetic analyses reveal low maternal gene flow among populations confined to isolated ocean basins (Dalebout and others 2005). Extensive surveys throughout the California Current System (CCS) show that *Z. cavirostris* is distributed offshore over the continental slope, occurring more frequently closer to shore and aggregated in areas of complex bathymetry (for example, Monterey Bay, California and within the Southern California Bight, see Fig. 2 in Moore and Barlow 2013). In the northern CCS, Moore and Barlow (2013) estimated that the *Z. cavirostris* population likely has decreased by approximately 30% from 10,771 in 1991 to approximately 7550 individuals in 2008, and they suggested that one potential cause could be ecosystem change, thus highlighting the need for additional information on food habits.

Heyning (1989) first summarized prey information for *Z. cavirostris* from around the world, a list that included 10 cephalopod families (16 genera), gadiform and atheriniform fishes, and 2 accounts of crustacean prey. Santos and others (2001) reported prey remains from 3 *Z. cavirostris* stranded in the eastern Atlantic and provided a review of known prey remains for the species. MacLeod and others (2003) extended the review of Santos and others (2001) to include comparison of *Z. cavirostris* with 2 additional beaked whales: *Mesoplodon* spp. and *Hyperoodon planifrons*. Combining these records with 7 *Z. cavirostris* stomachs evaluated by Santos and others (2007), the known diet of *Z. cavirostris* is based on prey remains recovered from only 45 individuals world-wide; diets consisted of 46 cephalopod species (15 families), infrequent crustacean remains, and rare representation among mostly unidentified fishes (MacLeod and others 2003). Compared with records from the Atlantic, food habits of *Z. cavirostris* off Alaska and in the eastern North Pacific are less well known ($n = 5$ individuals, and only 1 from California). Fiscus (1997) identified 6 cephalopod families (11 genera) from a subset of the stomach remains collected and described by Kenyon (1961) from a mature female *Z. cavirostris* that stranded in March 1959 on Amchitka Island, Aleutian Islands, Alaska. Foster and Hare (1990) identified 3 of the same cephalopod families (4 genera) as reported by Fiscus (1997) from a *Z. cavirostris* stranded in Kodiak, Alaska. In the Gulf of Mexico, Fertl and others (1997) identified a single beak of *Loligo peali* from an individual that stranded in Texas.

An adult female *Z. cavirostris* (Moss Landing Marine Laboratory Museum [MLMLM] #499, standard length 600 cm) stranded dead on 15 January 1998 at Marina State Beach, California (UTM: Zone 10S, 607191E, 4062264N, WGS84). During a 2-d field necropsy, to minimize the loss of contents, we tied-off both the esophageal and duodenal ends of the stomach before removing it on 16 January 1998. Prey remains were also collected from the whale's oral cavity. The stomach contents from 5 pyloric compartments (see Kenyon 1961 for a description of the stomach of an adult female *Z. cavirostris*) were gently rinsed and sifted through a 500-µm sieve. Cephalopod remains (whole beaks, beak fragments, and eye lenses) and fish remains (bones and eye lenses) were preserved in 50% isopropyl alcohol and fish otoliths were stored dry. Cephalopods were identified to lowest taxon using the

cephalopod beak reference collection housed at the National Oceanic and Atmospheric Administration (NOAA) National Marine Mammal Laboratory (NMML), Seattle, Washington. Lower beak rostral lengths (LRL) or hood lengths (HL; *Vampyroteuthis infernalis*) were measured (± 0.1 mm) with vernier calipers or an optical micrometer. Estimated dorsal mantle length (DML [mm]) and wet mass (g) were calculated using regression equations between LRL or HL and body size (Clarke 1986; Walker and others 2002 for *Gonatopsis borealis* [southern form]; and NOAA NMML, unpubl. data for *Taonius borealis*). Following Clarke (1986), we classified specimens of a given species as adult or juvenile based on the degree of pigmentation (darkening) of the wing portions of lower beaks. For the gadiform fish, Giant Grenadier (*Albatrossia pectoralis* [Macrouridae]), we measured otolith length and height (± 0.1 mm) using a calibrated video-imaging system, and otolith mass (± 0.001 g) using an analytical balance (Burton 1999). We estimated *A. pectoralis* total length (TL ± 1.0 cm) using linear regression equations between otolith mass and pre-anal fin length (PAFL; tip of snout to base of 1st anal fin ray), and PAFL to TL (Burton 1999). To estimate *A. pectoralis* mass (g), we used the regression equation reported in Clausen (2008) for both sexes combined. We quantified prey by percent of the total prey number (%N) and percent of the total reconstructed mass (%M); the number of unique lower rostra recorded gave us a minimum count per taxonomic group (Clarke and Trueman 1988).

Total recovered stomach contents consisted of 224 cephalopod upper rostra, 194 lower rostra in exceptionally good condition, numerous cephalopod lenses, unidentifiable rostral fragments, remains from a minimum of 5 *A. pectoralis* (otoliths, vertebrae, and cranial bone fragments), and a small amount of crustacean exoskeletal material (representing 1 pasiphaeid shrimp, *cf. Pasiphaea* spp.). We recovered no whole or partially digested prey items and no abiotic remains (for example, plastic or rock).

We identified 206 individual prey items (Table 1). Cephalopods comprised 97%N of the total items identified and included 11 taxa from 5 families: Gonatidae (69.4%N), Cranchiidae (18.4%N), Octopoteuthidae (5.8%N), Vampyroteuthidae (2.9%N), and Histioteuthidae (0.5%N). Remains included both adult and juvenile forms of *Gonatus onyx*, *Gonatus berryi*, *Gonatopsis borealis* (southern form), and *Galiteuthis phyllura* (Table 1). Among cephalopod remains, the most abundant were *G. onyx* adults (38%N), followed by *G. borealis* (southern form) adults and *Taonius borealis* adults (each 12%N). The largest squids in this sample were *G. borealis* (southern form) adults (maximum DML = 339 mm, mass = 1176 g). Adult *G. borealis* was the most important diet item in terms of reconstructed mass (21.6 kg representing 73%M). Of 7 *A. pectoralis* otoliths, we identified 2 matched pairs, setting a minimum of 5 individual fish. The mean estimated TL of *A. pectoralis* in this sample was $\bar{x}$ = 58 cm with standard deviation, s = 2 cm (range = 51 to 59 cm, n = 5). Although fewer by number (2%N), reconstructed mass of *A. pectoralis* ($\bar{x}$ = 494 g, s = 88 g; range = 339 to 555 g, n = 5) represented 8%M; greater than any cephalopod except *G. borealis* (Table 1).

Our findings are consistent with 2 other *Z. cavirostris* stomachs sampled thus far from the eastern North Pacific that contained squid beaks as the main prey remains. Fiscus (1997; single *Z. cavirostris* stranded on Amchitka Island, Alaska) reported contents dominated by 2 families: Gonatidae (51.8%N; including, *G. berryi* and *G. pyros*) and Cranchiidae (47.1%N; including *Taonius* spp., and *Galiteuthis* spp.). Foster and Hare (1990; single *Z. cavirostris* stranded on Kodiak Island, Alaska) also found stomach contents dominated by remains of these 2 oceanic squid families (including *Gonatopsis*/*Berryteuthis*, *Gonatus* spp., and *Taonius* spp.). Four species of the genus *Histioteuthis* have been previously identified in the stomachs of *Z. cavirostris* (Fiscus 1997; MacLeod and others 2003; Santos and others 2007); however, *H. heteropsis* observed here represents a newly reported species in the diet of *Z. cavirostris*. *Octopoteuthis* spp. were reported in stomachs of several beaked whale species, including *Z. cavirostris* (Sekiguchi 1994). *Octopoteuthis deletron* was previously reported in North Pacific Hubbs's (*Mesoplodon carlhubbsi*) and Hector's (*Mesoplodon hectori*) Beaked Whales (Mead and others 1982, later determined to be *M. perrini*; see Dalebout and others 2002), and in 1 *Z. cavirostris* (Heyning 1989). *Vampyroteuthis infernalis* is relatively infrequent in the diet of *Z. cavirostris*, and has only been identified in stomachs reported by Fiscus (1997) and Santos and others (2001, 2007). Foster and Hare (1990) and

TABLE 1. Prey remains according to taxon from the stomach of a Cuvier's Beaked Whale (*Ziphius cavirostris*) stranded in Monterey Bay, California. Beak lengths are lower rostral lengths for teuthid squids and hood lengths for *V. infernalis*.

Taxon	No.	%N	Beak length (mm)		Dorsal mantle length (mm)		Wet weight (g)	
			Range	Mean (*s*)	Range	Mean (*s*)	Sum	%M
Cephalopoda								
Order: Teuthida								
Family: Cranchiidae								
Taonius borealis [a]	24	12	3.0–5.7	4.0 (0.6)	170–273	209 (22)	750	3
Galiteuthis phyllura (juveniles)	4	2	1.5–2.3	2.1 (0.4)	80–129	115 (24)	45	<1
Galiteuthis phyllura	8	4	3.2–5.0	4.1 (0.5)	185–295	240 (33)	397	1
Galiteuthis spp. *cf. G. pacifica*	2	1	3.6–4.6	4.1 (0.7)	209–270	240 (43)	99	<1
Family: Gonatidae								
Gonatus berryi (juveniles)	3	1	1.8–2.2	2.0 (0.2)	34–51	42 (9)	16	<1
Gonatus berryi	1	<1	5.1		175		118	<1
Gonatus californiensis	1	<1	5.7		201		171	1
Gonatus onyx (juveniles)	21	10	1.5–3.0	2.1 (0.4)	41–70	54 (8)	122	<1
Gonatus onyx	78	38	2.9–4.8	3.8 (0.3)	68–104	85 (6)	1458	5
Gonatus pyros	3	1	3.9–4.3	4.1 (0.2)	124–141	131 (9)	168	1
Gonatopsis borealis (southern form, juveniles) [b]	11	5	1.1–4.1	2.2 (0.8)	51–159	92 (30)	473	2
Gonatopsis borealis (southern form) [b]	25	12	6.1–9.1	8.0 (0.6)	231–339	301 (23)	21,575	73
Family: Histioteuthidae								
Histioteuthis heteropsis	1	<1	3.1		66		76	<1
Family: Octopoteuthidae								
Octopoteuthis deletron	12	6	5.3–8.2	6.5 (1.1)	91–142	111 (19)	1091	4
Order: Vampyromorphida								
Family: Vampyroteuthidae								
Vampyroteuthis infernalis [c]	6	3	6.5–8[a]	7.4 (0.6)[a]	53–66	61 (6)	387	1
Fish								
Albatrossia pectoralis (Giant Grenadier, Fam. Macrouridae) [d]	5	2			54–59[b]	58 (2)[b]	2492	8
Crustacea								
cf. Pasiphaea spp. (bathypelagic shrimp, Fam. Pasiphaeidae)	1	<1						
Total Prey Items	206	100					29,415	100

[a] *Taonius borealis* DML and mass estimated using regression equations courtesy of National Oceanic and Atmospheric Administration, National Marine Mammal Laboratory, Food Habits Lab (unpublished)
[b] *Gonatopsis borealis* (southern form) dorsal mantle length (DML) and mass estimated using regression equations in Walker and others (2002)
[c] *Vampyroteuthis infernalis* upper hood length in mm.
[d] *Albatrossia pectoralis* estimated total length (TL) in cm from Burton (1999), mass (g) estimated from Clausen (2008)

Santos and others (2007) also noted the presence of bathypelagic pasiphaeid shrimp remains.

As extreme divers, *Z. cavirostris* off southern California engage in shallow and deep dives ($\bar{x}$ = 1401 m, s = 138 m) with diel depth variability including increased time near the surface with reduced frequency of shallow diving at night, but no difference in time spent at depth or maximum depth according to diurnal period (Schorr and others 2014). The majority of prey in the stomach contents analyzed in this study belonged to the family Gonatidae. Although abundant numerically (juveniles and adults together contributed 48% of the total prey number), *G. onyx* only contributed 6% to the overall reconstructed mass. *Gonatus onyx* is considered one of the more abundant cephalopods off California (Roper and Young 1975), and from extensive observations using submersible remotely operated vehicles (ROV), *G. onyx* undergoes diel vertical migration with discrete ontogenic modal depths occupied by schooling juveniles (400 m during day) and solitary adults (800 m during day; Hunt and Seibel 2000). Presence of intermediate-qsized *G. onyx* (mean DML = 54 mm) in the stomach of our specimen at the time of stranding (15 January 1998) is consistent with the timing of capture for this size class (DML approximately 40 to 50 mm, juveniles) in Monterey Bay (December and March) following juvenile schooling in May–August (Hunt and Seibel 2000). *Gonatus californiensis*, which occurs in the California Current System from northern Baja California to Oregon (Clarke 1986), is a newly reported prey species for *Z. cavirostris* that also has been identified in the stomachs of Swordfish (*Xiphias gladius*) caught off western Baja California, Mexico (Markaida and Hochberg 2005). In Monterey Bay, solitary *O. deletron* occurred between 344 and 1841 m (93% between 344 and 787 m) with no evidence of diel vertical migration (Bush and others 2009). *Vampyroteuthis infernalis* was captured by trawl surveys off Oregon infrequently and only at depths >500 m (Pearcy 1965) and observed via submersible ROV in Monterey Bay, CA between 600 and 900 m (Robison and others 2003).

Nishiwaki and Oguro (1972) found that squids dominated the stomach contents of Z. *cavirostris* captured in water <1000 m off Japan, whereas unidentified fish remains predominated in animals taken in deeper waters. *Albatrossia pectoralis*, an abundant macrourid fish distributed from southern California to the Bering Sea and Japan (Novikov 1970), is a new prey species for *Z. cavirostris*, but has been reported in the diet of Baird's Beaked Whale (*Berardius bairdii*) at similar latitude in the western Pacific off Honshu, Japan and in the boreal southern Sea of Okhotsk (Walker and others 2002). Novikov (1970) reported greater abundance of *A. pectoralis* associated with the continental slopes of the Bering Sea and North Pacific, where the species maintains sex-specific distributions and undergoes seasonal movements to occupy slightly shallower depths during spring (400 to 700 m) compared with winter, when animals concentrate in the deepest regions of the slope (Novikov 1970). *Albatrossia pectoralis* juveniles descend to demersal habitats after reaching a total length of 50 to 60 cm, similar to the estimated size of *A. pectoralis* found in our sample. *Albatrossia pectoralis* in the central Bering Sea had different depth associations according to sex and season. They occur from 200 to 2000 m depth, with greatest concentrations between 400 and 800 m (Novikov 1970). Foraging *A. pectoralis* may co-occur with mesopelagic squids as squids approach the bottom during their diurnal vertical migrations. Novikov (1970) reported the frequent occurrence of squids in *A. pectoralis* stomachs. Off California in the eastern North Pacific, *A. pectoralis* (size range: PAFL = 14 to 18 cm [TL = 53 to 59 cm]) were found to primarily consume midwater fishes and squids including considerable proportions of similar cephalopod prey as *Z. cavirostris* described here, including Cranchiidae, Gonatidae, *Histioteuthis* spp., *Octopoteuthis* spp., *V. infernalis*, and sergestid and pasiphaeid shrimps (Drazen and others 2001). Whereas large gonatid squids dominated *A. pectoralis* diet in deep catches (900 to 1260 m), juveniles were gravimetrically more important in shallower catches (605 to 900 m; Drazen and others 2001 [sizes and life stages not well described]). It is possible that some of the beaks from squids recovered in our sample represent remains from secondary prey originally consumed by *A. pectoralis*, which is known to take both juvenile squids and larger adults (Drazen and others 2001).

Overall, the high diversity of squid prey found in this sample and reported by other authors suggests that *Z. cavirostris* is an opportunistic, generalist predator that consumes both schooling

and solitary cephalopods. The benthopelagic nature of *A. pectoralis* and some squids, coupled with reports of coal-like material (Fertl and others 1997) and asphalt (Walker and Coe 1990) found in stomachs, provide evidence that other *Z. cavirostris* probably dove to the sea floor at least occasionally while foraging. The opportunity to acquire additional samples from *Z. cavirostris*, although rare, would help further our knowledge of the food habits and the ecology of the prey of this species.

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