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Stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on the central Pacific coast of Japan

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Abstract

We analyzed the stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on Suruga Bay, Pacific coast in the central Japan in September 1999. A total of 485 squid lower beaks were found in the stomach. Some pieces of crabs were also found, but no fish remains. Squids included six identified species; *Gonatus* spp. and *Taonius pavo* were the most important components. The prey species composition was similar to those in the limited published information from the colder waters in the northern North Pacific and northern North Atlantic, although the Kuroshio warm current meets the present stranding site. Most of the estimated dorsal mantle length of *G. onyx* and *T. pavo* ranged in 140–360 mm, which corresponds to the adult or sub-adult size of these species. The prey species and their size suggest that Cuvier's beaked whale dive to deeper than 300 m layer. Crabs in the stomach contents suggest foraging even to the bottom. Present and previous studies suggested that Cuvier's beaked whales off Japanese waters dive to 300–1000 m to forage.

Key words: Cuvier's beaked whale, foraging depth, *Gonatus onyx*, Pacific coast of central Japan, stomach contents, *Taonius pavo*, *Ziphius cavirostris*.

Introduction

Cuvier's beaked whale (*Ziphius cavirostris*) is a common ziphiid whale in the world's oceans, except in high polar waters (Heyning, 1989). Off Japan, Cuvier's beaked whales were once commonly hunted (Nishiwaki & Oguro, 1972), suggesting that this whale was abundant in the western North Pacific. Nevertheless the distribution, biology and ecology of this species are poorly known (Heyning, 1989).

The feeding habits of Cuvier's beaked whale have been investigated opportunistically, and the most common prey is squid, although there are a few actual stomach contents analyses (Heyning, 1989, Santos *et al*., 2001). In a general description, deep-sea fish and squid are the prey of Cuvier's beaked whales in the Pacific off Japan (Nishiwaki & Oguro, 1972), but there are almost no data on the prey species of Cuvier's beaked whales in the western North Pacific. Information of the diet with species level identification and prey size composition is very limited from around the world (e.g. Fiscus, 1997; Santos *et al*., 2001). The present study is the first report on the prey species and size composition in the western North Pacific.

Materials and Methods

A Cuvier's beaked whale was found dead on the Pacific coast of Yaizu, Shizuoka Prefecture, central Japan (34°50′N, 138°20′E) on the morning of 17 September 1999. Staff from the National Research Institute of Far Seas Fisheries, including the authors, arrived at the stranding site that afternoon, and examined the whale. The whale was a 5.3-m male which had 310 g (L) and 400 g (R) testes and erupted teeth having at least 13 growth layer groups. Its outer body looked fresh, but the inner tissues had begun to decompose. We necropsied the whale after measuring its external morphology to collect all the stomach contents, plus erupted teeth, testes, skin, and muscle samples.

In the laboratory, stomach contents were sorted, and squid lower beaks were identified to species by referring to the cephalopod beak collection of the National Science Museum in Tokyo, Clarke (1986) and Wolff (1984). Lower rostral length (LRL) was measured to the nearest 0.1 mm. The dorsal mantle length (DML) and body weight (BW) of the squid

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Table 1. Prey contributions in the stomach contents of a Cuvier's beaked whale.

Prey species		% number	% weight
Enoploteuthidae	*Enoploteuthis chuni*	0.41	NA
Onychoteuthidae	*Moroteuthis loennbergi*	0.21	0.35
Gonatidae	*Gonatus onyx*	79.59	80.83
	Gonatus sp.	2.27	6.55
	Gonatus sp. cf *berryi*	3.51	4.45
Ommastrephidae	Ommastrephidae sp.	0.21	0.22
Grimalditeuthidae	*Grimalditeuthis bonplandi*	0.21	NA
Canchiidae	*Megalocranchia* sp. cf *maxima*	0.21	0.37
	Galiteuthis phyllura	0.62	0.62
	Taonius pavo	6.80	5.16
Unknown Family	*Chiroteuthis*/*Mastigoteuthis*	5.57	1.44
Octopoda	Octopus sp.	0.41	NA
	Absolute no. in total	485 prey	49054 g

Table 2. Estimated dorsal mantle length of prey squids.

Prey species	Average DML (mm)	SD	Minimum DML (mm)	Maximum DML (mm)	n
Moroteuthis loennbergi	72	—	—	—	1
Gonatus onyx	165	17	113	225	386
Gonatus sp. cf *berryi*	180	17	141	205	17
Gonatus sp.	242	18	203	265	11
Ommastrephidae sp.	163	—	—	—	1
Megalocranchia sp. cf *maxima*	406	—	—	—	1
Galiteuthis phyllura	226	30	202	259	3
Taonius pavo	294	53	203	427	33
Chiroteuthis/*Mastigoteuthis*	100	9	85	129	27
All species pooled	173	46	72	427	480

were estimated from the regression on LRL from Clarke (1980) and Clarke (1986).

Results

The stomach contents included 485 squid lower beaks, 605 upper beaks, some pieces of crabs, Nematod parasites, pebbles, and a stone approximately 10 cm in diameter, but no fish remains. Most of the contents were found in the last pyloric chamber, and no contents were collected from the fundic chamber. All the prey items had been digested and only hard parts remained.

We found 12 cephalopod taxa, including six identified species (Table 1). These belonged to eight families and 10 genera. The most abundant squid was *Gonatus onyx*; about 80% by number. The second most abundant was *Taonius pavo*, a cranchiid squid (about 7%), followed by a *Chiroteuthis*/*Mastigoteuthis* type. This type could not be identified to a species, because the beak was very similar to *Chiroteuthis calyx* in morphology, but was very small resembling *Mastigoteuthis glaukopis*. It is unlikely that this type was a juvenile *C. calyx*, because the heavy pigmentation of the beak suggested that this squid was an adult (Clarke, 1986). This type accounted for about 6% of the prey by number. The total reconstituted weight of the squids was about 49 kg. The weight of *Gonatus onyx* was about 40 kg or about 81% of the total. *Gonatus* spp. and *T. pavo* amounted to several kilograms, while the other squid did not exceed 1 kg. Crabs were probably some species of Leucosiid, but their contribution to the diet was unclear.

The estimated DML of the squids ranged from 72 to 427 mm, and the average of all species was 173 mm (Table 2). The largest species was *T. pavo*,

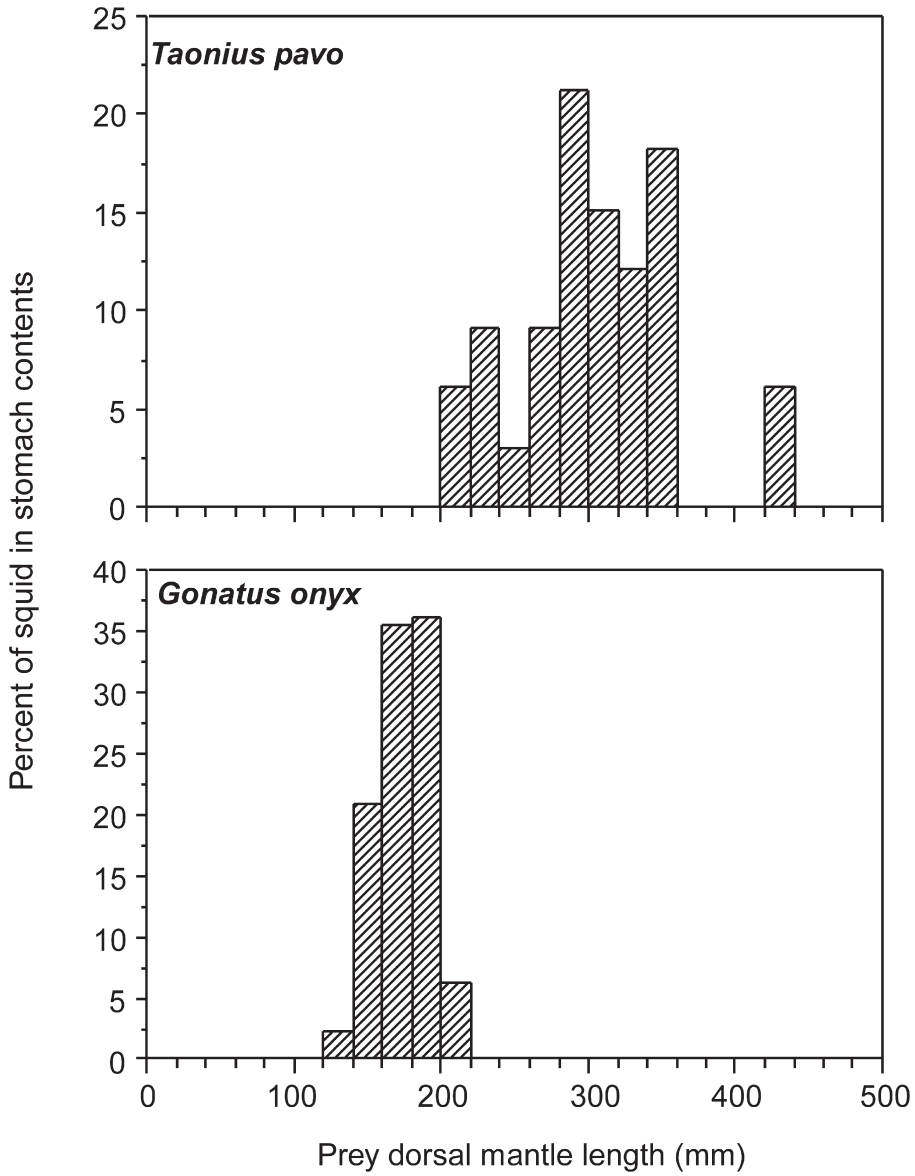

Figure 1. Frequency distributions of the squid in Cuvier's beaked whale stomach contents by dorsal mantle length of *Taonius pavo* and *Gonatus onyx*.

which averaged 293 mm (Fig. 1). The most important prey, *G. onyx*, was smaller, and ranged from 113 to 224 mm, averaging 165 mm (Fig. 1).

Discussion

Squid species found in the present study were comparable to those found in the stomach contents of Cuvier's beaked whales in the cold waters in the North Pacific (Fiscus, 1997) and North Atlantic (Santos *et al*., 2001) that include many *Gonatus* and Cranchiid squids. Fiscus (1997) examined cephalopod prey in the stomach contents collected from a Cuvier's beaked whale stranded on Amchitka Island, Alaska. The squid species were very similar to those that we found, although the stranding position was very different in terms of geography and oceanography. Our whale was stranded on

Suruga Bay, where the Kuroshio warm current meets the coast. However, *Gonatus* squids are typical cold-water species. This can be explained by subarctic mid-waters that originate from the Oyashio cold current. Suruga Bay is a very deep bay; the depth at the mouth exceeds 2000 m. Even several kilometres from the innermost coast, the depth is about 1000 m. The cold, heavy water of the Oyashio cold current submerges under the Kuroshio warm current and flows into Suruga Bay to form a mid-water layer at about 300 to 800 m. The temperature of this water is below 10°C year-round (Inaba, 1988). *Gonatus onyx* is also eaten by lancetfish (*Alepisaurus ferox*) in Suruga Bay (Okutani & Kubota, 1976). The DML of *G. onyx* eaten by lancetfish was 52 mm at the largest, and 77% were 15–30 mm. Although Cuvier's beaked whale and lancetfish feed on prey of different sizes, *G. onyx* could be a common prey for higher-trophic-level predators in Suruga Bay.

In the northern North Atlantic, the most frequent DML of prey *Gonatus* sp. and *Taonius pavo* are about 225–265 mm and 325 mm, respectively (Santos *et al*., 2001). Present estimations of DML were slightly smaller than these previous data. Probably this difference derives from the difference of body size between the species in the northern North Atlantic, *G. fabricii* that can be about 300 mm, and northern North Pacific, *G. onyx* that can be about 180 mm (Nesis, 1987). While, *T. pavo* can be 400 mm (Nesis, 1987). Data of prey size suggest that Cuvier's beaked whales feed on adult or sub-adult stage of *Gonatus* and *Taonius* squids. Most of the squid beaks found in our specimen had well-pigmented wings, which also suggests that most of the prey were adult squid (Clarke, 1986). Generally mesopelagic squids descend to deeper layers ontogenetically (Roper & Young, 1975); therefore, the whale might dive below 300 m, which is the probable upper most limit of the vertical distribution of *G. onyx* in Suruga Bay. The presence of some crabs and a stone suggest that this whale even dived to the bottom, although the depth is unclear. Heyning (1989) summarized the prey items of Cuvier's beaked whale, and concluded that it is an offshore, deep-diving species, although actual foraging depth is not shown. Nishiwaki & Oguro (1972) noted the variation of prey with water depth and reported that a transition from squid to 'deep-sea fish' occurs at a depth of roughly 1000 m in the western North Pacific off Honshu, Japan. Nishiwaki & Oguro (1971) also found 'deep-sea fish' as a main food of Baird's beaked whale (*Berardius bairdii*) in the same area. After 1980's Walker *et al*. (2002) and Ohizumi *et al*. (in press) found many hakes (*Laemonema* sp.) and rat-tails (*Coryphaenoides* spp.) in the stomach contents of Baird's beaked whales in the western North Pacific off Honshu. Therefore, 'deep-sea fish' probably means such demersal fishes and Nishiwaki & Oguro (1972) suggested that Cuvier's beaked whales dive to the bottom of 1000 m. Combined with our results, this suggests that Cuvier's beaked whale dives to 300–1000 m to forage off Japanese waters.

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