STOMACH CONTENTS OF SEVEN SHORT-TAILED ALBATROSS *PHOEBASTRIA ALBATRUS* IN THE EASTERN NORTH PACIFIC AND BERING SEA

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Information about the relationship between any marine bird and its food web is critical to assessing or monitoring population status. Changes in the food web structure over time can be a major determining factor in population growth. In addition, a species' position in the food web is largely determined by whether it is a predator or scavenger. While the foraging habitat use and movements of the endangered Short-tailed Albatross *Phoebastria albatrus* has been well documented, there is a lack of definitive information on its diet (Suryan *et al*. 2006, Piatt *et al*. 2006). To date, all prey accounts for this species have been confined to personal communications of cursory field observations of regurgitations by adult birds returning to nesting sites during the breeding season (Austin 1949, Hasegawa & DeGange 1982). It is extremely difficult to identify food remains, particularly cephalopods, at a species level reliably, based solely on field observations of regurgitated specimens unless made under controlled conditions. As a result, these kinds of accounts, while useful, are only reliable in terms of general categories, e.g. cephalopods, fish and crustaceans.

During the period 1995–2014, seven albatrosses and their stomach samples were collected and made available for detailed analysis. Six were obtained as bycatch, acquired by the National Marine Fisheries Service (NMFS) North Pacific Observer Program, which monitors Pacific cod *Gadus macrocephalus* and Sablefish *Anoplopona fimbria* long-line fisheries operating in the eastern Bering Sea shelf region and the Aleutian islands. The federal biological opinions for the endangered Short-tailed Albatross have required NMFS to retain birds that were incidentally taken in the groundfish fisheries (USFWS 2003). The other albatross was a fresh-dead beach-cast specimen found on the central California coast (Table 1). All samples were obtained during the non-breeding season (August–October). All seven birds had been leg-banded as chicks by Japanese researchers on the Torishima Island colony. Based on age, only one of the birds (7.5 years) was reproductively mature. The remaining six were immature to subadult, ranging in age from 0.3 to 5.5 years.

Food remains from four of the six Bering Sea samples were collected during the processing of intact frozen carcasses by Oikonos Ecosystem Knowledge, Santa Cruz, CA (http://oikonos.org). The remaining two fisheries specimens were processed at the University of Washington, Burke Museum. Food remains from the beach-cast bird were collected during specimen preparation at the Santa Barbara Museum of Natural History. Cephalopod beaks were preserved in 60% ethyl alcohol. Fish bones, teeth and otoliths

TABLE 1
Summary of background information on Short-tailed Albatross from which stomach contents were examined

Accession No.	Collection Date	Sex	Age,[e] years	Area	Location		Source	Fishery target	Legband number[f]
					Latitude	Longitude			
UWBM 55909[a]	28 Aug 1995	M	1.4	Aleutian Islands	53°31′N	165°38′W	Bycatch	Sablefish	13A0853
UWBM 56978[a]	27 Sept 1996	M	5.5	Bering Sea	58°37′N	177°04′W	Bycatch	Pacific Cod	13A0518
SBMNH 8593[b]	5 Aug 2006	M	0.3	Morro Strand, CA	35°22.5′N	120°51.5′W	Beach-cast	N/A	13B5298
UAM20,000[c]	28 Aug 2010	F	7.5	Bering Sea	56°51′N	173°21′W	Bycatch	Pacific Cod	13B2376
OR.029947[d]	14 Sept 2010	M	3.4	Bering Sea	59°20′N	176°33′W	Bycatch	Pacific Cod	13B9510
OR.029948[d]	25 Oct 2011	M	2.0	Bering Sea	56°42′N	172°37′W	Bycatch	Pacific Cod	13C2597
SBMNH 10652[b]	7 Sept 2014	F	5.4	Bering Sea	58°48′N	177°44′W	Bycatch	Pacific Cod	13C2173

[a] University of Washington Burke Museum.
[b] Santa Barbara Museum of Natural History.
[c] University of Alaska Museum, Fairbanks, Alaska.
[d] Museum of New Zealand Te Papa Tongarewa.
[e] Age determined as time between banding as a chick or fledgling to the collection day.
[f] Banding records are maintained by the Yamashina Institute for Ornithology, Japan.

were stored dry. Squid beak identification was conducted using the reference collection housed at the food habits laboratory, Alaska Fisheries Science Center, National Marine Mammal Laboratory (NMML), Seattle, WA. For future reference, representative voucher beaks of each identified cephalopod taxon in this study have also been incorporated into the NMML reference collection (catalog numbers NMMLceph 2868–2873).

This study focuses mainly on naturally occurring dietary composition (food species that would have been consumed in the absence of active commercial fisheries). Since fishery-related stomach contents (e.g. offal, bycatch discards and long-line bait) typically represent partial remains of an unknown number of individuals, food remains readily identifiable as long-line bait or vessel discards are not included in the species composition calculations. Food remains originating from commercial fisheries origin are, however, included in the frequency of occurrence calculations. Food remains were classified as fisheries offal or discards if they were from known commercial fisheries targets or common bycatch species and were of a body size that would make them otherwise unavailable to bird predation. Commercial long-line fishery bait was readily identifiable and typically took the form of precisely cut 40–50 mm tissue sections, sometimes accompanied

TABLE 2
Summary of diet species composition by number, occurrence and estimated dorsal mantle lengths (DML) for seven Short-tailed Albatross stomach samples from the eastern Bering Sea and North Pacific Ocean

	Species composition (n = 68)		Occurrence (n = 7)		Estimated DML (mm)	
Species	**No.**	**% by no.**	**No.**	**% frequency**	**Range**	**Mean**
FISHES			3	42.9		
Petramyzontidae						
Entosphenus tridentatus	1	1.5	1	14.3	–	–
Anoplopomatidae						
Anoplopoma fimbria (offal)	–	–	1	14.3	–	–
Gadidae						
Gadus chalcogramma (offal)	–	–	2	28.6	–	–
Scomberesocidae						
Cololabis saira (bait)	–	–	2	28.6	–	–
CEPHALOPODA		98.5	7	100.0		
Ommastrephidae						
Illex argentinus (bait)	–	–	3	42.9	–	–
Octopoteuthidae						
Octopoteuthis deletron	5	7.4	1	14.3	147–185	173
Gonatidae	24	35.3	6	85.7		
Eogonatus tinro	2	2.9	2	28.6	130–152	142
Gonatus middendorffi	2	2.9	2	28.6	216–372	294
Gonatus onyx	11	16.2	5	71.4	86–98	92
Gonatus pyros	5	7.4	2	28.6	75–83	77
Gonatus sp. Z[a]	1	1.5	1	14.3	149	–
Gonatus sp.	3	4.4	3	42.9	–	–
Histioteuthidae						
Histioteuthis heteropsis	1	1.5	1	14.3	–	–
Chiroteuthidae						
Chiroteuthis calyx	1	1.5	1	14.3	118	–
Mastigoteuthidae						
Mastigoteuthis pyrodes	1	1.5	1	14.3	103	–
Cranchiidae	35	51.5	7	100.0		
Taonius borealis	34	50.0	7	100.0	248–334	297
Unidentified cranchiid beak	1	1.5	1	14.3	–	–

[a] Undescribed species of *Gonatus.*

by isolated fish bones and squid beaks. Bait remains encountered in the stomachs consisted of two species, Argentine shortfin squid *Illex argentinus* and Pacific saury *Cololabis saira*. The beaks of *I. argentinus*, a species found only in the south Atlantic, are readily distinguishable from those of the neon flying squid *Ommastrephes bartrami*, the only ommastrephid squid known to occasionally occur in the Bering Sea (Roper *et al*. 1984). Bones and otoliths of Pacific saury are also readily distinguishable from other fish species in the region, and the occurrence of Pacific saury in the Bering Sea is questionable (Mecklenburg *et al*. 2000).

Counts of the minimum number of cephalopods represented are based on the larger number of upper or lower beaks of a given species. Specimen condition allowing, measurements of lower beak rostral length were made to the nearest 0.1 mm using an optical micrometer or Vernier calipers. Estimates of cephalopod dorsal mantle length (DML) were made employing regressions of beak size to body size presented in Wolff (1984), Walker *et al*. (2002), Spear *et al*. (2007) and unpublished regressions on file at NMML. Following Clarke (1986), estimation of the life history stage (juvenile, subadult, adult, etc.) of the cephalopod species ingested was based on the approximate DML at which the wings of the lower beaks become fully pigmented. For most species in this study, the approximate DML at onset of maturity was determined through examination of wing pigmentation of a size-stratified series of beaks in the NMML cephalopod beak reference collection. If beaks of a given species were unavailable in the reference collection, we utilized beak photographs presented in Young *et al*. (2012).

Both fisheries-associated and naturally occurring food items were identified (Table 2). Fishery-related food remains occurred in four of the seven (57.1%) samples. No fishery-related food items were present in the stomach of the central California bird. Food items scavenged from commercial fisheries sources took two forms: (1) freshly ingested tissue and partial cranial bones from processor discards (offal) of local fisheries that target species such as Walleye Pollock *Gadus chalcogrammus* and Sablefish, and (2) freshly ingested cut-bait portions of Pacific Saury, and Argentine Shortfin Squid from the long-line fishery. Food remains (teeth) from the Pacific Lamprey *Lampetra tridentata* occurred in one of the Bering Sea specimens. The provenance of this species in the Short-tailed Albatross stomach is uncertain. This fish had to have been scavenged dead at the surface as either a commercial fishery bycatch discard or as the result of natural circumstances. The teeth of another agnathiform fish (i.e. hagfish *Eptatretus* sp.) was reported as a naturally occurring diet component in a pellet regurgitated by a Laysan Albatross *Phoebastria immutabilis* on Guadalupe Island, Mexico (Pitman *et al*. 2004). As result, we tentatively include Pacific Lamprey in the naturally occurring diet category.

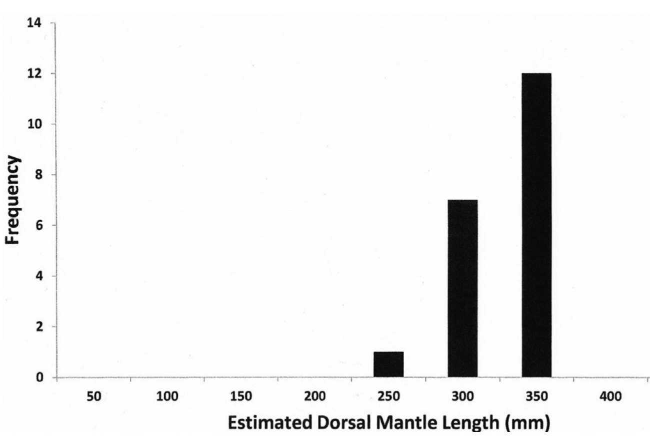

Fig. 1. Length frequency of estimated dorsal mantle lengths of *Taonius borealis,* based on 19 beaks from the stomachs of seven Short-tailed Albatross from the Bering Sea and North Pacific Ocean.

With the single exception of Pacific Lamprey, the dominant naturally occurring food component in the samples was squid (98.5%). Based on the identification of isolated squid beaks, the species composition of naturally occurring cephalopods consumed by Short-tailed Albatross was diverse (Table 2). Ten species representing six families were identified. Two families dominated the stomach contents. By number, five species of the family Gonatidae made up 35.3% of the contents and occurred in of 85.7% of the samples, with the species *Gonatus onyx* accounting for almost half the number of gonatids present. The family Cranchiidae, represented by a single species, *Taonius borealis*, dominated the dietary composition (50.0% by number) and occurred in 100% of the stomachs. The remaining four squid families, each represented by a single species, made up only 11.9% of the contents and were found only in the central California beach-cast sample. DML estimates reveal that most squid were subadult to adult, based on size. DML estimates of the predominant species, *Taonius borealis*, revealed that it was represented by adult-size squid ranging 248–334 mm DML and averaging 297 mm DML (Fig.1).

The adult stages of all of the naturally occurring cephalopod species represented in the stomach samples typically have a mesopelagic to meso-bathypelagic depth distribution (Roper & Young 1975, Nesis 1987) and must have been scavenged by Short-tailed Albatrosses at the surface. A scavenging strategy is particularly evident when one considers the depth distribution of *T. borealis*. In the Bering Sea region, it is meso-bathypelagic and does not undergo vertical migration (Nesis & Nikitina 1995). Mid-water trawls in this region reveal *T. borealis* to be concentrated at depths between 500 and 1 000 m, and it is not normally known to occur above 200 m (Radchenko 1992, Sobolevsky 1996). All of the cephalopod species represented in the Short-tailed Albatross stomach samples regulate their position in the water column through biochemical changes in tissue density or density of mantle cavity fluid (primarily ammonical compounds) relative to the surrounding seawater (Clarke *et al*. 1979). As a result, they can become positively buoyant and be subject to scavenging at the sea surface after injury or death. Cephalopods may die post-spawning, may be injured or disturbed by sub-surface predators, or may die after becoming overwhelmed and trapped in areas of strong upwelling.

Although our Short-tailed Albatross sample is comparatively small, there are marked similarities with a detailed study of the diet of Laysan Albatross *P. immutabilus*, a species with which Short-tailed Albatross shares considerable foraging area (Suryan *et al*. 2007, Fischer *et al*. 2009, Kuletz *et al*. 2014). In addition, Pitman *et al*. (2004) conducted a study based on identification of cephalopod beaks in 27 pellets acquired from Laysan Albatross chicks collected from nests at Guadalupe Island, Mexico. Although there were some regional differences in cephalopod species ingested, probably introduced by some foraging in the California Current System, all the cephalopod species found in the Short-tailed Albatross stomach samples were also represented in the Laysan Albatross samples. The squid families Cranchiidae and Gonatidae also played a major role in the diet. By number, cranchiid squid ranked first (32.0%) with gonatid squid second (19.8%) in the Laysan Albatross sample. Based on estimated squid DML frequency distributions, Pitman *et al.* (2004) also reported that most of the squid ingested were clustered around adult size classes. They suggested that diurnal surface scavenging on dead mesopelagic squid was probably the primary feeding strategy of Laysan Albatrosses. The results of our Short-tailed Albatross study, coupled with the findings of this prior study conducted on Laysan Albatrosses, leads us to conclude that the Short-tailed Albatross probably also employs surface scavenging as a primary foraging strategy in the eastern Bering Sea and California Current System.

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