STOMACH CONTENTS AND FECES AS INDICATORS OF HARBOR SEAL, *PHOCA VITULINA*, FOODS IN THE GULF OF ALASKA

Traditional methods of investigating pinniped feeding habits have involved examination of stomach contents from collected animals (Imler and Sarber 1947; Spalding 1964; Fiscus and Baines 1966). Recently, several scientists (Ainely et al.[1]; Calambokidis et al.[2]) have used scats collected from haulouts to study prey utilization of the California sea lion, *Zalophus californianus*, and the harbor seal, *Phoca vitulina*. This technique may be valuable in situations where killing animals is not feasible or desirable. No comparative information has been available for relating the results of scat analysis to stomach content analysis. Between 1975 and 1978 I identified food remains in stomachs and in feces from 351 harbor seals collected along the Gulf of Alaska coast from Yakutat Bay to Kodiak Island and was able to compare the data resulting from both sources. The sample of seals included both sexes and spanned all age-classes. Seals were collected during all months except December and January.

Methods

Seals were collected by shooting. Stomach contents were removed in the field, wrapped in muslin and preserved in a 10% Formalin[3] solution. Fecal material from large intestines was washed through nested sieves (2.00 and 0.84 mm²) and identifiable materials were recovered and preserved in 70% ethanol. Identifications of prey from both stomach contents and feces were based primarily on fish otoliths, cephalopod (squid and octopus) beaks and shrimp exoskeletons; occasionally vertebrae, preopercular bones, and intact specimens found in stomachs also were used. All otolith identifications were verified by John E. Fitch, California Department of Fish and Game, Long Beach.

Findings were compared by percentage of occurrences (number of stomachs or large intestines in which a prey species was found) in the stomach and fecal samples.

Results and Discussion

Spearman rank correlation analysis showed a significant positive correlation ($r_s = 0.79, P<0.01$) between the rankings of prey occurrences from stomach contents and feces (Table 1). The greatest discrepancy in rankings was for cephalopods which were ranked second in the analysis of stomach contents and ninth in the fecal analysis.

Occurrences of individual prey categories from stomach contents and feces showed good agreement when analyzed with contingency tables (Table 1). Only one significant statistical difference ($P<0.01$) was found among 10 testable categories. Cephalopods occurred more frequently ($P<0.001$) in stomach contents than in feces. The χ^2 value for cephalopods was so high (34.76) that rejection of the null hypothesis seemed justified even in light of potential type I errors resulting from multiple tests.

Cephalopods were identified primarily by their chitinous beaks in both stomach contents and feces. Beaks that were recovered in fecal material, although sometimes fragmented, were easily recognized. Apparently most beaks were regurgitated rather than passed through the intestinal tract. Captive northern fur seals, *Callorhinus ursinus*, which had been fed squid were observed regurgitating beaks (Miller[4]). Miller observed that the beaks appeared to be "trapped" in the stomach and were regurgitated at about 2-d intervals. This is probably also true in harbor seals as I have occasionally seen "wads" of beaks packed into the pyloric ends of stomachs. This would tend to exaggerate utilization of cephalopods in stomach contents if the beaks persisted longer than remains of other prey. Therefore cephalopods are apparently substantially underrepresented in feces and probably somewhat overrepresented in stomach contents.

[1]Ainley, D. G., H. R. Huber, R. R. LeValley, and S. H. Morrel. 1978. Studies of marine mammals at the Farallon Islands, California, 1976-77. Final report for MMC contract MM6AC027. Available National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151 as PB-286 603, 48 p.

[2]Calambokidis, J., K. Bowman, S. Carter, J. Cubbage, P. Dawson, T. Fleischner, J. Schuett-Hames, J. Skidmore, and B. Taylor. 1978. Chlorinated hydrocarbon concentrations and the ecology and behavior of harbor seals in Washington State waters. The Evergreen State Coll., Processed Rep., 121 p.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[4]Miller, L. K. 1978. Energetics of the northern fur seal in relation to climate and food resources of the Bering Sea. Final report for MMC contract MM5AC025. Available National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151 as PB-275 296, 32 p.

TABLE 1.—Comparative frequency of major prey identified in stomach contents and feces from 351 harbor seals collected in the Gulf of Alaska. Prey are ranked in descending order of occurrence. Comparisons of proportion of occurrence of prey found in stomach contents and feces were made by contingency table analysis when samples were adequate (minimum cell size ≥5).

	Stomach			Feces			
		Occurrences			Occurrences		
Prey	Rank	No.	%	Rank	No.	%	χ^2
Walleye pollock, *Theragra chalcogramma*	1	80	24.8	1	104	35.9	4.24
Cephalopods, squids and octopus	2	68	21.1	9	8	2.8	34.76*
Capelin, *Mallotus villosus*	3	33	10.2	2	33	11.4	0.00
Flatfishes, Pleuronectidae	4	21	6.5	4	21	7.2	0.00
Pacific herring, *Clupea harengus pallasi*	5.5	20	6.2	3	24	8.3	0.39
Pacific cod, *Gadus macrocephalus*	5.5	20	6.2	6	17	5.9	0.26
Pacific sand lance, *Ammodytes hexapterus*	7	15	4.7	5	7	2.4	3.00
Pacific sandfish, *Trichodon trichodon*	8	10	3.1	10	19	6.6	2.91
Shrimps	9	7	2.2	14	4	1.4	—
Sculpins, Cottidae	10	6	1.9	7	14	4.8	3.29
Eelpouts, *Lycodes* spp.	11	5	1.6	10	7	2.4	0.34
Salmon, *Oncorhynchus* spp.	13	4	1.2	15	0	0.0	—
Eulachon, *Thaleichthys pacificus*	13	4	1.2	13	5	1.7	—
Rockfishes, *Sebastes* spp.	13	4	1.2	10	7	2.4	—
Greenlings, *Hexagrammos* spp.	15	2	0.6	12	6	1.2	—
Others[1]		23	7.1		14	4.8	
Total occurrences		322			290		

*$P<0.01$.
[1]Others included unidentified prey and minor prey (those with <5 occurrences in both stomach contents and feces).

Salmon, *Oncorhynchus* spp., remains were identified in four stomachs while none were found in the fecal samples. I have examined nine harbor seal stomachs containing salmon remains and only one included a head with otoliths. It appeared that seals often fragmented large fish such as salmon while eating them, usually discarding the head. Thus, studies of feeding habits based on scat analyses (which require the presence of otoliths) probably underrepresent utilization of large fishes such as salmon. One occurrence of a cartilaginous fish was encountered (listed under others in Table 1). This was a skate, *Raja* sp., found in a stomach. It is unlikely that cartilaginous fishes would be detected in scats, as they have tiny, diffuse otoliths. (Lagler et al. 1962).

In summary, it appears that analysis of scats from harbor seals can provide accurate information on utilization of most kinds of prey. However, cephalopods, cartilaginous fishes, and large fishes such as salmon may be underrepresented. Cephalopod remains may be overrepresented in stomach contents.

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