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ASSESSING NORTHERN ELEPHANT SEAL FEEDING HABITS BY STOMACH LAVAGE

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ABSTRACT

Stomach lavaging was used to study the feeding habits of northern elephant seals (*Mirounga angustirostris*) found on San Miguel Island, California, during the spring of 1984. Fifty-nine elephant seals were chemically immobilized with an intramuscular injection of ketamine hydrochloride. Once immobilized, an animal's stomach was intubated, filled with 3–4 liters of water to create a slurry of the undigested food items, and evacuated into a collection device. The stomachs of 57 (96.6%) of the animals lavaged contained identifiable parts of prey. Twenty-nine different food items were identified, 12 of which have not been previously reported as prey of the northern elephant seal: two teleost fish, *Coryphaenoides acrolepis* (Pacific rattail) and another unidentified macrourid; two crustaceans, *Pasiphaea pacifica* (glass shrimp) and *Euphausia* sp.; six squid, *Abraliopsis felis*, *Gonatus berryi*, *Histioteuthis dofleini*. *Cranchia scabra*, *Taonius pavo*. and *Galiteuthis* sp. and two octopi, *Octopus dofleini* and *Octopus rubescens*.

The following prey species were found in at least 20% of stomachs lavaged: *Octopoteuthis deletron* (squid), *Merluccius productus* (Pacific whiting), *Gonatopsis borealis* (squid), *Pleuroncodes planipes* (pelagic red crab), *H. dofleini* and *H. heteropsis*. The diversity of habitats in which many of these prey are commonly found indicates that the northern elephant seals from San Miguel Island are capable of foraging in a variety of marine environments (epipelagic, mesopelagic, bathypelagic, neritic and benthic) and may only be limited by the depth to which they can dive.

Key words: Northern elephant seals, feeding habits, stomach lavage, ketamine immobilization.

Northern elephant seals have been the subject of numerous behavioral and population studies over the last three decades (*e.g.,* Bartholomew 1952, Le Boeuf 1974, Antonelis *et al.* 1981, Reiter *et al.* 1981, Cooper and Stewart 1983); yet relatively little is known about their feeding habits. Our knowledge of this species' diet has been principally based on the stomach contents of animals found dead or stranded along the coasts of California and Oregon (Huey 1930, Freiberg and Dumas 1954, Cowan and Guiguet 1956, Morejohn and Baltz 1970, Antonelis and Fiscus 1980, Jones 1981, Condit and Le Boeuf 1984, Huber *et al.* 1985, Hacker 1986). In many instances it is apparent that the health of these animals had been compromised prior to their death or discovery on shore. Consequently, current information on the feeding habits of northern elephant seals may not reflect the typical diet of healthy individuals capable of normal foraging behavior.

Several methods of obtaining dietary information from pinnipeds increase the probability of collecting data from healthy animals. Killing healthy animals to examine the contents of their stomachs is one method. This may not be desirable, however, if the individual animal of interest is part of a long-term behavioral study or if the species studied is threatened or endangered. Alternatively, nonlethal methods of collecting identifiable remains of prey species include the analyses of scats and spewings (Bailey and Ainley 1982, Brown and Mate 1983, North *et al.* 1983, Antonelis *et al.* 1984) and stomach lavaging (Hall 1977). Direct observation is also a technique which has been successful in unique circumstances where the animals forage in relatively shallow water and observations are made from land (*e.g.,* Jameson and Kenyon 1977, Bowlby 1981). Thus, a variety of methods are available for examining the feeding habits of healthy pinnipeds.

Here we detail a stomach lavaging technique used to assess the diet of northern elephant seals, and present the information on prey species obtained during our study. The undigested parts of food items (principally crustacean parts, cephalopod beaks and fish otoliths) recovered from the stomachs were used to identify the prey of the northern elephant seal. Possible differences between the diets of subadult males and adult females were examined, and comparisons were made between the use of stomach lavage and scat analysis for the assessment of dietary information. We also evaluated the use of ketamine hydrochloride for immobilizing northern elephant seals during the lavaging procedure.

Materials and Methods

This study was conducted on San Miguel Island, California, from 17 April through 3 May 1984. All of the animals lavaged were hauled out for spring molt on the sandy beaches at the west end of the island.

Assuming that elephant seals do not show obvious signs of molt until after they arrive on land, those showing the least amount of hair loss were presumed to be on land the least amount of time. Thus, we increased the probability of lavaging food parts from the stomachs of elephant seals by selecting those animals showing little or no sign of molt.

We captured each seal in a head bag (Stirling 1966) which measured 122 cm long, 70 cm in diameter at the opening and tapered to a diameter of 48 cm at the closed end. The bag was made of neoprene reinforced canvas with grommeted ventilation holes in the closed end. Ropes attached to four metal rings spaced equidistantly around the opening were used to hold the mouth of the bag open as it was placed over the animal's head and then pulled over the anterior portion of the animal's body.

After physically restraining each animal in the bag, we determined the sex and standard length in order to estimate the animal's weight using regression equations of length to weight. Standard length measurements ranged from 210–274 cm for females and from 203–300 cm for subadult males. Although we used the regression equations of the length to weight relationships reported for southern elephant seals (*Mirounga leonina*) by Ling and Bryden (1981), we assumed those weight estimates would be consistently more accurate than our subjective estimates. Weight estimates were used to calculate the dose of ketamine hydrochloride (hereafter referred to as ketamine) used for immobilization. All ketamine doses were injected intramuscularly in the pelvic area using a 20 cc syringe and a spinal needle (8.9 cm × 18 gauge). The capture bag was removed from the seal's head as soon as a decrease in muscle control was observed. If no evidence of immobilization was observed after 10 to 15 min the animal received an additional injection with half of the original dose of ketamine. A maximum of two additional half doses was used.

After immobilizing the seal a clear tube of flexible PVC (2.54 cm inside diameter, 0.48 cm wall thickness, 3 m length) was inserted into the stomach. Rounding the edges of the end of the tube and coating it with surgical lubricant facilitated passage of the tube into the stomach. To increase the chance of retrieving parts of prey species, a rectangular port (1.5 × 4.0 cm) was cut in the side of the tube about 1.5 cm from the end (Fig. 1). In most cases the lavage tube was passed through a 3.8 cm hole in a block of wood (60.0 cm × 3.8 cm × 7.6 cm) which was placed in the animal's mouth to prevent the seal from biting and collapsing the tube. Once in place, the lavage tube was connected to the discharge fitting of a manually operated suction pump and approximately 3 to 4 liters of sea water were pumped into the animals's stomach (Fig. 1a). The suction fitting of the pump was then connected to one of two hose fittings on an airtight 10 liter collecting bottle while the other fitting was attached to the lavage tube (Fig. 1b). A vacuum was created in the collecting bottle and the slurry of water and undigested food parts were suctioned from the stomach

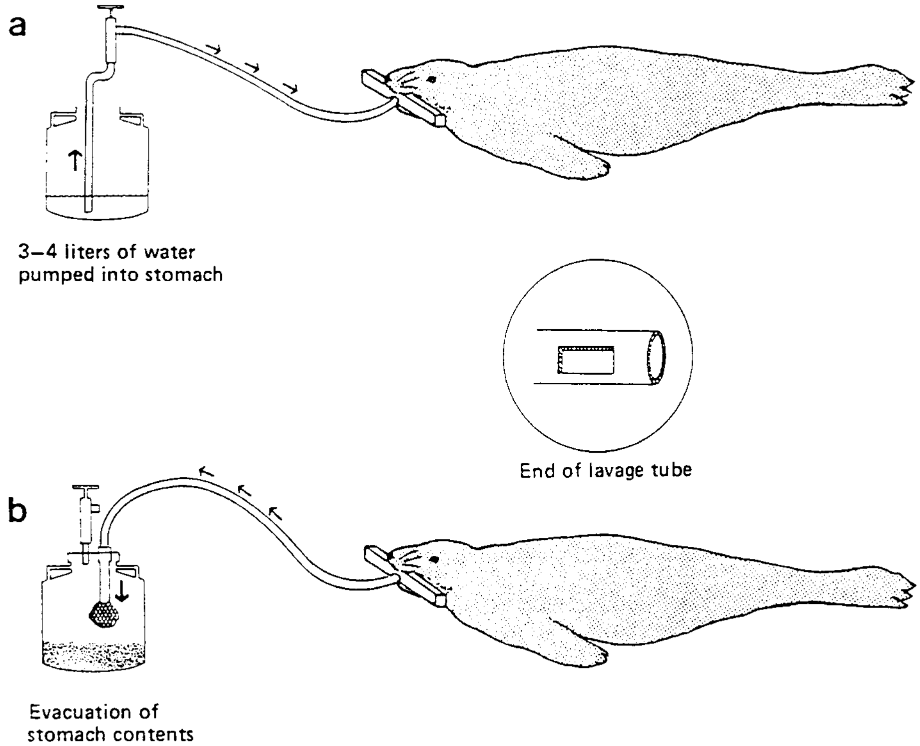

Figure 1. Illustration of the lavage apparatus used to (a) fill the seal's stomach with 3–4 liters of water and (b) evacuate the stomach contents.

into the bottle. An intermediate screen with a mesh size of approximately one mm was attached to the intake tube of the collecting bottle to separate the undigested food items from the liquid. The lavage tube was removed and rinsed with water immediately after the lavaging procedure. Any food items remaining inside the tube were rinsed into the sample. Finally, the remaining liquid in the collecting bottle was passed through a second screen (0.5 mm mesh) to insure that all identifiable parts of prey had been recovered.

To test the reliability of the lavaging procedure, we conducted a second stomach lavage on seven elephant seals immediately after the first lavage and then compared the frequency of occurrence of prey items in the two lavages. We also compared the success of obtaining feeding habit information from the lavaged seals with that from scat analysis. On 5 May 1985, 29 northern elephant seal scats were collected on the west end of San Miguel Island, California.

Two of the authors (G. Antonelis and M. Lowry) determined the prey species of teleost fish lavaged from the stomachs of the northern elephant seals by identification of sagital otoliths. Cephalopod beaks recovered from the stomach of the northern elephant seals were identified by another of the authors (C. Fiscus), and F. Hochberg (Santa Barbara Museum of Natural History, Santa Barbara, CA) identified the crustaceans and the tunicates.

Table 1. Occurrence of apnea in northern elephant seals immobilized with ketamine according to the dose rate (mg/kg) and sex and size range of the animals studied.

Sex of animal and dose rate of ketamine (mg/kg)	Single injection (n = 45)				Multiple injections (n = 14)[a]			
	Without apnea		With apnea		Without apnea		With apnea	
	No.	Percent of total	No.	Percent of total	No.	Percent of total	No.	Percent of total
Females[b] and males[c]								
2.01–2.50 (n = 2)	—	—	—	—	2	100	—	—
2.51–3.00 (n = 9)	6	67	2	22	1	11	—	—
3.01–3.50 (n = 19)	10	53	2	11	5	26	2	10
3.51–4.00 (n = 11)	5	45	5	45	1	10	—	—
4.01–4.50	—	—	—	—	—	—	—	—
4.51–5.0 (n = 2)	2	100	—	—	—	—	—	—
Males[d]								
2.01–2.50 (n = 10)	4	40	3	30	3	30	—	—
2.51–3.00 (n = 5)	5	100	—	—	—	—	—	—
3.01–3.50 (n = 1)	1	100	—	—	—	—	—	—

[a] Animals receiving a second or third injection of half the original dose rate if no evidence of immobilization was achieved after 10–15 min.
[b] 210–283 cm standard length (std. ln.).
[c] 203–249 cm std. ln.
[d] 250–300 cm std. ln.

The age composition of the Pacific whiting (*Merluccius productus*) consumed by the elephant seals examined in this study was determined from the sizes of otoliths recovered from stomachs. Because of the rapid growth of *M. productus,* otolith differences in year classes are conspicuous and easily recognized during the first 3 yr of life (*see* fig. 12, Dark 1975). After 3 yr the growth rate slows, making detection of year classes much more difficult. Due to the amount of digestive damage to these otoliths their ages could only be estimated by visually comparing them to voucher otoliths from known age fish and classifying them into age categories according to their relative size and shape. We categorized *M. productus* into five age class categories: <1, 1, 2, 3 and 4–6 yr of age.

Results

Immobilization with Ketamine

We immobilized 59 northern elephant seals with ketamine during this study. The responses of seals receiving various dose rates are shown in Table 1. Attempting to keep dosage levels to a minimum, we found that optimal dose rates for immobilization ranged from 2.51 to 3.50 mg/kg for males less than 250 cm in length and for all females (210 cm to 283 cm in length). The optimum dose for males greater than 250 cm was between 2.51 and 3.00

mg/kg. Forty-five seals were immobilized after the first injection, while 12 seals required a second injection and 2 required a third injection.

Apnea was observed in 23.7% of all seals injected. In those seals requiring additional doses apnea occurred only twice. Those seals exhibiting apnea remained immobile for an average of 81.6 min (n = 14, SD = 29.9 min), while those without apnea were immobile for an average of 12.1 min (n = 45, SD = 8.2 min). Muscle tremors were frequently observed during periods of apnea just prior to resumption of breathing.

One 4-yr-old male (length = 268 cm) died after being injected with a single 2.5 mg/kg dose of ketamine. Although a necropsy revealed no conspicuous abnormalities, a histological examination revealed some inflammatory cell infiltrates in the lung tissue.

Feeding Habits

The frequency of occurrence of the prey obtained from the stomachs of 59 northern elephant seals (25 subadult males and 34 adult females) by lavage are listed in Table 2. From this table it is apparent that cephalopods comprise the largest number of different prey species (n = 20) identified in this study. From this group *Octopoteuthis deletron* occurred most frequently (59.6%). Eight of the cephalopods that we identified (*Abraliopsis felis, Gonatus berryi, Histioteuthis dofleini, Cranchia scabra, Taonius pavo, Galiteuthis* sp., *Octopus dofleini, Octopus rubescens*) have not been previously reported as prey of the northern elephant seal. Forty-five (78.9%) stomachs contained either identifiable or unidentifiable parts of cephalopods.

Of the prey listed in Table 2 the crustacean *Pleuroncodes planipes* was the most frequently occurring (77.2%) prey species identified during this study. The two other crustaceans identified during this study (*Pasiphaea pacifica* and *Euphausia* sp.) have not been reported previously as prey of the northern elephant seal.

The identifiable parts from three groups of fishes (teleosts, elasmobranchs and cyclostomes) were obtained from lavaged stomachs (Table 2). *Merluccius productus, Sebastes* spp. and two macrourid species (*Caryphaenoides acrolopis* and an unidentified species) were identified from otoliths. Egg cases of two elasmobranchs (*Cephaloscyllium ventriosum* (Pacific rattail) and an unidentified species) and one cyclostome (*Polistotrema stouti*) were identified. The cyclostome, *Lampetra tridentata*, was identified on the basis of its characteristic mouth parts. The two macrourids have not been previously reported as part of the northern elephant seal's diet. Forty-five (75.7%) stomachs contained either identifiable or unidentifiable parts of fish.

Merluccius productus was the most frequently occurring prey species of fish (29.8%); 154 otoliths from this species were lavaged from the stomachs of the elephant seals in this study. Figure 2 illustrates the estimated age composition of all *M. productus* otoliths recovered from the stomachs of elephant seals in this study. Eighteen percent (n = 27) of the otoliths were classified as juveniles, less than 1 yr of age, and 19% (n = 29) of the sample consisted of 1-yr-

Table 2. Frequency of occurrence and habitat of prey lavaged from the stomachs of 59 northern elephant seals.

Prey species	Frequency of occurrence: Number of stomachs	Frequency of occurrence: Percent of stomachs	Marine environmental zone[b]
Cephalopods			
Octopoteuthis deletron[a]	34	59.6	Ba-M-E
Histioteuthis dofleini	18	31.6	Be-M-E
Histioteuthis heteropsis	16	28.1	Be-M-E
Gonatopsis borealis	13	22.8	M-E
Galiteuthis sp.[a]	11	19.3	M-E
Onychoteuthis borealijaponicus	10	17.5	E
Gonatus berryi[a]	10	17.5	M-E
Gonatus sp. (type 2)	10	17.5	M-E
Chiroteuthis calyx	7	12.2	M-E
Vampyroteuthis infernalis	5	8.8	Be-M
Chiroteuthidae	4	7.0	M-E
Taonius pavo[a]	4	7.0	Ba-M
Gonatus sp.	4	7.0	M-E
Ocythoe tuberculata	3	5.3	M-E
Abraliopsis felis[a]	2	3.5	M-E
Moroteuthis robusta	2	3.5	Be
Cranchiidae	2	3.5	E
Octopus rubescens[a]	2	3.5	Be
Cranchia scabra[a]	1	1.8	E
Octopus dofleini[a]	1	1.8	Be
Crustaceans			
Pleuroncodes planipes	44	77.2	E
Pasiphaea pacifica[a]	8	14.0	E
Euphausia sp.[a]	4	7.0	E
Teleosts			
Merluccius productus	17	29.8	N
Sebastes sp.	5	8.8	N-Be
Coryphaenoides acrolepis[a]	2	3.5	M
Macrourid (not *C. acrolepis*)[a]	1	1.8	M
Elasmobranchs			
Cephaloscyllium ventriosum (egg case)	4	7.0	Be
Elasmobranch (egg case)	1	1.8	Be
Cyclostomes			
Lampetra tridentata	4	7.0	A
Polistotrema stouti (egg case)	1	1.8	Be
Tunicate			
Pyrosoma atlanticum	10	17.5	M-E

[a] Not previously reported as prey of the northern elephant seal.
[b] E = epipelagic, M = mesopelagic, Ba = bathypelagic, Be = benthic, N = neritic, A = anadromous.

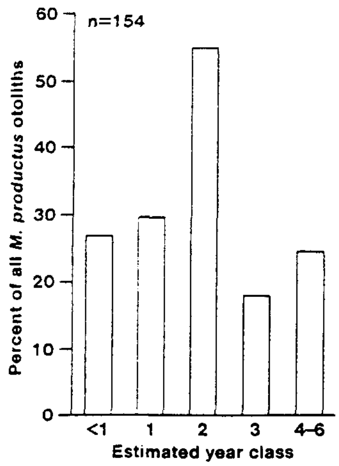

Figure 2. Estimated age of *Merluccius productus* (Pacific whiting) otoliths lavaged from the stomachs of northern elephant seals.

olds. The 2-year-old age class occurred most frequently (36%, n = 55), while 3-year-olds represented only 11% (n = 18) of the *M. productus* otoliths. The combined occurrence of the 4- to 6-year-olds was 16% (n = 25).

The tunicate *Pyrosoma atlanticum* was recovered from 18% (n = 10) of the elephant seal stomachs lavaged during this study.

Table 2 also lists the marine environmental zones where these various prey occur (Schmitt 1921, Thompson 1948, Cox 1963, Miller and Lea 1972, Roper and Young 1975, Butler 1980). Most prey (n = 24) occur in portions of the pelagic zone (epipelagic, mesopelagic, bathypelagic) while a few (n = 11) are found in the benthic or neritic zones. One prey item is anadromous.

For the seven seals that were lavaged twice, remains of 15 different prey were recovered during the first lavage, while evidence of only 7 prey was recovered from the second lavage. All of the prey species recovered from the second lavage were also present from the first lavage. Additionally, a necropsy of the subadult male (No. A66) that died during our study revealed that with the exception of two shark egg cases, which were too large to fit in the lavage tube, the same food items recovered from the lavage were also in the stomach.

Only 6 (21%) of the 29 scats collected contained identifiable parts from four prey species (*O. rubescens*, *Chiroteuthis calyx*, *Pleuroncodes planipes* and *M. productus*). In comparison, the recovery of identifiable prey species from the stomach lavaging technique (Table 2) was more productive, since it yielded dietary information from 57 out of 59 (97%) of the northern elephant seals examined. All of the prey found in the scats were also recovered from the stomachs of the lavaged seals.

The diets of 25 subadult male and 34 adult female northern elephant seals were compared according to the frequency occurrence of all prey identified in the six major prey categories: cephalopods, crustaceans, teleosts, elasmobranchs,

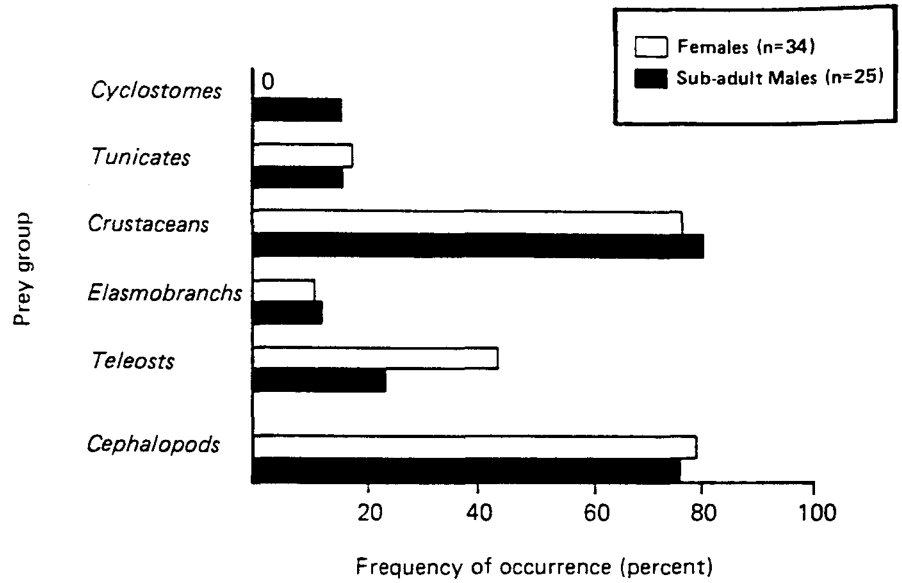

Figure 3. Frequency of occurrence of the six major prey categories lavaged from the stomachs of sub-adult male and female northern elephant seals.

cyclostomes and tunicates (Fig. 3). There was no significant difference between the two sexes (Chi-square test, $\alpha = .05$).

Discussion

The use of ketamine has been demonstrated to be a relatively safe drug for immobilizing northern elephant seals in both this study and in the study by Briggs *et al.* (1975). Slight muscle tremors have been reported as a common side effect of ketamine (Geraci 1973) and observed in both our study and in the study by Briggs *et al.* (1975). In our study, however, conspicuous muscle tremors were usually associated with apnea, a condition not reported by Briggs *et al.* (1975). Apnea occurred in 14 of 59 seals in our study. Increased lacrimation and salivation were also commonly observed in our study but were not reported by Briggs *et al.* (1975). Perhaps these differences are related to seasonal differences in the physiological condition of the seals during the late spring (this study) and late winter (Briggs *et al.* 1975). Differences may also be due to the use of the head bag for the capture of animals before they were injected with ketamine during our study. This method was not used by Briggs *et al.* (1975) as they did not restrain the animals before they were injected.

For future work with northern elephant seals, several other drugs may be used in conjunction with ketamine to reduce some of these undesirable side effects. Xylazine has been used in combination with ketamine to facilitate immobilization and inhibit muscle tremors, but its success at immobilizing animals without inhibiting respiration has been varied when used on Galapagos fur seals, *Arctocephalus galopagoensis*. Galapagos sea lions, *Zalophus californianus wollebaeki* (Trillmich and Wiesner 1979, Trillmich 1983) and gray seals, *Halichoerus grypus* (Parry *et al.* 1981, Baker and Gatesman 1985). Furthermore, Geraci *et al.* (1981) have used diazepam to reduce the side effects of ketamine on several species of phocid seals (gray seals, harbor seals, *Phoca vitulina*, harp seals, *Phoca groenlandicus* and ringed seals, *Phoca hispida*). Atropine can be used to reduce excessive lacrimation, salivation and mucus production (Geraci 1973, Baker and Gatesman 1985). This becomes especially important when attempting to minimize the accumulation of fluid in the lungs, a condition which could have been a complicating factor in the death of the animal in this study. Finally, doxapram hydrochloride has been used as a respiratory stimulant on gray seals (Parry *et al.* 1981) and should be considered during future work on northern elephant seals when apnea occurs.

Despite our attempts to standardize the dose rate of ketamine by estimating animal weight on the basis of standard length, and the use of syringe and needle to insure an accurate placement of the intramuscular injection, variation in animal response was observed. Similar dosages which had no effect on some animals were enough to completely immobilize or cause apnea in others. Possible explanations for this variability include: error in the estimation of animal weight, differences between sexes, variability in the degree of vascularization of a seal's muscle tissue around the site of injection or differences in the physiological condition of individual animals at the time of injection. Similar variation in animal response to comparable dosages of ketamine has also been observed in other field studies of phocids (Geraci 1973, Briggs *et al.* 1975, Engelhardt 1977). Fortunately, despite this variability in response, ketamine has a relatively wide margin of safety when used on phocids. Its use on some otariids, however, appears to inhibit breathing more frequently (Trillmich 1983, DeMaster and Antonelis unpublished observations) and may not be recommended if other alternative methods of immobilization are available.

It is apparent from this study that northern elephant seals that haul out at San Miguel Island, California, forage on a variety of prey species that range from squids, crustaceans and tunicates in several pelagic zones, to octopi, teleosts, elasmobranchs and cyclostomes occurring in the neritic and benthic areas of the sea. This indicates that northern elephant seals forage in a variety of marine environments and may be limited only by the depth to which they can dive. Our information from stomach lavage corroborates previous interpretations of this species' basic foraging habits which have been based primarily on the opportunistic examination of dead animals.

Of the 12 newly identified prey of the northern elephant seal 8 are cephalopods. *Octopoteuthis deletron* was the most frequently occurring cephalopod (59.6%) in our study and in that of Condit and Le Boeuf (1984). Other squid occurring in more than 10% of the stomachs examined in our study included: *Gonatus berryi*, *Gonatus* sp. (type 2), *Gonatopsis borealis*, *Histioteuthis dofleini*, *Histiotheuthis heteropsis*, *Chiroteuthis calyx* and *Galiteuthis* sp. These results may reflect the importance of squid in the diet, but interpretations should be made with caution since cephalopod beaks may resist digestion and result in an over-representation of squid and an under-representation of fish otoliths (*e.g.*, Miller 1978, Pitcher 1980). Further, if the frequency of occurrence of the identifiable and unidentifiable parts of cephalopods and fish are compared, the importance of the two groups appears to be much more similar with values of 78.9% and 75.4%, respectively.

The pelagic red crab (*Pleuroncodes planipes*) was also a frequently occurring prey of the northern elephant seals in this study. Although it has been reported as a prey of northern elephant seals in a recent report (Hacker 1986), its presence in 77.2% of the stomachs indicates it may be an important food item when available. Boyd (1967) found that pelagic red crab are normally found on the continental shelf of southern Baja California, Mexico, and are occasionally transported northward by the Davidson and California countercurrents into the waters off the California coast in January and February. During abnormal years, such as the 1983 El Niño Southern Oscillation (ENSO) event, these currents are intensified and persist for longer periods. This phenomenon results in the northward transport of large numbers of pelagic red crabs into northern latitudes. The occurrence of this prey in the diet of the northern elephant seal is apparently related to their availability at the San Miguel Island area during the 1983 ENSO. Given the high frequency of occurrence for this prey item, however, we would expect to identify the pelagic red crab as a common prey of the northern elephant seal at haul-out sites in Baja California.

Pacific whiting (*Merluccius productus*) was the most frequently occurring teleost prey of the northern elephant seal. California sea lions also prey on Pacific whiting in the waters near San Miguel Island (Antonelis *et al.* 1984). Apparently, both the elephant seal and the sea lion forage mostly on 1- and 2-year-old fish. This is consistent with out knowledge of the distribution of Pacific whiting: younger age classes are more abundant in the southern portion of their range especially during the spring when most of the older age classes move north of Point Conception (Bailey *et al.* 1982). When we compared the feeding habits of the subadult males and adult females, we were not surprised to find that the two groups do not differ significantly since individuals from both groups were presumably lavaged soon after they had returned to the island from feeding at sea during approximately the same time period. Both groups appear to exploit similar resources when foraging in the waters around San Miguel Island. Intraspecific differences are probably more likely to occur spatially and temporally as various age and sex classes migrate into different locations at sea (Condit and Le Boeuf 1984) or as seasonal changes in the availability of various prey items occur.

Results from the seven seals lavaged twice indicate that a relatively small proportion of identifiable prey items remain in the stomach after the first lavage and that a single lavage was sufficient to recover a representative sample of the prey items in the stomach. This is important when considering the prudence of subjecting an animal to a second lavage and to the effects of a possible additional injection of ketamine to maintain immobilization. Therefore, the well-being of the seal must be considered against the amount of added information that might be obtained when conducting multiple stomach lavages on a single animal. We believe that when the number of seals examined is large (*e.g.*, this study), a single stomach lavage per chemically immobilized seal is the preferred method of obtaining dietary information. However, when the number of seals examined is small or when the feeding habits of specific individuals are of interest, multiple stomach lavages may be necessary to maximize the amount of dietary information recovered from each individual.

Clearly additional information is needed to obtain a better understanding of this species' feeding habits which may change on a seasonal or annual basis. Possible differences between various age class and sex categories need to be examined for a better understanding of the species' foraging ecology. Feeding studies of captive animals are also necessary for a better understanding of prey digestion rates and the passage of hard parts of prey through the gastrointestinal tract, thus allowing us to more accurately interpret the results of stomach lavage studies on seals in the wild.

The stomach lavage technique described in this study does have some limitations. The size of the prey items recovered is limited to the inside diameter of the tube. This tends to bias the sample for small, digested prey and against large, undigested prey. There could also be a bias for prey with hard parts that tend to resist digestion and remain in the stomach for longer period of time. Furthermore, the possible occurrence of hard parts of secondary prey (*i.e.*, from the stomach of the prey) could bias the results of stomach content analysis (Perrin *et al.* 1973).

The results of this study have shown that a collection of scats from northern elephant seals for food habit information is not as productive as the stomach lavage. This observation is corroborated by numerous other unsuccessful attempts by one of the authors (Antonelis) and B. Stewart (personal communication, Hubbs Marine Research Center, San Diego, California) to describe the diet of the northern elephant seal through scat analysis. Clearly the most productive non-lethal method of collecting dietary information from healthy individuals of this species is through stomach lavage. We have also lavaged the stomachs of physically restrained northern fur seals, *Callorhinus ursinus* and California sea lions, *Zalophus californianus californianus*. with comparable success (unpublished observations). However, for these species scat analysis has proven to be a more productive method of determining the diet. Therefore, the preferred non-lethal method for obtaining feeding habit information may differ with each pinniped species. A distinct advantage in using the stomach lavage technique is the ability to select sample size, time, location, age and sex of the individual animals to be studied.

By modifying the stomach lavage techniques described by Hall (1977) and utilizing ketamine for chemical immobilization, we have obtained new information on the diet of the northern elephant seal. The diversity of its prey indicates that the northern elephant seal may be a true generalist in its foraging behavior, a factor which has probably enhanced its ability to recover from near extinction in the early 1900s.

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Assistance during the examination of several different cephalopod beaks from our collection by F. G. Hochberg resulted in the identification of *Gonatus berryi* and confirmation of the identity of several other species.

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