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Early Spring Feeding Habits of Bearded Seals (*Erignathus barbatus*) in the Central Bering Sea, 1981

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ABSTRACT. The diet of bearded seals, *Erignathus barbatus*, near St. Matthew Island, Bering Sea, was studied during the early spring of 1981. Eighty-six percent of the 78 seals' stomachs examined contained fish. Other prey taxon groups, in decreasing order of their percentages of occurrence, were crabs (73%), clams (55%), snails (47%), amphipods (32%), shrimp (18%), mysids (13%), marine worms (13%) and cephalopods (4%). The most frequently occurring prey species were capelin, *Mallotus villosus* (82%); codfishes, Gadidae (64%); narrow snow crab, *Chionoecetes opilio* (63%); eelpouts, *Lycodes* spp. (56%); longsnout prickleback, *Lumpenella longirostris* (49%); nutshell clams, *Nuculana* sp. (42%); and moon snails, *Polinices* sp. (27%). Seventy-seven percent of the seals examined had consumed prey from three or more different taxon groups. We identified seven food items not previously reported as prey of the bearded seal in the Bering Sea.

No differences were detected between the diets of males and females and between adults and juveniles, indicating no apparent segregation of foraging by sex or age.

Bearded seals in the St. Matthew Island region of the Bering Sea forage in a manner similar to their conspecifics in other areas where fish constitute a major portion of their diet. Prey selection is probably dependent on availability, and diet may be highly diversified even within a relatively small area during a short period of time. Variety in prey consumption exemplifies the ability of the bearded seal to forage in the seasonally changing habitat associated with the advance and retreat of the ice front.

Key words: bearded seal, *Erignathus barbatus*, diet, demersal and pelagic fish, benthic invertebrates, prey species diversity

RÉSUMÉ. On a étudié le régime alimentaire du phoque barbu, *Erignathus barbatus*, près de l'île Saint Matthew dans la mer de Béring, tôt au printemps de 1981. Quatre-vingt six p. cent des 78 estomacs de phoques examinés contenaient du poisson. Parmi les autres groupes de taxons servant de proies, on retrouvait, par pourcentages décroissants, les crabes (73 p. cent), les myes (55 p. cent), les gastéropodes (47 p. cent), les amphipodes (32 p. cent), les crevettes (18 p. cent), les mysis (13 p. cent), les vers marins (13 p. cent) et les céphalopodes (4 p. cent). Les espèces de proies les plus courantes étaient le capelan, *Mallotus villosus* (82 p. cent); la morue, gadidé (64 p. cent); le crabe des neiges, *Chionoecetes opilio* (63 p. cent); la lotte, sp. *Lycodes* (56 p. cent); *Lumpenella longirostris* (49 p. cent); sp. *Nuculana* (42 p. cent); et la natice, sp. *Polinices* (27 p. cent). Soixante-dix-sept p. cent des phoques étudiés avaient ingéré des proies venant d'au moins trois différents groupes de taxons. On a identifié sept produits alimentaires qui n'avaient pas encore été reportés comme constituant une proie pour le phoque barbu dans la mer de Béring.

On n'a détecté aucune différence entre les régimes alimentaires des mâles et ceux des femelles, ni entre ceux des adultes et ceux des petits, ce qui indique qu'il n'existe apparemment pas de ségrégation quant au sexe ou à l'âge lors du comportement visant la quête de nourriture.

Les phoques barbus de la région de l'île Saint Matthew dans la mer de Béring recherchent leur nourriture comme leurs congénères dans d'autres régions où le poisson constitue une grande partie de leur régime. La sélection des proies dépend probablement de leur disponibilité et le régime peut être hautement diversifié, même dans une zone relativement petite et durant une courte période. La variété qui se manifeste dans la consommation des proies montre bien la capacité du phoque barbu à rechercher sa nourriture dans un habitat qui varie selon les saisons et est associé à l'avancée et au retrait du front glaciaire.

Mots clés: phoque barbu, *Erignathus barbatus*, régime alimentaire, poissons démersaux et pélagiques, invertébrés benthiques, variété des espèces servant de proie

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INTRODUCTION

Bearded seals, *Erignathus barbatus*, occur most commonly on pack ice and seasonally migrate with the advance and retreat of the ice front (Burns and Frost, 1979). Their circumpolar range extends throughout the northern polar region and includes the Bering Sea, which is the largest single area of bearded seal habitat (Burns and Frost, 1979). Because of its extensive range, the bearded seal is considered the most widely distributed phocid seal in the Bering Sea region, with an estimated population of 300 000 (Burns, 1981).

Several studies on the foraging ecology of bearded seals in the Bering Sea described bearded seals as benthic feeders with a highly diversified diet (Kenyon, 1962; Burns and Frost, 1979; Lowry *et al.*, 1980). Lowry *et al.* (1980) reported that the bearded seals in the Bering Sea fed primarily on benthic invertebrates, specifically crabs, clams and shrimp, and that fish are of minor importance. Kosygin (1971) also found benthic invertebrates to be an important part of the bearded seal diet in the Bering Sea, but indicated that fish may also be important prey. In other areas, such as the Kara and Barents seas (Chapskii, 1938), the Sea of Okhotsk (Pikharev, 1941), the waters off the coast of Northwest Greenland (Vibe, 1950) and Grise Fiord, Pond Inlet and Clyde River in the Canadian High Arctic (Finley and Evans, 1983), various species of fish have been reported as frequent prey of bearded seals. Thus, regional differences in the feeding habits of bearded seals exist, although sufficient evidence is not available to accurately categorize their diet throughout their range.

In this study, scientists from the United States and Russia collaborated to investigate the foraging ecology of bearded seals in the Bering Sea under the auspices of the Agreement on the Cooperation in the Field of Environmental Protection of 1972 (Miller, 1984). This paper presents new information on the diet of bearded seals during early spring in the central

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Bering Sea, and comparisons are made between the diets of males and females and subadults/adults and juveniles. The size of prey consumed by bearded seals is estimated for some prey species.

METHODS

From 18 March through 18 April 1981, a joint U.S.-Russian marine mammal research expedition was conducted in the Bering Sea aboard the Russian vessel ZRS *Zvyagino*. During this cruise a total of 78 bearded seals were collected from 12 to 15 April along the southern margin of the pack ice in the vicinity of St. Matthew Island (Fig. 1). The depth of the water in the study area ranged from 64 to 92 m. Seals were shot with 7.62 mm rifles (~.30 caliber, U.S.) while hauled out on the pack ice and then brought aboard ship, where the stomach and intestines were removed and frozen 3-12 h post-mortem. All samples were thawed and analyzed within 2 months after collection.

The age of each seal was determined by counting ridges on the largest claw of a foreflipper (Burns, 1970). Wear of claws precluded exact aging of seals older than 8 years of age; these seals were classified as adults.

The contents of stomachs were used to identify the prey species of 74 bearded seals. Intestinal tract contents were used to determine the diet of four seals with empty stomachs. Stomach and intestinal contents were rinsed with water into a 20 L plastic bucket and poured through a series of nested sieves ranging in mesh size from 4.0 to 0.5 mm. The identifiable hard parts of prey were removed; all otoliths were either stored dry or in 70% isopropyl alcohol and the remaining parts were preserved in 10% formalin.

Hard parts from prey were identified with the aid of several publications on fish and other fauna of the Bering and Chukchi seas (MacIntosh, 1976; Kessler, 1985; Lang and Milward, 1987). Prey species were identified from sagittal otoliths for fish; exoskeletal parts for crabs, amphipods, shrimp and mysids; operculum for snails; shells for clams; beaks for cephalopods; and mouth parts or whole specimens for marine worms. The percent occurrence for each prey was calculated as the percentage of stomachs in which it occurred. The number of each fish species consumed was determined by dividing the total number of otoliths by two. Intact carapaces were used to determine the number of crabs, amphipods, shrimp, and mysids consumed. The number of cephalopods consumed was determined from the maximum count of either upper or lower beaks.

No volumetric measurements of specific prey species were determined because the contents of each stomach were digested beyond our ability to evaluate intact individual prey

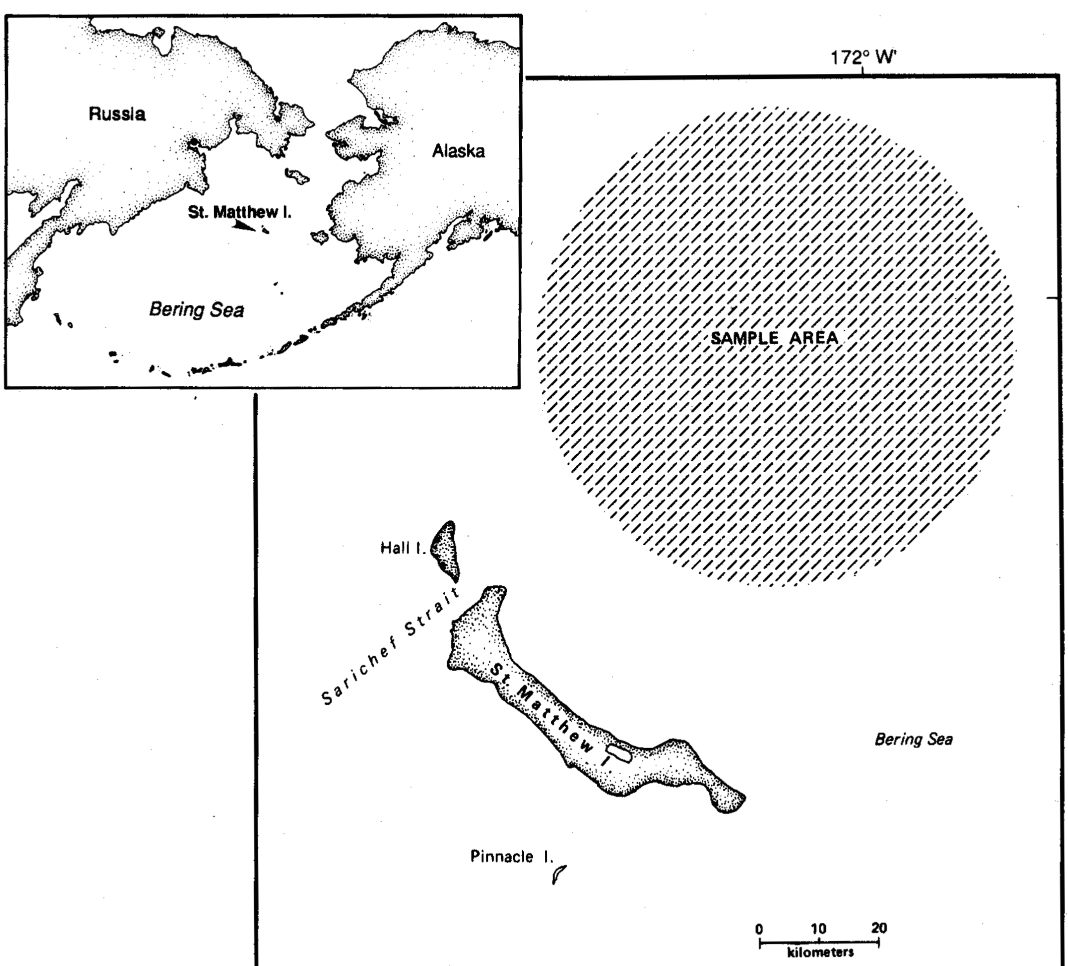

FIG. 1. Bearded seal study area near St. Matthew Island, Bering Sea.

items. In some instances, however, the remaining hard parts of prey species were used to estimate the size of prey consumed by bearded seals. Size estimates of walleye pollock (*Theragra chalcogramma*) were calculated by using the relationship between otolith length and fish length (Frost and Lowry, 1981) and between fish length and weight (Pereyra *et al.*, 1976). All otolith lengths were corrected to account for a 30% reduction in size due to digestion (Harvey, 1987). The size of narrow snow crab (*Chionoecetes opilio*) was estimated by using the relationship between weight and dorsal carapace width (Somerton, 1981).

Chi-square and Fisher Exact Tests (Siegel, 1956) were used to compare the occurrence of prey in the diets of males with females, and subadults/adults ($\geq$3 years of age) with juveniles (1-2 years of age). The Fisher Exact Test was used in cases when sample size in any cell was less than 5. An alpha value of 0.05 was used in all cases when testing the null hypothesis.

RESULTS

Diet Composition

Thirty-three different prey species were identified from the stomachs of 78 bearded seals collected near St. Matthew Island (Table 1). Seven of the species indicated in Table 1 have not been previously reported as prey of bearded seals in this area. Eighty-six percent of the seals examined had consumed fish. Capelin was the most prevalent, occurring in 82% of the stomachs (n = 16 940). Other common fish prey were codfishes (Gadidae), eelpouts (*Lycodes* spp.) and longsnout pricklebacks (*Lumpenella longirostris*), with percentages of occurrence of 64% (n = 517), 56% (n = 162) and 49% (n = 273) respectively. Crabs occurred in 73% of the seals' stomachs and narrow snow crab had the highest percentage of occurrence (63%, n = 2399). Other frequently occurring taxon groups included clams (55%), snails (47%) and amphipods (32%). Shrimp, mysids, marine worms and cephalopods occurred in less than 20% of the seals examined.

Comparisons of prey consumed by males (n = 21) and females (n = 57) and by juveniles (n = 13) and subadults-adults (n = 65) indicated no significant differences ($P > 0.05$).

The mean number of different prey taxon groups eaten by individual seals ranged from 1 to 7 (Fig. 2). Seventy-seven percent of the seals consumed food items from three or more taxon groups.

Estimated Prey Size of Commercial Species

The average estimated length and weight of walleye pollock eaten by bearded seals was 118 mm (n = 56, sd = 1.47, range = 69-143 mm). Corresponding weight estimates for walleye pollock of this size average 11.6 g and range from 2.4 to 20.6 g. The average estimated weight of narrow snow crabs was 86.2 g (n = 336, sd = 86.5, range = 21.9-798.1 g) based on a mean carapace width of 57 mm (n = 336, sd = 12.0, range = 32-123 mm).

DISCUSSION

Bearded seal foraging ecology has been characterized by the great diversity of prey that they consume (Chapskii, 1938; Pikharev, 1941; Vibe, 1950; Johnson *et al.*, 1966; Kosygin, 1971; Lowry *et al.* 1980; Finley and Evans, 1983). The relative proportions of prey species in the bearded seal's diet change with seasonal and geographical differences in prey availability and may also be influenced by interspecific competition with Pacific walrus, *Odobenus rosmarus*, where both species occur (Lowry *et al.*, 1980).

Our results indicate that bearded seals in the central Bering Sea forage extensively on schooling fish such as capelin. These findings are consistent with those of Finley and Evans (1983) for bearded seals in the Canadian High Arctic and differ from those of Lowry *et al.* (1980) in the Bering and Chukchi seas. It is impossible to determine if the consumption of capelin and other fish species in our study is associated with the relative availability of other prey resources or preferential selection of prey. We suspect, however, that the high percentage of occurrence of capelin was related to the presence of dense schools that rise in the water column and move toward shore in the spring prior to spawning (Pahlke, 1985; Kessler, 1985), thus making them vulnerable to predation (Macy *et al.*, 1978). Had capelin not been available, it seems likely that other prey such as crabs or codfishes would have been the most frequently utilized prey because of their abundance around St. Matthew Island (Sample *et al.*, 1985; Somerton, 1981).

Bottom trawl surveys in our sample area during the summer of 1981 (unpublished data for haul numbers 75 and 76, National Marine Fisheries Service, Seattle, Washington) confirm the presence of most prey species identified in this study, but the evaluation of their relative abundance (catch per unit effort) differed somewhat from their occurrence in the diet of the bearded seal. Trawl survey data indicated that the top five species in decreasing order of abundance were narrow snow crab, snails (*Neptunia* spp.), eelpouts, sculpins (Cottidae) and codfishes. Narrow snow crab, eelpouts and codfishes were also among the five most important prey of the bearded seal, but snails and sculpins had relatively low frequencies of occurrence. Conversely, capelin was poorly represented in the trawl surveys but was the most frequently occurring prey species. Such discrepancies between abundance estimates from trawl surveys and dietary results from bearded seals are probably due to factors such as sampling biases (seals vs. bottom trawls), temporal differences in prey availability and preferential prey selection. More work is needed to address these possible biases and to obtain better assessments of the relationship between prey resource availability and the foraging ecology of the bearded seal.

Geographic differences in the local fauna have undoubtedly influenced the diet of bearded seals (Pikharev, 1941; Burns and Frost, 1979; Lowry *et al.*, 1980). This may have been especially true in the waters near St. Matthew Island where high nutrient levels (Hanada and Tanoue, 1981) were augmented by the spring bloom of phytoplankton associated with the ice edge and warming water temperatures (Niebauer *et al.*, 1981). The apparent high productivity of this area probably contributed greatly to the availability of the wide variety of prey taxa consumed by bearded seals within such a relatively small area (Fig. 1) over a short period of time (4 days).

TABLE 1. Occurrence (percentage and number) of prey species recovered from bearded seals (n = 78) near St. Matthew Island, Bering Sea, in early spring 1981

	Prey species		Occurrence[1]	
General taxon	Common name	Scientific name	%	n
Fish	Capelin	*Mallotus villosus*	82	16 940
	Codfishes	Gadidae	64	517
	Eelpouts	*Lycodes* spp.	56	162
	Longsnout prickleback[2]	*Lumpenella longirostris*	49	273
	Snailfish[2]	Liparididae	27	30
	Righteye flounder	*Hippoglossoides* sp.	15	15
	Arctic cod	*Boreogadus saida*	9	55
	Walleye pollock	*Theragra chalcogramma*	8	21
	Sculpins	Cottidae	6	5
	Sculpins	*Myoxocephalus* spp.	3	4
	Pacific cod[2]	*Gadus macrocephalus*	1	1
	Total fish		86	18 023
Crab	Narrow snow crab	*Chionoecetes opilio*	63	2 399
	Tanner crab	*Chionoecetes* sp.	12	10
	Hermit crab[2]	Paguridae	4	3
	Total crabs		73	2 412
Clams	Nut shells[2]	*Nuculana* sp.	42	131
	Unidentified		12	8
	Total clams		55	139
Snails	Moon snail	*Polinices* sp.	27	121
	Whelk	*Buccinum* sp.	17	56
	Whelk	*Neptunia* sp.	3	3
	Moon snail	*Nautica* sp.	3	2
	Unidentified		18	85
	Total snails		47	267
Amphipod	Gammarid	Gammarid (not *Maeras* sp.)	19	28
	Gammarid	*Maeras* sp.	5	9
	Hyperid	Hyperid	4	13
	Unidentified		5	4
	Total amphipod		32	54
Shrimp	Pandalid shrimp	*Pandalus* sp.	5	4
	Crangonoid shrimp	*Crangon* sp.	4	3
	Crangonoid shrimp	*Argis* sp.	1	1
	Hippolytid shrimp	*Eualis* sp.	1	1
	Unidentified		8	6
	Total shrimp		18	15
Mysid	Mysid	Mysid	13	94
	Mysid	*Neomysis* sp.	6	8
	Mysid	*Neomysis raii*	1	3
	Total mysids		13	105
Marine worms	Echiuroid worm	*Echiurus* sp.	9	23
	Priapulid worm	Priapulid	6	—[3]
	Chaeopterid worm[2]	Chaeopterid	3	—
	Total worms		13	—
Cephalopod	Octopus[2]	*Octopus* sp.	3	51
	Unidentified		1	1
	Total cephalopod		4	52

[1] % = percent of occurrence = (no. samples with prey item/total no. samples) × 100.
n = total number of individual prey recovered from all seals.
[2] Not previously reported as prey for bearded seals in the Bering Sea.
[3] Values impossible to determine are designated with a dash (—).

The similarities in the diets of males and females agree with previous studies (e.g., Johnson *et al.*, 1966; Lowry *et al.*, 1980) and support the hypothesis that there is no segregation in the foraging habits of males and females. The diets of juvenile seals less than 3 years of age and those older than 3 years of age were also similar. These results differed from a study by Lowry *et al.* (1980) in which juveniles ate primarily shrimp, crab and fish (mostly sculpins) and the

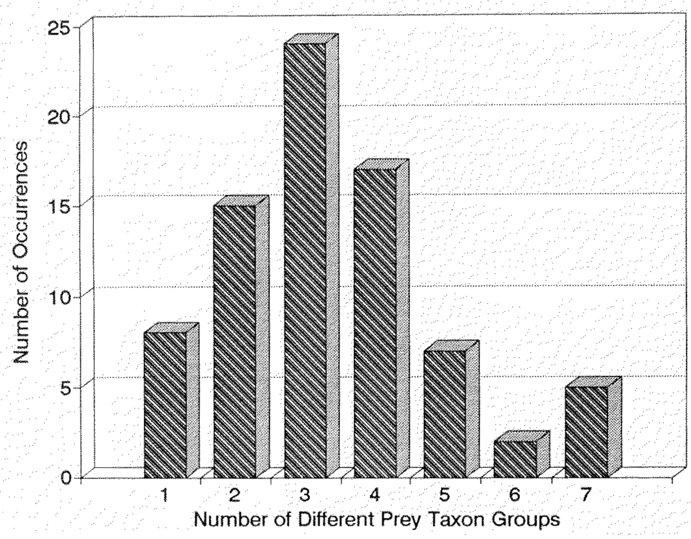

FIG. 2. Occurrence of single and multiple prey from different taxon groups found in the stomachs of bearded seals collected near St. Matthew Island, Bering Sea.

adults ate mostly clams. Differences between the two studies are probably largely due to duration of sampling periods and the availability and abundance of a more diversified prey assemblage in the shallow waters near St. Matthew Island in the spring. Also, biases may have resulted from differences in sample sizes.

Two prey species, walleye pollock and narrow snow crabs, are commercially important in the Bering Sea, although our results indicate that the sizes of these prey are smaller than those taken by fisheries controlled by the United States and Russia. Commercial fisheries take walleye pollock, which are usually greater than 28 cm in length and are 2 years of age and older (Wespestad and Traynor, 1988), and narrow snow crabs with a minimum carapace width of 78 mm (Somerton, 1981). Bearded seals consume walleye pollock 0-1 year of age ($\overline{x}$ = 11.8 cm in length) and narrow snow crabs with a mean carapace width of 57 mm with average estimated weights of 11.6 g and 86.2 g respectively. Other studies, however, have shown that bearded seals are capable of consuming larger prey up to 510 g (e.g., Finley and Evans, 1983). Such variation in size selection of prey indicates that both direct and indirect conflicts (Lowry, 1982) between bearded seals and commercial fisheries are possible and need to be considered when managing the resources of the Bering Sea.

In conclusion, our results further exemplify the bearded seal as a true foraging generalist, capable of preying on demersal and pelagic fish and on epifaunal and infaunal invertebrates (e.g., Vibe, 1950; Finley and Evans, 1983). Few, if any, other pinniped species exploit such a wide range of prey taxon groups. Although the high percentages of occurrence for capelin, codfishes, longsnout pricklebacks and snailfish have not been previously reported for bearded seals in the central Bering Sea, these results are consistent with reports of the bearded seal's diet in other areas (Chapskii, 1938; Pikharev, 1941; Vibe, 1950; Finley and Evans, 1983). It is difficult to predict, however, the degree to which bearded seals will forage on fish in the Bering Sea without a better understanding of their foraging behavior and the movements and life histories of their prey. Determination of predation rates is further complicated by variable movement patterns of the ice front, which greatly influences where bearded seals forage (Lowry *et al.*, 1980).

U.S. and Russian scientists plan to continue their cooperative efforts studying the foraging ecology of bearded seals as part of an ongoing effort by their countries to investigate biological and ecological questions concerning the conservation and management of resources they share in the Bering Sea.

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