A Conceptual Assessment of Biological Interactions Among Marine Mammals and Commercial Fisheries in the Bering Sea

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Introduction

Over the past 2 centuries the Bering Sea has supported extensive harvests of marine mammals and, later, fishes and shellfishes. Human harvests resulted in drastic reductions in the population size of many major species such as sea otters (*Enhydra lutris*), walruses (*Odobenus rosmarus*), fur seals (*Callorhinus ursinus*), halibut (*Hippoglossus stenolepis*), herring (*Clupea harengus*), and yellowfin sole (*Limanda aspera*) (Pruter, 1973; Fay, 1981). Changing economic factors, improved scientific understanding of animals and processes, and implementation of programs for protection and management have allowed many populations to recover over the past few decades. Management regimes that have been implemented were based on primarily single-species, maximum sustainable yield concepts.

Recent trends in management philosophy reflect a desire to develop multi-species, ecosystem-based management programs. In particular, two pieces of federal legislation have had far-reaching impact on management of fishery and mammal resources in marine waters of the United States. The Marine Mammal Protection Act (PL-92-522) recognizes marine mammals as significant functional elements of marine ecosystems and requires the maintenance of "optimum sustainable populations," with the primary objective of maintaining the "health and stability of the marine ecosystem." The Magnuson Fishery Conservation and Management Act (PL-94-265) established a 200-mile Fishery Conservation Zone in seas adjacent to the United States and provided a framework for management and development of commercial fisheries within that zone. However, in spite of the recent desire and requirements for ecosystem-based management of resources in areas such as the Bering Sea, such has yet to become a reality.

Attempts to incorporate marine mammal food requirements into the Bering Sea/Aleutian Islands fishery management plan have been only partially successful due to the lack of adequate data and models with which to analyze and simulate possible interactions (Lowry et al., 1982). Nonetheless, available data do allow a preliminary, conceptual assessment of biological interactions among marine mammals and commercial fisheries. In this paper I refer only to trophic interactions that primarily involve the responses of marine mammals and fisheries to changes in fish (and shellfish) stock abundance and characteristics. A listing of Bering Sea marine mammal species and an indication of their abundance are given in Table 1.

Documentation of Interactions

As one would expect, the earliest observations of stomach contents of marine mammals showed that marine fishes and shellfishes were major items in their diets. However, prior to 1950, few studies of marine mammals documented their foods in any quantitative fashion. In the Bering Sea and North Pacific, Soviet commercial harvests of ice-associated seals provided some data on foods of those species (e.g., Arseniev, 1941; Pikharev, 1941, 1946; Fedoseev, 1965; Shustov, 1965; Gol'tsev, 1971; Kosygin, 1971). Other experimental and opportunistic observations added data on foods of fur seals, sea lions, and harbor seals (e.g., Scheffer and Sperry, 1931; Imler and Sarber, 1947; Scheffer, 1950). Interestingly, although several samples were collected at areas and times when salmon (Oncorhynchus spp.) were present, fishes of the cod (Gadidae), herring (Clupeidae), and smelt (Osmeridae) families were usually the major prey. Nonetheless, due to acknowledged direct interactions with salmon fisheries and a perceived competition for resources, harbor seals and sea lions in particular were subject to bounties and control programs to reduce their effects on fisheries (Mate, 1980). Such control programs were terminated by 1970. Further studies of foods of pinnipeds generally confirmed the dietary importance of herring, smelts, and cods (see summaries by Lowry and Frost, 1981; Perez and Bigg, 1981; Pitcher, 1981).

General information on foods of cetaceans became available with the examination of animals taken in commercial harvests (e.g., Tomilin, 1957; Zimushko and Lenskaya, 1970). This has been supplemented by data from animals, particularly small cetaceans, that were taken by subsistence hunters (e.g., Seaman et al., 1982), caught in fishing gear (e.g., NMML, 1981), or washed up dead on shore (Scheffer, 1953). In general, zooplankton, squids, and small schooling fishes have been found to be the major prey of cetaceans, and, given the offshore distribution of most species and their observed foods, interactions with fisheries have appeared slight. A notable exception involves belukha whales in Bristol Bay. There, a systematic study (summarized in Lensink, 1961) documented the consumption of adult and smolt salmon by belukhas in the Kvichak and Nushagak River estuaries. Calculations indicated that belukhas consumed 2.7% of the sockeye (Oncorhynchus nerka) runs in 1954 and 1.0% in 1955, which was considered significant, especially in light of the depleted status of stocks. This led to the development of a nonlethal acoustic system which was used to displace the whales from the rivers at critical times (Fish and Vania, 1971). With improved management and recovery of sockeye stocks, use of this system was discontinued.

Table 1. Categorization of maximum numerical abundance and biomass of marine mammals in the Bering Sea.

Species	Maximum numerical abundance			Population biomass (mt)		
	< 10,000	10,000-100,000	> 100,000	< 10,000	10,000-100,000	> 100,000
BALEEN WHALES						
Gray whale *Eschrichtius robustus*		X				X
Fin whale * *Balaenoptera physalus*	X				X	
Minke whale *Balaenoptera acutorostrata*	X				X	
Blue whale * *Balaenoptera musculus*	X			X		
Sei whale * *Balaenoptera borealis*	X			X		
Humpback whale * *Megaptera novaengliae*	X			X		
Right whale * *Balaena glacialis*	X			X		
Bowhead whale *Balaena mysticetus*	X				X	
TOOTHED WHALES						
Sperm whale *Physeter macrocephalus*		X				X
Belukha *Delphinapterus leucas*		X		X		
Cuvier's beaked whale * *Ziphius cavirostris*	X			X		
Baird's beaked whale * *Berardius bairdi*	X			X		
Stejneger's beaked whale * *Mesoplodon stejnegeri*	X			X		
Killer whale * *Orcinus orca*	X			X		
Dall's porpoise *Phocoenoides dalli*		X		X		
Harbor porpoise * *Phocoena phocoena*	X			X		
PINNIPEDS						
Northern fur seal *Callorhinus ursinus*			X		X	
Steller sea lion *Eumetopias jubatus*		X			X	
Pacific walrus *Odobenus rosmarus*			X			X
Harbor seal *Phoca vitulina richardsi*		X		X		
Spotted seal *Phoca largha*			X		X	
Ribbon seal *Phoca (Histriophoca) fasciata*		X		X		
Ringed seal *Phoca (Pusa) hispida*			X		X	
Bearded seal *Erignathus barbatus*			X		X	
CARNIVORES						
Polar bear *Ursus maritimus*	X			X		
Sea otter *Enhydra lutris*		X		X		

* Indicates population estimated at 1,000 or less.

Major changes in the pattern of exploitation of Bering Sea fish stocks occurred during the period following the end of World War II (Bakkala et al., 1981), of which the development of the groundfish fishery is probably most significant. The aggregate catch of groundfish by all nations increased from 12,500 mt in 1954 to over 2.2 million mt in 1972; the 1972 harvest was 176 times greater than that in 1954. In addition, due at least in part to depletion of stocks of other target species (Pruter, 1973), the percentage of pollock (Theragra chalcogramma) in the harvest increased from 0 to 83% during that period (Bakkala et al., 1981).

The increased harvests of Bering Sea groundfish, particularly pollock, and the improved data base on marine mammal foods suggested a major potential competition for resources (McAlister and Perez, 1976; Lowry et al., 1979). Frost and Lowry (1981a) documented the presence of pollock in the diet of 11 species of marine mammals and 13 species of seabirds. Calculations by McAlister and Perez (1976) indicated that 2,853,000 mt of finfish were consumed annually by pinnipeds in the Bering Sea, an amount considerably in excess of the harvest by fisheries. Two questions could then be formulated, each of which could be applied either specifically to pollock and their predators or to the entire suite of Bering Sea marine mammals and fisheries. First, is predation by marine mammals impacting the harvests that can be taken by commercial fisheries? Second, is the take by commercial fisheries affecting food availability and therefore population status of marine mammals?

The magnitude of consumption of commercial fish resources by Bering Sea marine mammals is without doubt substantial (McAlister and Perez, 1976). However, predation by marine mammals has not been documented as a factor resulting in the depletion of commercially important fish stocks in the Bering Sea. Observations of sea otters in California (Lowry and Pearse, 1973) and walruses in the Bering Sea (Fay and Lowry, 1981) demonstrate the ability of certain mammals to deplete local stocks of fishable resources. Calculations by Winters and Carscadden (1978) for North Atlantic capelin have assumed that potential yields to fisheries are a direct function of marine mammal abundance.

The question of the effect of fisheries on marine mammals is more complex and is supported by a less well-developed array of observations, data, and theory. In order to postulate that the actions of a fishery affect populations of marine mammals, four criteria must be met. First, the removals of forage species by the fishery, in combination with other predators, must affect forage stocks differently than predation alone. Second, changes in forage abundance must affect intake of food by marine mammals. Third, a change in food intake must result in a change in vital parameters (e.g., growth, survival, reproduction) of individual marine mammals. Fourth, changes in individual parameters must affect population parameters such as abundance and productivity. If these four linkages must be established in order to conclusively demonstrate the existence of a significant interaction between marine mammals and fisheries in the Bering Sea, such interactions have not been documented. Instead, however, attempts have been made to correlate observed population characteristics of marine mammals with observed fisheries or presumed changes in fish stock characteristics. Such studies dealing with fur seals (Swartzman and Haar, 1980) and sea lions (Braham et al., 1980) have not succeeded in conclusively documenting causal relationships.

Despite the lack of adequate documentation for the Bering Sea, information from other areas suggests that marine mammals may respond to changes in their food supply. The evidence is based on the assumption that a reduction in population size of the principal or competing species changes the relationship of the population to its food resources in such a way as to eliminate or reduce the effects of food limitation. Populations should then respond to increased food availability by increased productivity and/or survival, and, in the absence of continued excessive harvesting, the population size should increase. In the North Atlantic, a reduction of the harp seal (Phoca groenlandica) population during 1952 to 1972 was accompanied by a significant increase in fertility rate (from 85 to 94%) and decrease in mean age at maturity (from 6.5 to 4.5 years) (Bowen et al., 1981). These responses should have increased productivity, and indeed the population size has probably increased in spite of continued harvesting (Bowen and Sergeant, 1983). A second example involves the Antarctic ecosystem, where a single species of krill (Euphausia superba) is the principal food of many species of birds and marine mammals. Recent increases in populations of several krill predators, including penguins (Aptenodytes patagonica and Pygoscelis spp.), minke whales, crabeater seals (Lobodon carcinophagus), and fur seals (Arctocephalus spp.), are thought to be the result of an increase in availability of krill brought about by the reduction of large whale populations which had formerly consumed great quantities of that species (Laws, 1977).

Thus, the available information suggests that populations of some marine mammal species can be limited by food availability and that individual and population parameters will respond to changes in levels of available food. It must be noted that the important factor is the relationship between abundance of predator and prey populations rather than the absolute size of either. That is, a reduction in a marine mammal population while abundance of prey remains constant would have a similar effect to enhanced prey abundance with a constant mammal population. In order to facilitate such considerations, many investigators have found it useful to consider this relationship in terms of per-capita food availability.

Conceptual Assessment of Marine Mammal-Fishery Interactions in the Bering Sea

It is comparatively easy to document which species of marine mammals consume commercial fish species. Analysis of opportunistically obtained specimens (e.g., stomachs) and observations of distribution and behavior of animals in fishing areas are usually adequate to detect which target species are eaten. For most species a careful evaluation of all available food habits data can provide a semi-quantitative assessment of the dietary importance of commercially exploited prey, as has been done by Fiscus (1979, 1980), Frost and Lowry (1981b), and Lowry and Frost (1981). An evaluation of this type for Bering Sea marine mammals and fisheries is given in Table 2, based on the data summarized in Lowry et al. (1982). However, such an evaluation must be accepted with caution since reasonably adequate descriptions of diet for mammals of the Bering Sea, including at least seasonal and

Table 2. Importance of present and potential commercial fishes and shellfishes in the diets of Bering Sea marine mammals.

	COMMERCIAL FISH SPECIES/GROUP											
	Present								Potential			
	Groundfish	Herring	Salmon	Halibut	Squid	King crab	Tanner crab	Snails	Capelin	Saffron cod	Shrimp	Clams
MYSTICETE CETACEANS												
Gray whale	0	1	0	0	0	1	1	1	1	0	1	1
Fin whale	3	3	1	0	3	0	0	0	3	2	0	0
Minke whale	3	2	0	0	2	0	0	0	2	1	0	0
Blue whale	0	1	0	0	1	0	0	0	1	0	0	0
Sei whale	1	1	0	0	1	0	0	0	1	1	0	0
Humpback whale	3	3	1	0	1	0	0	0	3	3	1	0
Bowhead whale	0	0	0	0	0	0	0	0	0	0	0	0
Right whale	0	0	0	0	0	0	0	0	0	0	0	0
ODONTOCETE CETACEANS												
Sperm whale	2	1	1	1	3	1	1	0	1	0	0	0
Belukha	2	3	3	1	1	0	1	1	2	3	2	0
Beaked whales	1	0	1	0	3	0	0	0	0	1	0	0
Killer whale	2	2	2	1	1	0	0	0	1	1	1	0
Dall's porpoise	2	2	1	0	3	0	0	0	3	0	1	0
Harbor porpoise	2	2	1	0	1	0	0	0	2	3	1	0
PINNIPEDS												
Northern fur seal	3	2	1	0	3	0	0	0	3	0	1	0
Steller sea lion	3	2	1	1	1	0	0	0	2	1	1	0
Pacific walrus	0	0	0	0	0	1	1	2	0	0	1	3
Harbor seal	3	3	1	1	1	0	0	0	3	0	2	0
Spotted seal	3	3	1	0	1	0	0	0	3	3	2	0
Ribbon seal	3	1	0	1	2	0	0	0	2	2	3	0
Ringed seal	1	1	0	0	1	0	1	0	1	3	3	0
Bearded seal	1	0	0	0	0	1	3	2	0	1	3	3
CARNIVORES												
Polar bear	0	0	0	0	0	0	0	0	0	0	0	0
Sea otter	1	0	0	0	0	2	2	2	0	0	0	2

3 = Known major
2 = Potentially major
1 = Known or potentially minor
0 = Probably not eaten

geographical resolution, are available only for fur seals and perhaps ringed seals, bearded seals, and walruses.

In order to derive the most elementary assessment of the impact of marine mammals on commercial fish stocks, it is necessary to know the quantities of commercial species consumed by each type of mammal on an annual basis. Obviously the distribution of this predation by age and sex class of prey and by area and time of year are also important but only represent levels of refinement of the initial estimate of total amounts. Published estimates of the amounts of finfish consumed by marine mammals in the Bering Sea are on the order of 1.6-2.5 million metric tons per year, an amount which equals or exceeds the annual harvest by commercial fisheries (McAlister and Perez, 1976; Dunn 1979; McAlister, 1981).

Calculations of the amount of food consumed by a marine mammal species are usually made by multiplying the population biomass (derived from population size and average individual weight) times the number of days spent feeding in the area (assumed to equal residence time), times a daily consumption rate (usually expressed as a percentage of body weight). The amounts of various prey species consumed can then be estimated based on knowledge of the species composition of the marine mammal's diet. Various refinements to this estimation technique can be made, for example, by making food consumption rate proportional to temperature.

Inaccuracy in the results of such calculations is likely to occur from two principal sources. First is that the required input data may not be available. In Table 3 I have indicated the general availability of necessary data for those species which may consume at least moderate amounts of commercial fishes (based on Table 2). There are major deficiencies in the data base, particularly with respect to population size, residence time, and weight of cetaceans, and diet composition of all species with the exception of fur seals. Although population size estimates are available for several large cetaceans, those estimates refer to entire North Pacific populations, and it is not known how many animals actually occur in the Bering Sea. For most species there are some data on the length-weight relationship; however, information on the size structure of the population is needed to calculate an average weight, and those data are not usually available. General observations on the diet of most species have been made (or the diet can be inferred from data from other areas), but sufficient data to quantify the diet in the Bering Sea, taking into account seasonal and geographical variations, are available only for fur seals.

The second source of inaccuracy results from variability and errors in assumptions and values chosen for input parameters. Assuming reasonable error bounds for parameters for the fur seal, which has the most extensive data base of any species, the total calculated food consumption in the Bering Sea could range from 0.2 to 1.5 million metric tons if all errors were cumulative (Lowry et al., 1982). Larger error bounds would be possible for species where little or no data are available for parameters such as population size or residence time, although in many instances it is likely that errors may tend to cancel one another, resulting in gross estimates that are close to the true value.

Table 3. Availability of data required for the calculation of quantities of commercial fishes eaten by marine mammals in the Bering Sea. (Based primarily on Lowry et al., 1982.)

Species	Population size	Residence time	Average weight	Consumption rate	Diet composition
CETACEANS					
Fin whale	*	*	*	**	*
Minke whale	*	*	*	**	*
Humpback whale	*	*	*	*	*
Sperm whale	**	*	*	**	*
Belukha	**	**	**	**	*
Beaked whales	*	*	*	*	*
Dall's porpoise	**	**	**	**	*
Harbor porpoise	*	*	*	*	*
PINNIPEDS					
Northern fur seal	***	**	***	***	***
Steller sea lion	**	**	**	**	*
Harbor seal	**	***	**	***	*
Spotted seal	**	**	**	***	*
Ribbon seal	**	**	**	*	*
Bearded seal	**	**	***	*	**
CARNIVORES					
Sea otter	***	***	**	***	*

*** - extensive data; ** - moderate data; * - little or no data

In considering the likelihood that a particular species of marine mammal may be affected by Bering Sea commercial fisheries, three factors in addition to diet composition appear to be of major importance. Those are:

1) Feeding strategy; i.e., specialist vs. generalist.
2) Overall importance of feeding which occurs in the Bering Sea in the annual nutrition of individuals and the population.
3) Relationship of the present population to carrying capacity; i.e., is per-capita food availability presently limiting population size?

A general assessment of these factors can be made given the presently available data base. For example, although many types of prey are eaten by both walruses and bearded seals, walruses obviously specialize in clams, while bearded seals can and do eat large amounts of clams, shrimps, crabs, snails, and fishes. Minke, fin, and humpback whales are generalists, while right and bowhead whales are much more specialized.

Although distinctions are not completely clear-cut, residency of Bering Sea marine mammal species can be largely classified into three categories: 1) year-round residents (harbor seal, ribbon seal, sea lion, and some belukha whales, Dall's porpoise, and harbor porpoise); 2) summer seasonals (fur seals, sperm whales, and all baleen whales except bowheads); and 3) winter seasonals (ringed seals, bearded seals, most walruses, and bowhead whales). Generally speaking, feeding in the Bering Sea is most important for resident species and summer seasonals, although winter feeding in the Bering is considered important for ice-associated seals and walruses. Summer feeding in the Bering Sea may be somewhat optional for most baleen whales since their relative summer distributions in the Bering and North Pacific appear to fluctuate in different years, presumably based on where optimum feeding conditions exist (e.g., see Bryant et al., 1981).

We have considered two factors as indicative of the relationship of a population to carrying capacity: 1) the present abundance compared to historical levels as indicated by direct estimates of population size or by harvest records, and 2) the recent trend in abundance. Obviously, it is unlikely that a population that is increasing in numbers or is at a low level compared to previous abundance will presently be limited by food availability. Where no data on abundance are available, we have considered populations to be stable and at abundance levels comparable to historic.

We have assigned ranked values to feeding characteristics, based on whether they suggest a probable interaction with fisheries, and to population size and trend values, based on whether they indicate probable food limitation (Table 4). A species that is stenophagous on commercially exploited prey, uses the Bering Sea as a major feeding area, and is near carrying capacity would receive high ranks (maximum total of 15). Conversely, a mobile and omnivorous species that consumes prey not exploited by fisheries, feeds only briefly in the Bering Sea, and is below carrying capacity would receive low ranks (minimum total of 5).

Results of this analysis, considering all factors combined (Table 5), produce total rank values ranging from 13 (highest probability of significant interaction) to 8 (lowest probability of interaction). Species are ranked in order of probability of interaction in Table 6 as categories 1 (ranked value of 13) through 6 (ranked value of 8).

The species for which there is greatest potential for interaction are the northern fur seal, Steller sea lion, and harbor seal. For all three species the Bering Sea is a major feeding area, and commercially exploited fishes (principally pollock, herring, and salmon) comprise substantial portions of the diet. In addition, although they are somewhat opportunistic, their feeding areas may be limited at times by the proximity of terrestrial hauling areas. Based on available data, populations are probably at levels close to carrying capacity, and reductions in prey abundance would be likely to affect ingestion rates and population productivity.

Species in category 2 also rely on the Bering Sea as an important feeding area and are thought to be presently near carrying capacity. In the case of the sea otter the probability of interactions with fisheries is lessened slightly due to a moderate proportion of commercial species in the diet. Although belukha and harbor porpoise forage extensively on commercial species, their mobility may reduce the probability of significant interactions. Much of the feeding of spotted

Table 4. Criteria for assigning ranked values of the likelihood of marine mammal-fishery interactions in the Bering Sea. Low values indicate that the described characteristics suggest a low probability of significant interactions.

	Feeding			Relation to carrying capacity	
Rank value	Composition of the diet	Feeding strategy	Importance of Bering Sea as feeding area	Relative population size	Population trend
1	Feed principally on noncommercial species	Omnivorous with high mobility of predators and prey	Important only for a small fraction of annual nutrition or feeding available elsewhere	Greatly reduced	Increasing
2	Feed moderately on commercial species	Moderately diverse diet (opportunistic)	Moderately important	Slightly reduced	Stable
3	Feed heavily on commercial species and use size classes similar to those targeted on	Stenophagous or with low mobility of predators and prey	Major feeding area without other regular or optional feeding grounds	Comparable to historic	Declining

Table 5. Ranked values of the likelihood of marine mammal-fishery interactions in the Bering Sea, based on characteristics of feeding and population status.

Species/group	Feeding			Status		Total
	Diet composition	Feeding strategy	Bering Sea importance	Relative size	Population trend	
MYSTICETE CETACEANS						
Gray whale	1	3	3	3	1	11
Fin whale	2	1	2	1	2	8
Minke whale	2	1	2	2	2	9
Blue whale	1	3	1	1	2	8
Sei whale	1	3	1	1	2	8
Humpback whale	2	1	2	1	2	8
Bowhead whale	1	3	1	1	2	8
Right whale	1	3	1	1	2	8
ODONTOCETE CETACEANS						
Sperm whale	1	1	2	2	2	8
Belukha	3	2	2	3	2	12
Beaked whales	1	1	2	3	2	9
Killer whale	2	1	1	3	2	9
Dall's porpoise	2	2	2	2	2	10
Harbor porpoise	3	1	3	3	2	12
PINNIPEDS						
Northern fur seal	3	2	3	2	3	13
Steller sea lion	3	2	3	2	3	13
Pacific walrus	1	3	3	3	1	11
Harbor seal	3	2	3	3	2	13
Spotted seal	2	2	3	3	2	12
Ribbon seal	2	2	3	2	1	10
Ringed seal	1	1	2	3	2	9
Bearded seal	2	1	2	3	2	10
CARNIVORES						
Polar bear	1	2	1	3	2	9
Sea otter	2	2	3	3	2	12

Table 6. Summary of probability of interaction with commercial fisheries for Bering Sea marine mammals. Species are not prioritized within categories.

Probability of interaction	Category #	Species
HIGH	1	Northern fur seal
	1	Steller sea lion
	1	Harbor seal
	2	Spotted seal
	2	Belukha whale
	2	Harbor porpoise
	2	Sea otter
MODERATE	3	Gray whale
	3	Pacific walrus
	4	Dall's porpoise
	4	Ribbon seal
	4	Bearded seal
LOW	5	Killer whale
	5	Minke whale
	5	Beaked whales
	5	Ringed seal
	5	Polar bear
	6	Fin whale
	6	Blue whale
	6	Sei whale
	6	Humpback whale
	6	Bowhead whale
	6	Right whale
	6	Sperm whale

seals occurs in the northern Bering Sea and is concentrated on species that are not presently fished commercially. Populations of all three species are probably near carrying capacity at present.

Species for which the probability of interaction is ranked as moderate are either stenophagous on noncommercial species (walrus and gray whales), or feed moderately on commercial species but are rather mobile and opportunistic (Dall's porpoise, ribbon seal, and bearded seal). Available data indicate that the populations of Dall's porpoise and ribbon seals may presently be somewhat below carrying capacity.

Species for which the probability of interaction is considered low either do not feed significantly on commercially important fishes or are opportunistic feeders that are presently at reduced levels of abundance. Although they may be affected by changes in trophic relationships caused by manipulation of other system components, the probability of a significant effect due to commercial fishing is low compared to other species.

Conclusions

The above assessment is admittedly limited in accuracy due to gaps in available data and is based on single-species rather than ecosystem-related considerations. However, in an area such as the Bering Sea with a rich marine mammal fauna and diverse commercial fisheries, ecosystem-based management schemes which allow decision makers to predict all the effects of possible actions may never become a reality. Therefore, it is of utmost importance at present to focus attention on the most probable areas of interaction such that the nature and significance of interactions can be assessed.

Although much of the data used in this assessment has been subjectively evaluated, the rankings derived are probably an accurate indication of the proximate probability of interaction, at least within the high, medium, and low categories, and generally agree with previously published reports (Lowry et al., 1979; Braham et al., 1980; Swartzman and Haar, 1980; Frost and Lowry, 1981; Lowry and Frost, 1981). The marine mammal-fishery combinations which merit immediate study are summarized in Table 7.

Table 7. Marine mammal species for which the probability of interaction with fisheries is high, and the fisheries with which they are likely to interact.

Marine mammal species	Fisheries
Northern fur seal	Groundfish, capelin, squid, herring
Steller sea lion	Groundfish, herring, capelin
Harbor seal	Groundfish, herring, capelin, shrimp
Spotted seal	Groundfish, herring, capelin, saffron cod, shrimp
Belukha whale	Herring, salmon, saffron cod, groundfish, capelin, shrimp
Harbor porpoise	Saffron cod, groundfish, herring, capelin
Sea otter	King crab, tanner crab, snails, clams

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