# Chapter 6

## Marine Mammal Abundance and Habitat Use

by

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## SUMMARY

Shipboard surveys were conducted to census abundance and distribution of marine mammals in the Unimak Pass area in fall, 1986, and winter and spring, 1987. Important findings include the following:

(1) The overall density of marine mammals in the area was highest in fall (0.223 mammals/$km^2$), lower in winter (0.104 mammals/$km^2$), and lowest in spring (0.076 mammals/$km^2$).

(2) Dall's porpoises were in all seasons the most numerous of the marine mammals; their abundance patterns among seasons paralleled the patterns described for all species combined. During winter and spring, Dall's porpoises were restricted to the deeper portions of the study area but during fall they were much more widespread.

(3) Northern fur seals were never encountered with high frequency in the study area but they were the second most numerous mammals in the fall when they peaked in abundance (0.039 mammals/$km^2$). Most fur seals were encountered in the Bering Sea portion of the study area.

(4) Sea otters were the only other marine mammals commonly encountered in areas sampled by shipboard surveys. They were found primarily among the Krenitzin Islands but also close to Unimak Island. Sea otters were considerably more numerous in the fall than during winter and spring (0.029/$km^2$ vs. ≈0.008/$km^2$).

(5) Humpback whales were encountered during fall north of Unimak Pass in an area noted by prior investigators to have relatively high abundances of this species.

(6) Fin whales were encountered during spring in and north of Unimak Pass.

(7) High numbers of several marine mammals, including Dall's porpoises, sea otters, and humpback whales were found in fall in an area of potential upwelling located northeast of Akun Island.

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## INTRODUCTION

Unimak Pass is one of the major migration corridors for mammal populations entering and leaving the Bering Sea (Thorsteinson 1984). The diversity and seasonal abundance of marine mammals that occur in and adjacent to Unimak Pass and along the continental slope can be found in no other part of Alaska and perhaps the world (Braham et al. 1982), though the ecological significance of the region to marine mammals is not yet fully understood.

An oil spill in Unimak Pass could potentially impact major portions of regional populations of some species. Major portions of populations of humpback, fin, and gray whales and northern fur seals move seasonally through the pass. Indeed, gray whale passage through the Aleutian Chain appears to be restricted to Unimak Pass itself, though humpback and fin whales also use other Aleutian passes. A spill large enough to significantly oil waters of the pass in early spring or late fall could expose great numbers of fur seals and gray whales to hydrocarbon contaminants. Mortalities of fur seals during these periods would likely be high.

Additional information on marine mammal use of the area is needed to help assess potential impacts from development. The purpose of this study was to help evaluate the seasonal abundances and distributions of marine mammals in Unimak Pass habitats to help fill this need.

## CURRENT STATE OF KNOWLEDGE

Many surveys of marine mammals, especially those for endangered whales, have included the Unimak Pass area in their regions of coverage. These survey programs were usually broad scale with the eastern Bering Sea serving as the study area. Consequently, sampling within a small area such as the eastern Aleutians has been very limited, and the precise locations of sightings made in the Unimak Pass area are often difficult to ascertain.

However, these studies are useful for placing the eastern Aleutian region in perspective with reference to the surrounding Bering Sea and North Pacific. Particularly useful reviews were provided by Leatherwood et al. (1983), Lowry et al. (1982b), Truett and Craig (1986), Thorsteinson (1984), and Hameedi (1982). Materials from these reviews were drawn upon extensively in the species summaries that follow.

The selection of marine mammal species on which to focus survey effort is easy because few are sufficiently abundant for surveys of them to provide meaningful information. The RFP requested that northern fur seals receive emphasis, and this species is among those that have been most

frequently encountered in previous surveys. Other species of greatest abundance include sea otter, Steller sea lion, Dall's porpoise, and gray whale (Tables 1 and 2). Although now rare, several species of endangered whales were formerly frequent in this area. Life history information of these five abundant species and brief summaries of the endangered whales and a few additional species of regular occurrence are provided below.

## Key Species

### *Gray Whale* (Eschrichtius robustus)

The gray whale is the most numerous and thoroughly-studied whale occurring within the study area. It is a coastal species with regular, well-defined patterns of migration. Although formerly classed as an endangered species because it had been reduced to low populations by intensive whaling, gray whales have recovered to population levels at or near their pre-exploitation stock size (Reilly 1984, Reeves and Mitchell 1988). Despite this recovery, gray whales are still officially considered a threatened species. Results of the numerous recent studies of this species have been summarized by Lowry et al. (1982a, b).

The majority of the 17,000 eastern Pacific gray whales (Rugh 1984, Reilly 1984) migrate annually from breeding/calving lagoons off Baja California and mainland Mexico to feeding grounds that extend from the central Bering Sea northward and eastward into the Chukchi and Beaufort seas. All of the gray whales entering the Bering Sea travel through Unimak Pass (Rugh and Braham 1979, Braham et al. 1982, Hessing 1981). Scattered groups summer along much of the migration corridor although none have been reported residing within our study area. The nearest regularly-used summering areas are Nelson Lagoon on the north side of the Alaska Peninsula (Gill and Hall 1983) and Kodiak Island south of the Peninsula (Leatherwood et al. 1983).

The northward migration occurs in two pulses, the first consisting of nonparturient adults and immature animals, the second principally of females and their calves of the year (Rugh 1984). These migrants move through Unimak Pass near the eastern shore (=west coast of Unimak Island) between March and June (Rugh and Braham 1979, Braham 1984, Rugh 1984) and then continue along a narrow coastal corridor into Bristol Bay. A few may migrate directly northwestward to the Pribilof and St. Matthew islands.

The southbound migration has not been as clearly described. Based on shore censuses of gray whales migrating through Unimak Pass in fall 1977-79, Rugh (1984) concluded that the exodus from the Bering Sea occurs from late October through early January, with peak numbers passing during mid-November and mid-December. As in spring, the whales remain very close to the eastern shore as they transit the Unimak Pass area. Rugh (1984) found no

Table 1. Densities of marine mammals (/km$^2$) in Unimak Pass recorded during North Aleutian Shelf aerial surveys (Troy unpubl.).

| SPECIES/SEASON | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sea Otter | 0.03 | 0.02 | 0.03 | 0.02 | | 0.08 | | 0.05 | | 0.08 | 0.15 | 0.12 |
| Steller's Sea Lion | 0.27 | 0.60 | 0.35 | 1.42 | | 0.00 | | 0.04 | | 0.13 | 0.00 | 0.66 |
| Northern Fur Seal | 0.00 | 0.02 | 0.00 | 0.00 | | 0.00 | | 0.00 | | 0.00 | 0.00 | 0.00 |
| Pac. White-sided Dolph | 0.00 | 0.00 | 0.00 | 0.01 | | 0.00 | | 0.00 | | 0.00 | 0.00 | 0.00 |
| Harbor Porpoise | 0.01 | 0.00 | 0.00 | 0.00 | | 0.00 | | 0.00 | | 0.00 | 0.00 | 0.00 |
| Dall's Porpoise | 0.00 | 0.00 | 0.00 | 0.00 | | 0.01 | | 0.00 | | 0.01 | 0.00 | 0.00 |
| Gray Whale | 0.00 | 0.00 | 0.00 | 0.03 | | 0.01 | | 0.00 | | 0.00 | 0.00 | 0.03 |
| TOTAL | 0.30 | 0.65 | 0.38 | 1.51 | | 0.10 | | 0.10 | | 0.23 | 0.15 | 0.80 |

Table 2. Densities of marine mammals (/km$^2$) in the Unimak-Krenitzin Islands area (FWS pelagic database).

| SPECIES/SEASON | April-May | June-Aug | Sept-Oct | Nov-March |
|---|---|---|---|---|
| Dall's Porpoise | | 0.19 | 0.03 | |
| Killer Whale | 0.04 | | | |
| Minke Whale | | 0.01 | | |
| Sea Otter | | 0.04 | | |
| pinniped | | 0.01 | | |
| Steller's Sea Lion | | 0.13 | 0.07 | |
| Northern Fur Seal | | 0.08 | 0.13 | 0.18 |
| Harbor Seal | | 0.01 | | |

whales more than 3.7 km west of Unimak Island; the whales observed were at a median distance of 0.5 km. from shore.

Gray whales apparently feed during migration (Braham 1984, Norris 1979), although the frequency and intensity of feeding during migration is much less than during the summer. Gray whales feed almost exclusively on nektobenthic, epifaunal, and infaunal invertebrates. Primary prey in certain parts of the northern Bering and Chukchi seas are ampeliscid and gammarid amphipods that form dense mats. The distribution of gray whales during the summer is probably determined by the presence of large amphipod beds. Important amphipods in the summer diet include *Amphelisca macrocephala, Lembos arcticus, Anonyx nugax, Pontoporeia femorata, Eusirus* sp., and *Atylus* sp. (Zenkovich 1934, Tomlin 1957). Gray whales also consume polychaetes, small bivalves, gastropods, mysids, and herring (Zimushko and Lenskaya 1970, Frost and Lowry 1981, Nerini 1984).

**Dall's Porpoise** ***(Phocoenoides dalli)***

Dall's porpoise is distributed widely within the cool temperate to subpolar waters of the North Pacific. Probably the most numerous cetacean in the area of interest, Dall's porpoise is present year-round. They are most abundant in deep pelagic waters and in areas along the continental shelf break. Summer observations, particularly those in June and July (e.g., Kawamura 1975, Wahl 1978), indicate that Dall's porpoises are abundant near the Aleutians and along the edge of the continental shelf, particularly between the Pribilof Islands and Unimak Pass. Migratory movements are not well understood but seasonal movements evidently occur (Braham et al. 1982). The distribution shifts southward in winter, with some animals leaving the Bering Sea (Fiscus 1980).

Analyses of the stomach contents of porpoises caught in the Bering Sea and Aleutian Islands region by the high seas salmon gillnet fishery have provided some information on their foods. Mizue and Yoshida (1965) and Mizue et al. (1966) found mostly squid and small amounts of fish bones and shrimps in stomachs collected between May and August 1964 and 1965. Stomach contents from 457 Dall's porpoises taken during the 1978 and 1979 fishing seasons have been described in Crawford (1981). Squids, mostly belonging to the family Gonatidae, were the major volumetric (90%) constituent of the stomachs. Euphausiids occurred in about 4% of the stomachs in insignificant quantities. Fishes were identified and enumerated, based on otoliths: 33 species of epi- and meso-pelagic fishes were found. Over 94% of the number of otoliths recovered were from fishes of the family Myctophidae (principally *Protomyctophym thompsoni*). In 1978, sand lance occurred in substantial numbers and pollock occurred in small numbers; Atka mackerel were found in low numbers both 1978 and 1979. Fishes eaten ranged from 20 to 480 mm in length, with a modal size of 60-70 mm, based on

partially digested whole specimens. No differences in quantities or types of prey were found among porpoises of different sex, stages of maturity, or reproductive state.

Dall's porpoises feed primarily upon a deep-water-based food web. Small meso- and bathypelagic fishes and cephalopods are the primary prey type. Squids, especially those of the family Gonatidae, are heavily utilized by Dall's porpoise. Myctophids constitute over 94 percent of all the fish consumed by Dall's porpoise (Crawford 1981), with capelin, herring, hake, sand lance, cod, and deep sea smelts also constituents of their diet (Kajimura et al. 1980). Many of these prey species undergo a diel vertical migration toward the surface at night. Preliminary data suggest that Dall's porpoise take advantage of this movement by feeding primarily at night. Kajimura et al. (1980) reported the items occurring in stomachs of seven animals collected near Unimak Pass and in the Bering Sea from June to October 1960-68; these porpoises had been preying on squid, capelin, and pollock.

Dall's porpoise may be of particular interest or concern in terms of environmental monitoring because of studies in the northwestern Pacific where this species has been shown to be accumulating heavy metals—zinc, nickel, lead, cadmium, manganese, and copper (Fujise et al. 1988). Porpoises from the northwestern Pacific and the Bering Sea are also accumulating PCBs and other persistent organochlorides (Subramanian et al. 1988).

**Steller Sea Lion *(Eumetopias jubatus)***

This species is most numerous in and near the Aleutian Islands, where they are year-round residents. The total estimated population for the eastern Aleutians (including Amak Island and Sea Lion Rock) is 30,000. (The Alaska population is estimated to be in excess of 250,000 [Fiscus et al. 1981].) During winter there is apparently an influx of sea lions into the eastern Aleutians and northeastern Pacific Ocean. Numerous haulout areas and a few rookeries are known from the area of interest.

Important pupping areas are Cape Morgan on Akutan Island and Ugamak Island in Unimak Pass; these two sites account for over 55 percent of the total animals (15000-35000) seen on breeding islands or sites in the eastern Aleutians (Braham et al. 1980).

Sea lions are regularly found in midshelf waters (Scheffer 1958, King 1964, Schusterman 1981). Their pelagic occurrence is most likely related to food searching. Pollock compose roughly 80% (wet-weight volume) of the sea lion diet. Other fish (flatfish, capelin, herring, salmon, cod, cottids) and invertebrates (squid predominate) make up the rest of their diet (Braham et al. 1982, Lowry et al. 1982b). Most studies of Steller sea lion food habits have been made southeast of our area of interest. Fiscus and Baines (1966) reported

on a small sample from the Unimak Pass area and found the prey ranking to be capelin, sand lance, sculpins, pollock, flatfish, and Atka mackerel.

Sea lion populations have followed a downward trend in the eastern Aleutian Islands (and some other portions of the Bering Sea including Amak Island, Pribilof Islands) since the late 1970's. For example counts at the haulout areas on Unimak Island including Sea Lion Point/Cape Sarichef, Oksenof Point, and Cape Mordvinof were as high as 4,000 in 1960, but less than 100 in 1975-77. The current status of the sea lion population is unknown, but between 1971 and 1975 the decline was estimated to be 50 percent (Braham et al. 1982). (Mathisen and Lopp [1963] noted 50,000 in 1957, whereas Braham et al. [1980] found fewer than 25,000 in 1975 to 1977.) The causes for these apparent changes are unknown; however, the apparent decline in the eastern Aleutians corresponds to a concurrent increase in commercial groundfish fisheries that presumably competed for preferred foods (Braham et al. 1980). Fowler (1982) has recently suggested that entanglement with net fragments in areas of intense foreign fishing may be a significant source of mortality for fur seals, and the same may be true for sea lions.

**Northern Fur Seal *(Callorhinus ursinus)***

Over 70% of the world's population of northern fur seals breeds and pups on the Pribilof Islands (Kajimura et al. 1980, Kozloff 1981, Braham et al. 1982). Numbers of fur seals breeding in the Pribilof Islands have been decreasing markedly during the years preceding (and during) this study. Mortality of fur seals due to entanglement in marine debris is believed to have contributed significantly to the trend of reduced population size (Fowler 1982, 1987).

From late May through early November, most of these animals are found in the Bering Sea. During the summer, adult females and subadult animals range far from the Pribilof Islands in search of prey. Most of these animals appear to move south towards the shelf break, but others disperse widely over the shelf, including into midshelf waters. An unknown number of adult males may overwinter in Bristol Bay (Braham et al. 1982). During winter most seals remain 46 to 93 km offshore. The information on the pelagic distribution of fur seals indicates that the Bering side of our area of interest is an area of relatively high density of fur seals. All the eastern Aleutian passes, but apparently primarily Unimak (Braham et al. 1982), serve as migration corridors in spring (April-June) and fall (August and November).

Fur seals feed primarily at night and early in the morning. In areas where food species remain in upper water layers, fur seals are known to feed actively throughout the day. Their major foods remain the same each year, changing only in rank of importance. In the Bering Sea their diet consists of squid, pollock, seal fish (*Bathylagus* sp.), salmon, and lamprey (Scheffer 1950).

Kajimura et al. (1980) reported that fur seals collected in the Bering Sea had been feeding primarily on capelin, pollock, Atka mackeral, deep sea smelt, and gonatod squids (*Berryteuthis magister* and *Gonatopsis borealis*). Lander and Kajimura (1976) state that fur seals feeding over the continental shelf tend to feed on fishes, while in areas beyond the shelf they feed mostly on squids.

The most complete analysis of fur seal feeding habits appears to be a series of reports which were prepared using the pelagic collections of fur seals made by the US and Canada during 1958 to 1974 as the data base (Perez and Bigg 1981a, b). Fishes of the gadid and osmerid families and squid of the gonatid family made up the most important components in the fur seals' diet in the eastern Bering Sea. The primary species taken were walleye pollock, capelin, and *Berryteuthis magister*. In the Unimak Pass area, the most important prey species was capelin during all months. The second most important were the squid *Berryteuthis* in June, pollock in July and August, *Berryteuthis* again in September, and Atka mackerel in October. Perez and Bigg (1981b) found that the diet for both male and female fur seals was essentially similar in general pattern of diversity, preference, and importance of prey within the diet.

**Sea Otter *(Enhydra lutris)***

Sea otters were formerly widespread and abundant throughout the southern Bering Sea, but by the early 1900's hunting had reduced the population to a small colony near Unimak Island and perhaps a few individuals in the Fox Islands. During the past 70 years the numbers of sea otters have increased remarkably, but large areas of uninhabited or partially repopulated habitat remains (Schneider 1981). The area of highest abundance just barely encroaches on our area of interest, extending from mid-Unimak Island east beyond Izembek Lagoon.

Four separate colonies became established in the Fox and Krenitzin islands during the 1960's. All are growing, but they amount to only a few hundred animals, and most of the reproductive animals remain concentrated in small areas (Schneider 1981). Use of our area of interest was no doubt substantially greater in the past than it is today.

Sea Otters are shallow-water animals rarely seen in water deeper than 55 m. But Leatherwood et al. (1983) reported "significant numbers of individuals to depths of 128 m." During summer otters are more widely distributed (less confined to the nearshore) and some are found in the deep water north of the Aleutians (Leatherwood et al. 1983).

As winter advances sea otters move to the west and possibly south of the peninsula. If a southward migration occurs, False Pass has been hypothesized to be the route (see Armstrong et al. 1984).

Sea otters eat a wide variety of bottom-dwelling invertebrates and will also eat fishes if the invertebrate population becomes depleted (Kenyon 1969, Calkins 1978). The diets of sea otters in the Bering Sea area have not been comprehensively examined; preliminary results of ongoing OCSEAP studies indicate that otters may feed predominantly on yellowfin sole. Other prey include crabs, snails, shrimp, and bivalve molluscs in unknown proportions. In the Aleutian Islands, benthic invertebrates (mostly sea urchins) comprised the entire diet of newly-established otter populations, whereas fishes were the major prey of long-established populations, probably due to changes in prey availability (Estes et al. 1982). Sea otters are highly opportunistic feeders and will exploit and often deplete whatever food sources might be available.

In or near to our area of interest, Kenyon (1969) reported on two sea otters collected in 15-20 fathoms of water north of Unimak Island (July 1960). By volume they contained 63% clam, 17% hermit crab, 14% fish (greenling), and 5% tanner crab.

## Endangered Whales

Several endangered whales were once sufficiently numerous to form the basis of a shore-based whaling industry situated on Akutan Island. Two species—fin and humpback whales—were the most numerous within our area of interest and are still the most regularly encountered. Other species were never as numerous in the study area, due either to lower abundance or to more peripheral centers of abundance. These whales are described here (fin and humpback in the most detail) because of the particular interest in them as endangered species and because they formerly occupied the Unimak Pass area. Most of these populations remain severely depressed even though whaling ceased in this area in 1939. Aerial surveys of this area in the summer of 1984 failed to locate any of these species except fin whale (Stewart et al. 1987).

### Fin Whale *(Balaenoptera physalus)*

Fin whales were formerly abundant in the southeastern Bering Sea and along the south side of the Aleutian Islands. This abundance is shown by the large numbers of fin whales killed by shore-whalers operating from Akutan (Reeves et al. 1985.), by Japanese whalers operating around the Aleutians and along the continental shelf northwest from Akutan towards the Pribilofs (Nemoto 1963), and by Soviet whalers operating with pelagic fleet expeditions to the eastern Bering Sea (Berzin and Rovnin 1966, cited in Leatherwood et al. 1983). The take by the Akutan fishery indicates that fin whales were relatively abundant near Unalaska and Akutan islands.

The Japanese take in particular suggests an affinity of fin whales for the shelf edge north of the Aleutians. There were heavy catches from 1954 to 1964 in the waters between ca. 54°N and 55°N and 165°W and 172°W (Nemoto

1963, Nishiwaki 1966, Nasu 1966). This productive whaling ground for fin whales is centered on our area of interest. Nasu (1974) attributed concentrations of fin whales northwest of Unalaska Island to the presence of an oceanic front and associated high marine productivity. Observations by Japanese scouting boats indicate that fin whales continued (1965-1979) to exist at relatively high levels of abundance in our area of interest (Wada 1980), particularly in the Unimak Pass area and along the 100 m contour north of there. Lowry et al. (1982b) list the area "north of Unalaska Island" as one of the areas where fin whales are most often sighted.

All of the sightings of fin whales made by Leatherwood et al. (1983) were in water less that 110 m, indicating that this species regularly inhabits continental shelf waters. However, Leatherwood et al. (1983) did not record any fin whales in our area of interest. Stewart et al. (1987) report two sighings of fin whales during the summer of 1984 just west of Akutan Island in Akutan Pass.

Leatherwood et al. (1983) encountered fin whales in the Bering Sea only between April and September. Most are presumed to be present for only the six-to-eight month spring-to-fall period. but there are records from off the Commander and Aleutian islands through October and November (Votrogov and Ivashin 1980). Some fin whales reportedly winter in the Bering Sea, e.g., near the Commander Islands (Barabash-Nikiforov 1938), and others may winter at the ice edge near St. Matthew Island (Brueggeman et al. 1983). The "American" stock may migrate annually between Baja California and the Bering and Chukchi seas (Lowry et al. 1982b). Migration into the Bering apparently takes place through both Unimak and Akutan passes (Stewart et al. 1987).

Fin whales prey within the pelagic food web; they are probably the most polyphagous of the baleen whales (Lowry et al. 1982b). In the Bering Sea they consume a larger number of species than in the Antarctic, where they eat almost exclusively euphausids (Nemoto 1957). Their diet appears to change from year to year and from location to location, depending on whether euphausids, copepods, fishes, or squids are most abundant.

The diet of 156 fin whales taken on the continental shelf consisted of 97 percent fish (mostly pollock) and only 3 percent copepods; the pollock were apparently restricted to fish less than 30 cm. Herring and capelin are also frequently eaten. Fin whales also eat arctic cod, saffron cod, Pacific cod, Atka mackerel, rockfish, sand lance, smelt, Japanese anchovy, Pacific saury, chum salmon, among others (Tomilin (1957). Squid are occasionally taken.

In the Bering Sea, *Thysanoessa inermis* is the most important euphausiid prey of fin whales, as well as most other baleen whales. This euphausiid forms extensive swarms over the continental shelf margin from July to September (Nemoto 1970). *Calanus cristatus* is the most important

copepod prey of fin whales in the Bering Sea (Nemoto 1959). Only the copepodite-5 stage, an immature form which is present in near-surface waters, is eaten by the whales. Copepods tend to be an important food item in spring and early summer when water temperatures are low; later in the year euphausids assume greater importance.

**Humpback Whale (*Megaptera novaeangliae*)**

The humpback whale is another endangered species occurring within the area of interest, formerly in some abundance. At least 1793 humpbacks were landed at Akutan from 1914 to 1939 (Leatherwood et al. 1983). Humpbacks were caught mainly in the Pacific, Unimak Pass, and the Bering Sea just north of the pass (Reeves et al. 1985, Stewart et al. 1987). During the early 1960's large numbers of humpbacks could still be found around the eastern Aleutians and south of the Alaska Peninsula from 150°W to 170°W (Rice 1974). Berzin and Rovnin (1966, cited in Leatherwood et al. [1983]) considered "the center of the summer habitat" of humpbacks in the North Pacific to be between 145°W and 170°W south of the Aleutians, and "to the north of Unimak Strait."

Recent observations indicate that humpbacks continue to be widely distributed during summer on the continental shelf of the southeastern Bering Sea (mostly outside our area of interest) (Nemoto 1978, Strauch 1984) and in the Unimak Pass area (Braham et al. 1982). All observations of humpback whales made by Leatherwood et al. (1983) were in shallow shelf waters less than 154 m deep.

The sightings in the Unimak Pass area demonstrate that humpbacks are there, mainly along the narrow shelf to the west of the pass. Judging by seasonal plots, humpbacks expand their range during summer and fall into many parts of the southeastern Bering Sea as well as along both the north and south sides of the Aleutians. Humpback whale use of the Unimak Pass area is likely to be predominantly from April through October.

Humpback whales prey within the pelagic food web. In the North Pacific, both zooplankton and fishes are major foods of humpbacks (Nemoto 1959, Kawamura 1980, Winn and Reichley 1984). In the northern part of the North Pacific, Nemoto (1959) found only euphausids in 203 of 272 stomachs containing food. Fifty-three stomachs contained only fishes, and the remainder a combination of fishes and euphausids. Squids were present in only two stomachs. The pollock in the diet were predominantly of fish 40-50 cm in length (larger than the size class selected by fin whales). Near Attu and south of Amchitka humpbacks ate Atka mackerel (Nemoto 1957); whereas in other parts of the Aleutians they fed on euphausids and pollock (Nemoto 1959). Other fish eaten by humpbacks include herring, capelin, sand lance, smelt, cods, salmon (pink and chum), rockfishes, greenling, saffron cod, and arctic cod (Nemoto 1959, Tomilin 1957).

**Right Whale (*Eubalaena glacialis*)**

Right wales occur in northern waters (north of 50° N) only during the summer (April-September). They were formerly taken by aboriginal hunters in the Aleutian Islands (Mitchell 1979) and by commercial whalers based at Akutan (see Leatherwood et al. 1983). Two records are from Unimak Pass itself. Modern sightings of this very rare animal are quite infrequent (see summary in Leatherwood et al. 1983) and no positive records from our study area are evident. (Many records are presented by general region that sometimes include portions of our area.) There are records for the Bering Sea as recent as 1982 (Brueggeman et al. 1983), hence this species may still use the Unimak Pass area during migration.

**Blue Whale (*Balaenoptera musculus*)**

Another endangered species, the blue whale, is not to be expected to occur in appreciable numbers within the study area. Historically, vessels based at the Akutan whaling station regularly took blue whales, and at least 1,000 were taken between 1914 and 1939 (Leatherwood unpubl. data). Evidently most of these were killed south of the Aleutian chain, many near Davidson Bank (Birkeland 1926). Rice (1974) considered the area south of the Aleutian Islands between 160°W and 180°W to have been a major summer concentration area. The available information suggests that the Bering Sea portion of our study area was historically of little importance to blue whales.

**Sei Whale (*Balaenoptera borealis*)**

Sei whales prefer subtropical to cold temperate pelagic regions and avoid polar and shallow coastal waters (Tomilin 1957). Like other balaenopterids, sei whales apparently migrate to lower latitudes in winter and to high latitudes in summer. Thus, they would be expected well south of our area of interest during winter months. In summer, sei whales reportedly are common along the Aleutian Islands (Murie 1959, Masaki 1977, Nemoto and Kawamura 1977). Sei whales were rarely taken by the shore whalers at Akutan during the first 40 years of the twentieth century (Leatherwood, unpublished data), but the population has been dramatically reduced since the early 1960's when intensive whaling began for this species.

**Sperm Whale (*Physeter macrocephalus*)**

Most sperm whale hunting historically took place south of the 40°N latitude (Townsend 1935, Banister and Mitchell 1980); however, some were taken by the Akutan whalers (Birkeland 1926, Leatherwood unpubl. data). In the Unimak Pass area, they presently occur mainly during summer and fall, in or near Unimak Pass and on the continental slope west of the pass.

Sperm whales are said to arrive near the Aleutians in March (some may overwinter there), and large numbers appear in the eastern Bering Sea by April (Berzin and Rovnin 1966). The greatest concentration in the Bering Sea is reportedly to the north of Atka Island (Omura 1955, Berzin and Rovnin 1966). In September, many of the sperm whales that summered near the Aleutians begin to move south. Only males have been recorded in the Bering Sea; females usually remain south of 45°N. Sperm whales show a clear preference for deep waters at the shelf edge, on the continental slope, or over offshore canyons. The distribution in the eastern Bering Sea mapped by Nishiwaki (1966) based on Japanese whaling data, and by Berzin and Rovnin (1966) based on their own observations supplemented by Soviet whaling data, shows a remarkably close correlation with the shelf edge. The narrow width of the shelf along the south side of the eastern Aleutians ensures that sperm whales appear regularly within our area of interest.

### Other Mammals

A few additional species of marine mammals occur regularly within the study area. None were identified as a key species for purposes of our study.

#### Minke Whale (*Balaenoptera acutorostrata*)

The minke whale has a worldwide distribution. Because of its small size, it was not a major target of commercial whalers in most areas until the reduction in populations of larger, more valuable species required a shift in whaling effort. The lack of whaling effort has resulted in a poor historical record for this species in comparison with records for the previously discussed whales.

Minke whales are common during the spring and summer months in the Bering Sea and coastal Gulf of Alaska (see Stewart and Leatherwood 1985). Frost et al. (1982) stated that this species is most abundant in the Aleutians from May to July. The minke whale is the most numerous baleen whale in the study area (Braham et al. 1977).

Minke whales are found in shallow shelf waters as well as deep areas far from shore (Lowry et al. 1982b, Strauch 1984, Armstrong et al. 1984). It has been suggested that minke whales occupy the St. George Basin year-round, with greatest concentrations in summer (May to July) near the eastern Aleutian Islands (Braham et al. 1982). Sightings indicate that winter densities are lower and that the animals are generally found farther from shore during winter.

Direct evidence concerning diets of minke whales in the southeastern Bering Sea is sparse, but Frost and Lowry (1981) indicated that euphausids and

pelagic and semidemersal fishes, including herring, are taken. Leatherwood et al. (1983) reported seeing minke whales swim through (and presumably feed upon) schools of fish (thought to be herring) in Bristol Bay.

**Killer Whale (*Orcinus orca*)**

Killer whales occur in all oceans and may be encountered in marine waters anywhere. Killer whales occur both north and south of the Aleutians. They seem more abundant in the eastern islands (Braham et al. 1977), where they occur primarily on the continental shelf in waters less than 200 m deep and along the 200 m contour northwest to 60°N (Braham and Dahlheim 1982, Braham et al. 1982). They probably occur year round within the area of interest. Surveys by Leatherwood et al. (1983) indicated that killer whales make equal use of continental shelf, continental slope, and pelagic waters.

Killer whales are opportunistic feeders and have one of the most diverse diets of any of the marine mammals. Worldwide the diet includes seals, sea lions, cetaceans, fishes, sharks, seabirds, sea turtles, and squids (Rice 1968, Caldwell and Caldwell 1969). Pods of whales use coordinated feeding behavior when preying on marine mammals (e.g., Smith et al. 1981) and perhaps also on fishes (herring) (Steiner et al. 1979). Lowry et al. (1987) described an incident of killer whales pursuing a minke whale and causing it to beach itself at Unalaska Bay, within our study area.

**Harbor Porpoise (*Phocoena phocoena*)**

Little detailed information is available regarding the distribution of this small cetacean. Records within the Aleutians are not numerous (Murie 1959, Alaska Maritime National Wildlife Refuge 1981). Seasonal shifts in abundance suggest that migrations of some sort occur (Leatherwood and Reeves 1978) but data are insufficient to detail the patterns. In southern portions of harbor porpoise range, they are generally seen near the coast in waters less than 20 m deep (Leatherwood and Reeves 1978). Very little of our study area, and none of it accessible by ship, is this shallow. Leatherwood et al. (1983) did not encounter this species in our area, although they did frequently record harbor porpoises within Bristol Bay, generally (79% of sightings) nearshore of the 128m contour.

**Harbor Seal (*Phoca vitulina*)**

Harbor seals occur in littoral waters throughout the Unimak Pass area. Concentrations occur at the Baby Islands and off the northwest end of Tigalda Island and Rootok Island (Braham et al. 1977, Everitt and Braham 1978). The population throughout the eastern Aleutian Islands is estimated to be approximately 4,000 seals (Everitt and Braham 1978, 1980, Braham et al. 1977). In comparison with populations on the Alaska Peninsula and elsewhere in

the Aleutians, these are relatively small populations; they appear to be resident, breeding on the islands and feeding year-round in adjacent waters.

Haulouts are used for resting, molting, and care of young. Seals haul out on sand bars and other areas exposed by the tides, and more animals have been observed hauled out at low than at high tides (Everitt and Braham 1980). Peak use of haulout areas occurs during the molt in June and July and apparently tapers off in September and October when seals spend more time in the water.

## METHODS

Distributions and abundances of marine mammals were assessed using shipboard rather than aircraft-based surveys. Ship-based surveys have several advantages. Use of a ship as a sampling platform permits more detailed study of the smaller organisms that often cannot be detected or identified from the air. The ship allows more precise documentation of certain important behaviors that cannot be ascertained from the air. Most importantly, use of a ship permits concurrent measurements of prey availability and oceanographic conditions—information that is critical when trying to determine correlative and/or probable causative factors for marine mammal distributions.

Unfortunately, shipboard counts suffer from the problem that the organisms being censused move much more rapidly than the counter; this fact alone makes reliable density estimation impossible (Burnham et al. 1980). While this problem is not as extreme with marine mammals as it is with birds, it still remains. Dall's porpoise is an example of a marine mammal that frequently overtakes ships. This species also provides problems in density estimation since it appears to be attracted to vessels. Many *ad hoc* methods of minimizing this inherent bias have been employed but the accuracy of none of them is verifiable. Another problem is that surveys near shore are impossible using deep-draft ships. For example, the minimum sampling depth from the R/V *Miller Freeman* was approximately 20 m, and much more in areas of irregular bottom. Within the Unimak Pass study area it was rarely feasible to conduct shipboard transects in water less than 50 m depth.

Counts of marine mammals were made concurrently with surveys of marine birds during three cruises of the R/V *Miller Freeman*--fall (18 Sept 7-Oct 1986), winter (14 Feb-9 Mar 1987), and spring (21 Apr-14 May 1987). Surveys were made along predetermined survey lines while the ship was at or near full steam. Many lines were surveyed repeatedly each season to ensure sampling of all major depth classes and (expected) oceanographic domains (e.g., survey lines passed through Gulf of Alaska and Bering Sea sides of the Aleutians and all passes and straits within the Krenitzin Islands). Transects were defined as the segments of survey lines covered each 10-min

interval, as is the customary protocol for conducting marine surveys in Alaska. The biologist censused from the flying bridge, counting all animals seen within a 90° arc.

Marine mammals seen were recorded as being in one of four distance increments parallel to the course of the boat: 0-100 m, 100-200 m, 200-300 m, and >300 m. Calculations of densities were based on sightings in the first three bands only; the fourth zone was used to record off-transect sightings. Due to the low number of encounters of marine mammals, calculations were based on animals seen in the entire 300 m wide transect.

During the conduct of each transect, observers recorded the time, date, ship speed, water depth, and location coordinates of starting and end points. Weather information included temperature, cloud cover, sea state, precipitation, wind speed, and temperature (air and sea surface), and was obtained hourly from the ship's log. During most survey periods, the ship's echosounders were run to provide a qualitative record of prey availability. Both 100 kHz (invertebrate) and 38 kHz (fish) recorders were used. Sea surface temperatures were recorded using a temperature probe affixed to the side of the ship near the waterline, or as recorded at the seawater intake of the ship, just below the surface.

Analyses conducted included tests for differences in mammal abundance among cruises (seasons) and summaries of densities in each water mass (Chapter 10, Appendix A). Because these water masses were also used to characterize zooplankton abundance patterns (see Chapter 3: ZOOPLANKTON ABUNDANCE AND DISRIBUTION, this volume), we were able to discuss apparent correlations between distributions of the mammals and the invertebrates. To separate the northern parts fron the southern parts of Gulf of Alaska Water and Alaska Coastal Water (see Chapter 10, Appendix A), we arbitrarily drew a line joining points of land across the narrowest portion of Unimak Pass. Thus, most of Unimak Pass itself is in the northern portion of the Alaska Coastal Water.

Locations of all on-transect sightings were transferred onto maps of the study area on which the survey lines were depicted. Each sighting location was plotted at the midpoint of the transect on which the marine mammal was seen. Finally, maps were prepared that represented the densities of mammals by circles of varying sizes; the area of each circle was proportional to the density of the animals recorded.

## RESULTS

### Seasonal Abundance

The abundance of most marine mammals species differed appreciably among the three cruises (Table 3). Three species—sea otter, northern fur seal,

Table 3. Densities of marine mammals by cruise along with test results for differences in abundance among cruises (seasons).

| SPECIES/SEASON | Fall 86 | Winter 87 | Spring 87 | $\chi^2$ | prob |
|---|---|---|---|---|---|
| Sea Otter | 0.029 | 0.007 | 0.009 | 13.739 | < 0.005 |
| Steller's Sea Lion | 0.003 | 0.002 | 0.000 | | |
| Northern Fur Seal | 0.039 | 0.000 | 0.000 | 48.971 | < 0.005 |
| Harbor Seal | 0.004 | 0.000 | 0.000 | | |
| Killer Whale | 0.005 | 0.000 | 0.009 | | |
| Dall's Porpoise | 0.139 | 0.074 | 0.051 | 32.910 | < 0.005 |
| Gray Whale | 0.000 | 0.000 | 0.003 | | |
| Minke Whale | 0.004 | 0.003 | 0.001 | | |
| Fin Whale | 0.000 | 0.000 | 0.003 | | |
| small whale | 0.000 | 0.002 | 0.000 | | |
| sea mammal | 0.000 | 0.017 | 0.000 | | |
| Total | 0.223 | 0.104 | 0.076 | | |
| Area Sampled ($km^2$) | 748.772 | 593.974 | 670.452 | | |

and Dall's porpoise—were sufficiently numerous to permit statistical testing for differences in abundance (testing the null hypothesis that the number of mammals enumerated in proportion to the sampling effort was not different among seasons). All of these had very significant ($p < 0.005$) departures from equal abundance among cruises.

**Fall**

Most species peaked in abundance during the fall cruise. This was true of all species for which testing for seasonal changes in abundance could be done. The total density of marine mammals during the fall was twice as high (0.223 mammals/$km^2$) as during any other season.

The most numerous species of marine mammal encountered at sea during the fall (and in all other seasons) was Dall's porpoise. Next in abundance was northern fur seal, the key mammal study species. Third in abundance was sea otter. The observation that the sea otter was one of the most numerous mammals encountered on transects indicates the overall rarity of marine mammals, since sea otters are primarily coastal in distribution and would not have been expected to occur in most of the study area.

Two humpback whales were encountered northeast of Akun Island near the area of seabird concentrations, though they were not seen on a transect. This was our only sighting of this endangered species during the three cruises for this study.

**Winter**

The winter cruise results indicated that the overall density of marine mammals was approximately half of that present during the fall cruise. Dall's porpoise continued to be the most numerous species, and all other species were very infrequent. Minke whales were at or near their maximum abundance among all three cruises (the unidentified small whale could have been a minke whale).

**Spring**

Results of the spring cruise suggested that marine mammals were scarcest at this season. Overall densities were only one-third of those recorded during the fall cruise. Dall's porpoise continued to be the most numerous marine mammal species encountered. This was the only cruise during which gray and fin whales were encountered.

Another cetacean seen only during the spring cruise was Baird's beaked whale (*Berardius bairdi*). A small pod of these whales (≈ 5 animals) was seen repeatedly on 11 May 1987 while we occupied a time-series CTD station north

of Unalaska Island, at location 54.17.8° N 166.27.2° W (station 21.1). This location was in the restricted area of deep water (≈ 1000 m) on the Bering Sea side of our study area.

## Spatial Distribution

### Fall

Most marine mammals sightings were within the Bering Sea (Fig. 1). The only species encountered that were not seen in the Bering Sea were killer whale (one sighting south of Ugamak Strait) and minke whale (one sighting south of Rooktok Island). Within the Bering Sea there was a tendency for most mammal sightings to be northeast of Akun Island, in the northern portion of Unimak Pass. This was particularly true of Dall's porpoise but was also evident for sea otter. The single harbor seal seen was also there. Northern fur seals were restricted to the Bering Sea west of Unimak Pass.

### Winter

The winter sightings of marine mammals indicate a southern shift in distribution relative to fall (Fig. 2). Minke whales and sea otters were seen only within the protected waters of the Krenitzin Islands. The only Steller sea lion encounter during a shipboard transect was also in this area, in Unalga Pass (the sighting cannot be discriminated from a transect point in Fig 2). Dall's porpoise sightings were restricted to the southernmost portions of the study area in the deep waters of the Gulf of Alaska.

### Spring

During the spring cruise marine mammals were somewhat more diffuse than during the other two cruises, and fewer were seen in the Krenitzin Islands (Fig. 3). Dall's porpoises were found in the two regions of deep water in the study area--the portion of the Bering Sea north of Akutan Pass (most sightings were in this area) and the deep Gulf of Alaska water at the southernmost limits of the study area. As during previous cruises killer whales were found close to the Krenitzin Islands. A minke whale appeared to be feeding within the Krenitzin Islands at station 22-11 (54°05.7N 165°33.1 W) while we were sampling with bongos.

Two endangered whale species were found during the spring cruise. Fin whales were seen just north of Unimak Pass. Gray whales were encountered close to Unimak Island on both the Bering Sea and Gulf of Alaska sides of the Island.

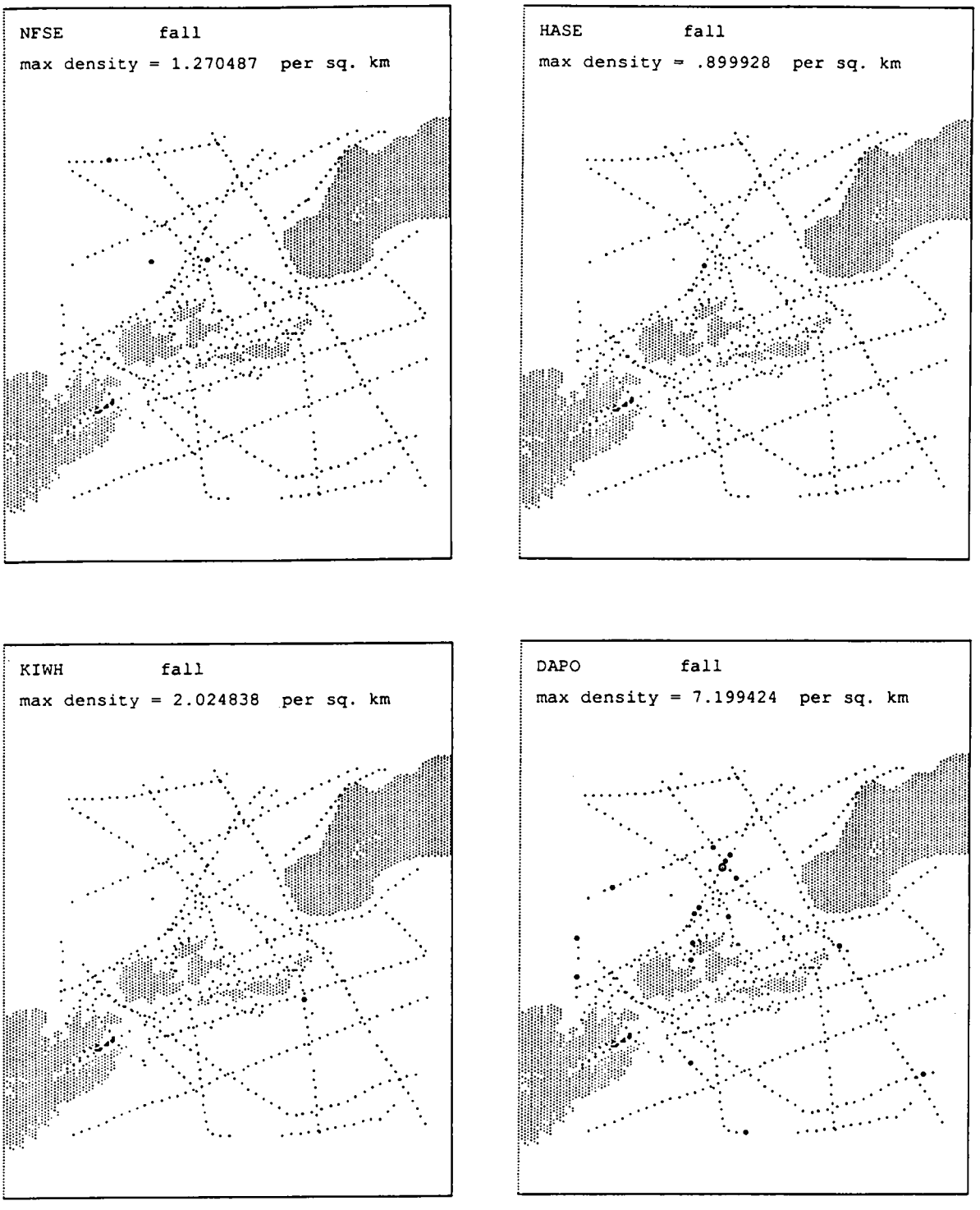
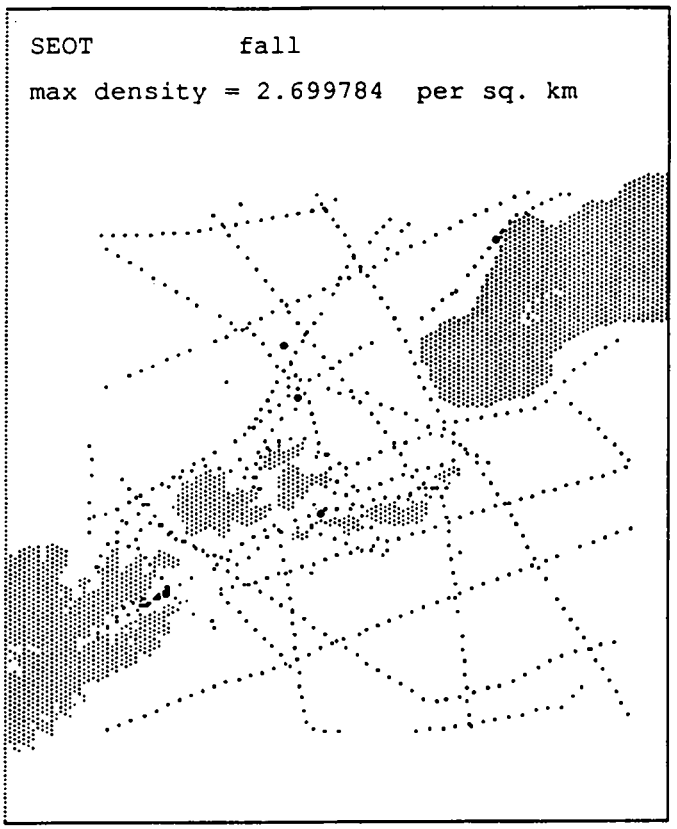



Figure 1. Distribution of marine mammals recorded on transects during the fall cruise (Each dot represents a transect surveyed). Density of mammals is indicated by the size of the circle; area of the circle is proportional to the density. The maximum density is listed at the top of each map. (DAPO=Dall Porpoise, SEOT=Sea Otter, KIWH=Killer Whale, MIWH=Minke Whale, NFSE=Northern Fur Seal, HASE= Harbor Seal.)



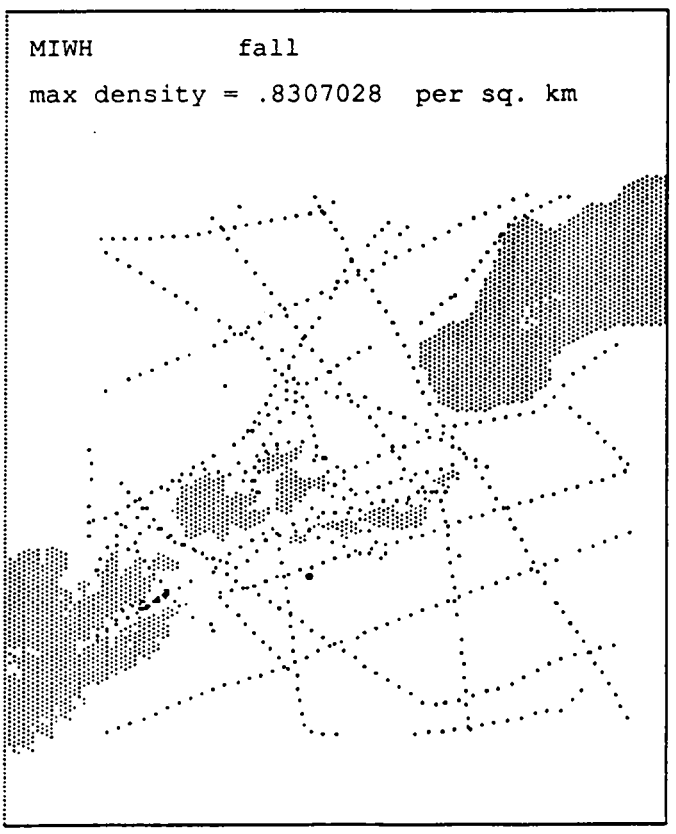




Figure 1 (cont.)

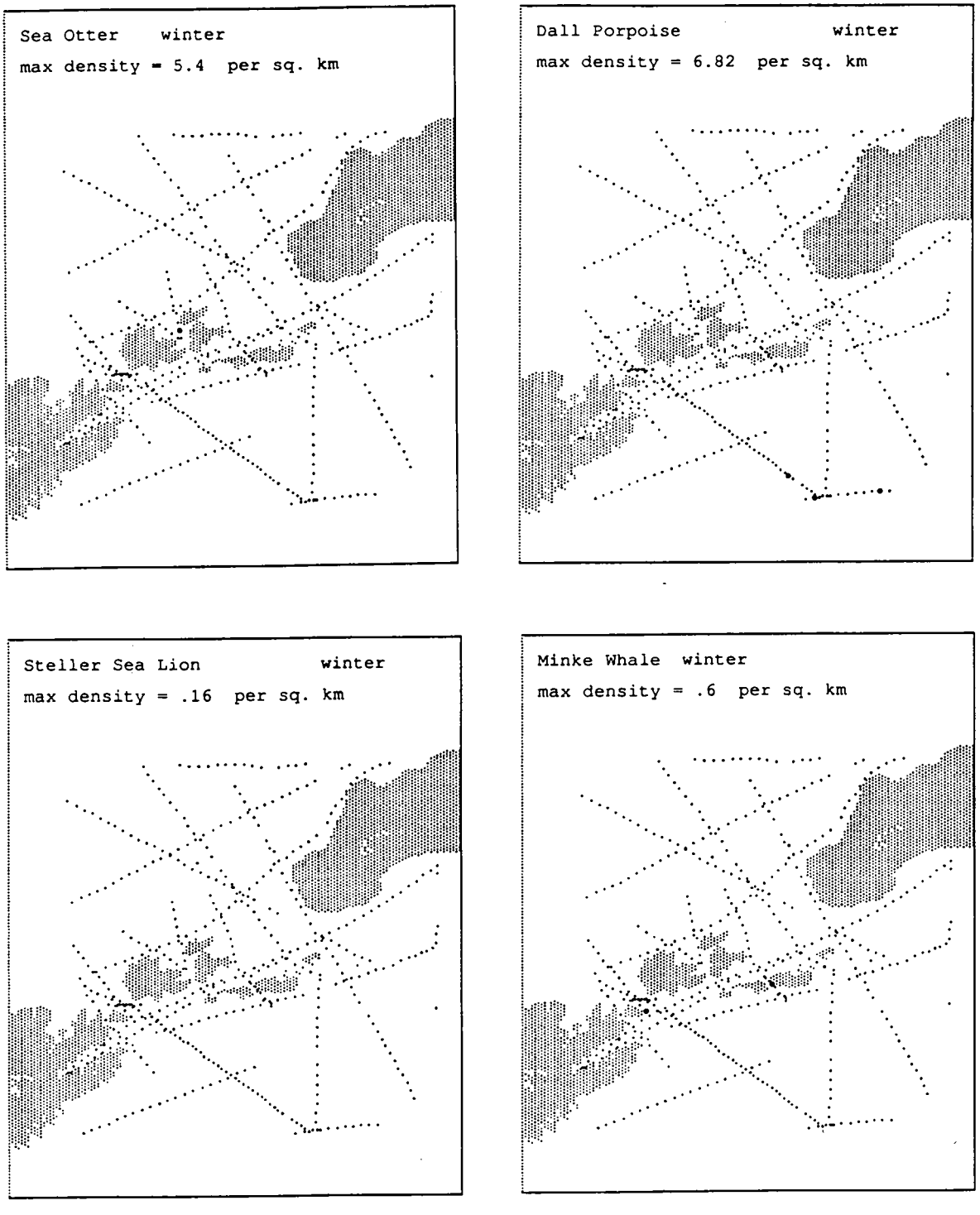



Figure 2. Distribution of marine mammals recorded on transects during the winter cruise (Each dot represents a transect surveyed). Density of mammals is indicated by the size of the circle; area of the circle is proportional to the density. The maximum density is listed at the top of each map.

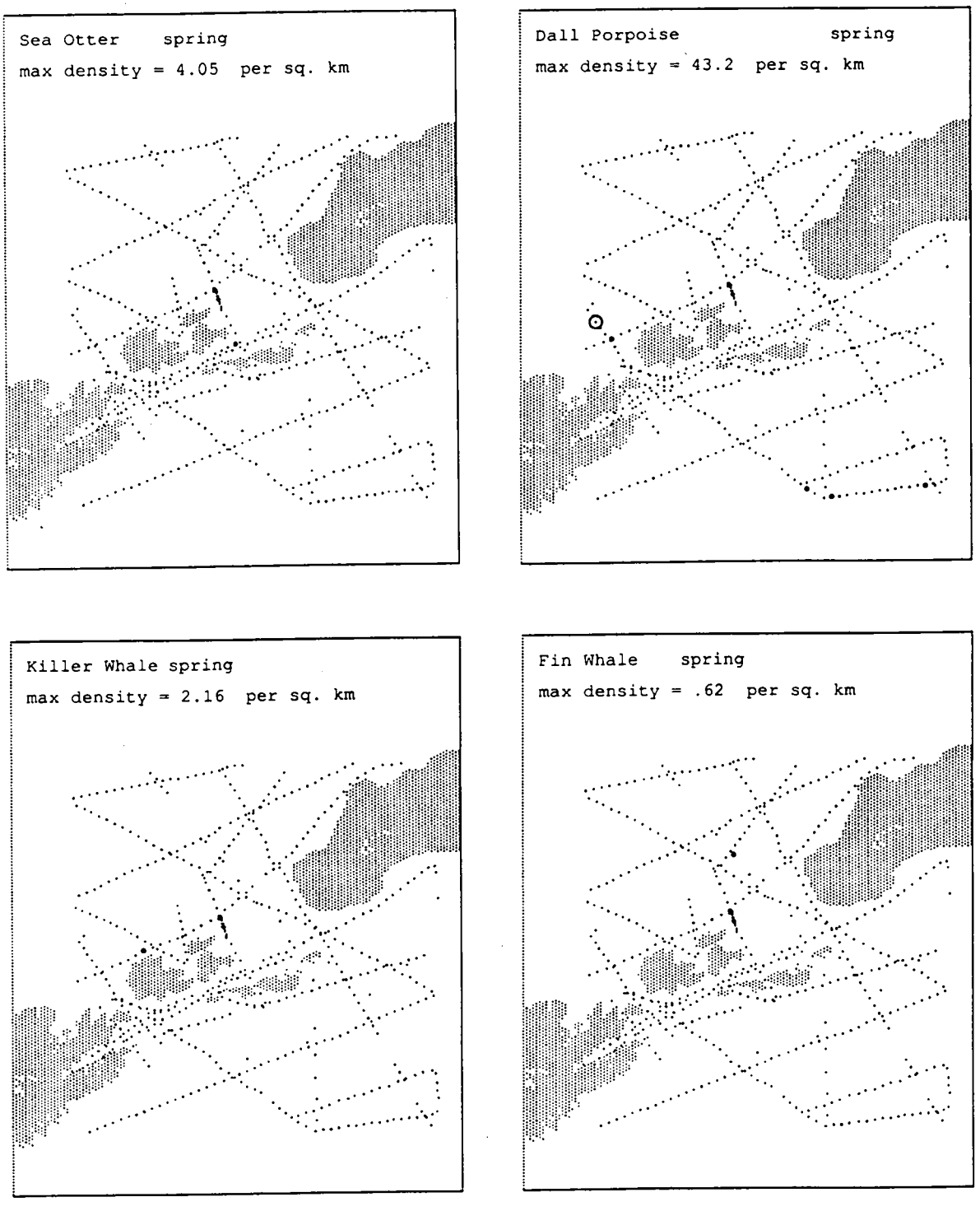



Figure 3. Distribution of marine mammals recorded on transects during the spring cruise (Each dot represents a transect surveyed). Density of mammals is indicated by the size of the circle; area of the circle is proportional to the density. The maximum density is listed at the top of each map.

## Associations with Water Masses

### Fall

Marked differences in abundances of marine mammals were evident among water masses (Table 4). The highest densities occurred in the Gulf of Alaska Water north of the pass (GAWn) and relatively high densities were found in the Shelf Break Water (SBW). (see Chapter 10, Appendix A for water mass distributions.) In both these water masses Dall's porpoise contributed most to the high densities (this species was the most common marine mammal in all water masses except the Tidally Mixed Water [TMW]). GAW was the only water mass where minke whales were found on transect. SBW was the water mass favored by northern fur seal. This species was also present in moderate abundance in the GAW (north and south) but very rare elsewhere.

The Alaska Coastal Water was quite depauperate in marine mammals in both the north (ACWn) and south (ACWs) regions. Not a single marine mammal was seen on transect in the south portion of this water mass. The northern portion of the ACW had relatively few marine mammal; however, harbor seals were at highest densities in this area.

Although absolute densities in the Tidally Mixed Water (TMW) were substantially lower than in the more structured water masses to the north, two species—sea otter and killer whale—were largely restricted to this water mass. Sea otter was the most numerous marine mammal recorded on transects within the TMW.

### Winter

Use of the various water masses during winter differed markedly from the use observed during the fall cruise. No marine mammals were encountered on transects in the SBW or the GAWn, the two transects with the highest densities during the fall. As in the fall, the ACWs was lacking in marine mammals.

The highest densities, by an order of magnitude, occurred in the GAWs (Table 4). Only one species, Dall's porpoise, contributed to this density. Similarly, the ACWn was dominated by a single marine mammal species; in this case only sea otter was recorded on the transects.

The Tidally Mixed Water had the most diverse marine mammal fauna with three species recorded on transects. Minke whale was found only in this water mass during the winter cruise. The appearance of Steller sea lion during the winter cruise highlights the importance of the qualification "on transect". Sea lions occurred in this region quite abundantly during all seasons, as will be shown in Chapter 7 (COASTAL MARINE BIRDS AND

Table 4. Average densities by water mass of the most common marine mammals sighted during each of the three cruises. The highest density of each species is shown in bold face. See Appendix 1 for water mass distribution. SBW=Shelf Break Water, TMW= Tidally Mixed Water, GAW=Gulf of Alaska Water (north and south), ACW=Alaska Coastal Water (north and south).

| | WATER MASS | | | | | |
|---|---|---|---|---|---|---|
| SPECIES | SBW | TMW | GAWn | GAWs | ACWn | ACWs |
| Fall | | | | | | |
| Northern Fur Seal | **0.042** | 0.005 | 0.019 | 0.014 | 0.000 | 0.000 |
| Harbor Seal | 0.003 | 0.000 | 0.000 | 0.000 | **0.006** | 0.000 |
| Sea Otter | 0.014 | **0.029** | 0.000 | 0.000 | 0.013 | 0.000 |
| Dall's Porpoise | 0.105 | 0.020 | **0.174** | 0.046 | 0.039 | 0.000 |
| Killer Whale | 0.000 | **0.007** | 0.000 | 0.000 | 0.000 | 0.000 |
| Minke Whale | 0.000 | 0.000 | **0.005** | **0.005** | 0.000 | 0.000 |
| Total | 0.164 | 0.061 | **0.197** | 0.064 | 0.058 | 0.000 |
| Winter | | | | | | |
| Steller Sea Lion | 0.000 | **0.002** | 0.000 | 0.000 | 0.000 | 0.000 |
| Sea Otter | 0.000 | 0.004 | 0.000 | 0.000 | **0.009** | 0.000 |
| Dall's Porpoise | 0.000 | 0.000 | 0.000 | **0.098** | 0.000 | 0.000 |
| Minke Whale | 0.000 | **0.004** | 0.000 | 0.000 | 0.000 | 0.000 |
| Total | 0.000 | 0.009 | 0.000 | **0.098** | 0.009 | 0.000 |
| Spring | | | | | | |
| Sea Otter | 0.000 | 0.011 | 0.000 | 0.000 | 0.005 | **0.305** |
| Dall's Porpoise | 0.000 | 0.013 | 0.015 | **0.090** | 0.000 | 0.000 |
| Killer Whale | 0.000 | **0.013** | 0.000 | 0.000 | 0.000 | 0.000 |
| Gray Whale | 0.000 | 0.000 | 0.000 | 0.000 | **0.005** | 0.004 |
| Fin Whale | 0.000 | 0.000 | **0.008** | 0.000 | 0.000 | 0.000 |
| Total | 0.000 | 0.038 | 0.023 | 0.090 | 0.011 | **0.309** |

MAMMALS), this volume, but its behavior of hauling out on beaches during the day resulted in there being virtually no sea lions observed during ship board surveys. They were seen around the ship during night operations, however.

### Spring

In spring, marine mammals were found in all water masses except the SBW. The highest densities occurred in the Alaska Coastal Water south; sea otters accounted for almost all the marine mammals in this area.

GAWs had the next highest density of marine mammals in spring; Dall's porpoise was the only species recorded on transect. This species was also the most numerous marine mammal in GAWs, GAWn, and TMW. The GAWn area was the only water mass in which fin whales were recorded in spring.

The Tidally Mixed Water continued to support the most diverse marine mammal fauna. Dall's porpoise and killer whale tied as the most numerous species. Sea otters were also present although not as numerous as in the ACWn.

## DISCUSSION

### Seasonal and Spatial Distribution

Most species recorded during this study exhibited rather substantial seasonal variations in abundance and distribution. Overall abundance of marine mammals was highest during the fall and decreased with each successive cruise. Presumably abundance increases again later in the spring or during the summer. In the case of some migratory species such as the northern fur seal the lower abundance in spring than in fall may indicate that they pass through rapidly in spring but loiter in the area during fall migration, or that our spring surveys coincided less with migration timing than did fall surveys

Dall's porpoise, minke whale, and sea otter were the only species present during every cruise. Dall's porpoise was the most numerous marine mammal in all seasons, but their distribution changed markedly each season. They were widespread in the fall, shifted to the extreme south in the winter, and restricted themselves to very deep waters in the spring. They possibly were found in the deep waters of the Bering Sea in winter, but since this habitat was quite restricted in our study area they could have been overlooked. Minke whales and sea otters were found near the Krenitzin Islands during all seasons but they, especially the sea otter, ranged farther from land during the fall.

Some comparisons between the present study and the similar North Aleutian Shelf (NAS) studies (Troy and Johnson 1987) are of interest. Although the study areas were adjacent and even overlapped slightly, the patterns of distributions and abundances of their mammals seemed often dissimilar. The season of highest marine mammal abundance in the North Aleutian Shelf was during summer, a season for which we are lacking comparable data from the Unimak Pass area. Northern fur seal, Dall's porpoise, and minke whale all peaked in abundance in the North Aleutian Shelf at this season. Stewart et al. (1987) found Dall's porpoise, killer whale, harbor porpoise, fin whales, and unidentified beaked whales within our area of interest during aerial surveys during the summer of 1984. Except for the Dall's porpoise, most of these cetaceans were close to the Krenitzin Islands (as were many of the Dall's porpoises). Overall abundance on the North Aleutian Shelf was at a minimum during the fall, the period when it peaked in the Unimak Pass area. Distributional patterns of individual key species in these areas are discussed below; unless otherwise noted the data from the NAS studies pertain to shipboard results since these are most comparable with data from the Unimak Pass studies.

**Sea Otter**

Sea otter abundance in the NAS was always at least an order of magnitude greater than in the Unimak Pass area. This is not too surprising since virtually all of the NAS was suitable for sea otters (the area was generally less than 50 m deep) whereas a great deal of the Unimak Pass study area would not have been expected to harbor sea otters.

The seasonal trends in census results also contrasted sharply. Sea otters were most numerous in the NAS during winter and lowest in the fall, opposite to the pattern in Unimak Pass. Aerial surveys in the NAS, which provided better coverage of the shoreline areas where most otters were present, showed highest densities to occur in October, but did confirm that winter was also a high abundance period for otters. High winter densities on the NAS may have been caused by influxes of otters from ice-bound waters farther northeastward and perhaps also from the Krenitzin Islands.

**Steller Sea Lion**

One conclusion that can be drawn from both the Unimak Pass and NAS studies is that shipboard surveys are inappropriate for censusing Steller sea lions. The shipboard surveys in both cases revealed only trivial numbers of this large pinniped. However, in both studies independent means of surveying shorelines (the coastal surveys in Unimak Pass and aerial surveys in the NAS) revealed a large number of sea lions present on the beaches. The NAS aerial surveys revealed that sea lion abundance peaked during winter and spring, especially in the portion of the study area near Unimak Pass.

### Northern Fur Seal

As mentioned above, northern fur seal abundance in the NAS peaked during the summer, perhaps because of seals foraging afar from the Pribilof rookeries. Unfortunately we have no Unimak census data from this season. At other seasons, patterns of abundance were similar between Unimak Pass and NAS, i.e., fur seals were present only during the fall. Abundance in fall appeared to be considerably higher in the Unimak Pass area (density of .039 vs .006 fur seals per $km^2$).

### Killer Whale

Killer whale abundance appeared to be similar in both study areas. They occurred on transects only during the fall in the NAS but were also present in spring in Unimak Pass.

### Dall's Porpoise

Dall's porpoises were quite rare in the NAS. They peaked in abundance in summer during a period when the middle oceanographic domain moved uncharacteristically shoreward, as shown by both the aerial and shipboard surveys. The only other NAS sightings were during spring but in much lower densities than occurred at any time in the Unimak Pass area. Based on the peak occurrence of Dall's porpoise in fall in Unimak Pass, we would have expected most sightings in the NAS to be during the fall, but none was recorded at this season. Since Dall's porpoise is a deep-water species, its absence from the NAS is not surprising.

During winter and spring, Dall's porpoises were largely restricted to the deep-water portions of the Unimak Pass study area. These areas corresponded to the areas where myctophids, a key prey of this porpoise, were captured in the mid-water trawls. During the fall, however, Dall's porpoises were much more widespread than myctophids, perhaps indicating that the porpoises were feeding on other prey, such as the abundant small pollock, at this season.

### Gray Whale

Similar maximum densities of gray whales (0.003 whales per $km^2$) occurred in both study areas although they occurred in different seasons. Most shipboard sightings of this whale in the NAS were during fall, whereas most were recorded in the Unimak Pass study area in spring. The NAS aerial surveys revealed that the highest densities occured during spring, and that the timing of fall migration was much later than the fall cruise for the Unimak Pass study. In both studies the sampling for gray whales was

marginal since the majority of gray whales migrate through the area in waters too shallow for surveying from a ship.

### Minke Whale

Minke whales were present in the NAS during spring and summer (highest density) whereas in the Unimak study area they appeared to be year-round residents, peaking in abundance in the fall.

### Endangered Whales

The low numbers of endangered whales recorded was no doubt influenced by their rarity and perhaps also by the timing of the cruises. A somewhat later cruise in spring or earlier cruise in fall may have turned up a few more summering individuals. Nemoto (1957) found that dense swarms of euphausiids (*Thysanoessa inermis*) occurring between July and September, were the major prey of all baleen whales in the Bering Sea.

Another factor may have been that concentrations of copepods, which form the major prey of several baleen whales including right whales, were too low along our transects to attract whales. A few stations we sampled had abundances in excess of 1 g wet wt m-3; however, Wishner et al. (1988) found average densities of copepods in patches frequented by right whales off New England to be 4 times as high as our maximum values. It is not clear why we did not find higher copepod densities.

## Associations with Water Masses

All the species examined exhibited rather striking associations with particular water masses or with subsets of water masses. As was found with birds, there was considerable temporal variation among species in their associations with water masses.

Northern fur seal, present only during fall, was most common in Shelf Break Water (Fig. 4). Except for Alaska Coastal Water, other water masses within the Bering Sea also were used, but not to the same extent.

Three cetaceans—Dall's porpoise, fin whale, and minke whale—appeared to be most commonly associated with Gulf of Alaska Water (Figs. 5, 6, and 7). In previous discussions, we noted that minke whales were associated with the Krenitzin Islands, which are surrounded by Tidally Mixed Water (TMW). But as best we can determine they were in the GAW (both north and south), although near the islands, and only during winter were they clearly in the TMW. Fin whales were rarely seen and then only in the spring, but they were unambiguously in the GAWn. Dall's porpoises exhibited some seasonal variation in where they occurred, but most of this

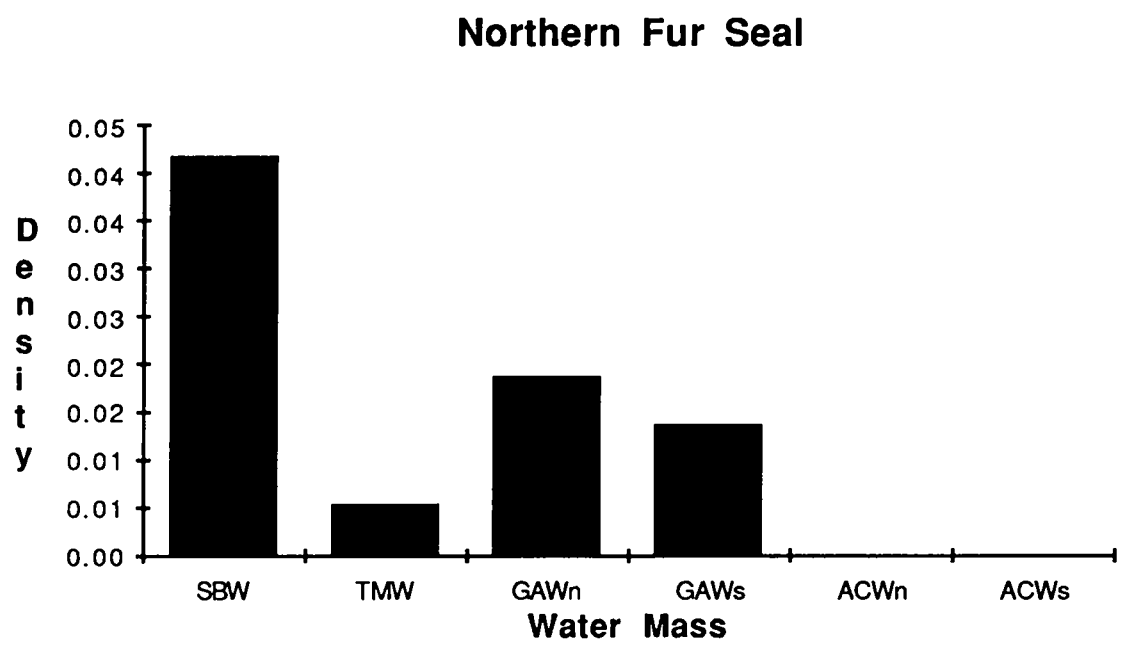



Figure 4. Summary of densities of northern fur seal by water mass during the fall cruises. Water masses are as follows: SBW=Shelf Break Water; TMW=Tidally Mixed Water; GAWn=Gulf of Alaska Water northern (Bering Sea) portion; GAWs=Gulf of Alaska Water south; ACWn=Alaska Coastal Water north (Bering Sea); and ACWs= Alaska Coastal Water south.

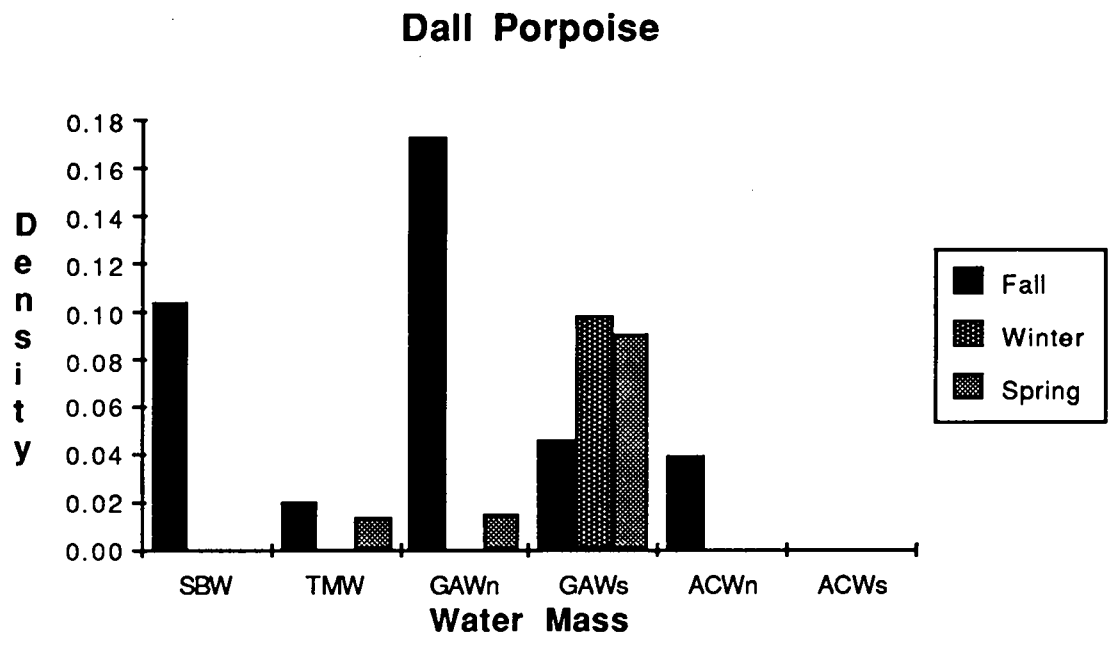



Figure 5. Summary of densities of Dall's porpoise by water mass during the three cruises. Water masses are as follows: SBW=Shelf Break Water; TMW=Tidally Mixed Water; GAWn=Gulf of Alaska Water northern (Bering Sea) portion; GAWs=Gulf of Alaska Water south; ACWn=Alaska Coastal Water north (Bering Sea); and ACWs= Alaska Coastal Water south.

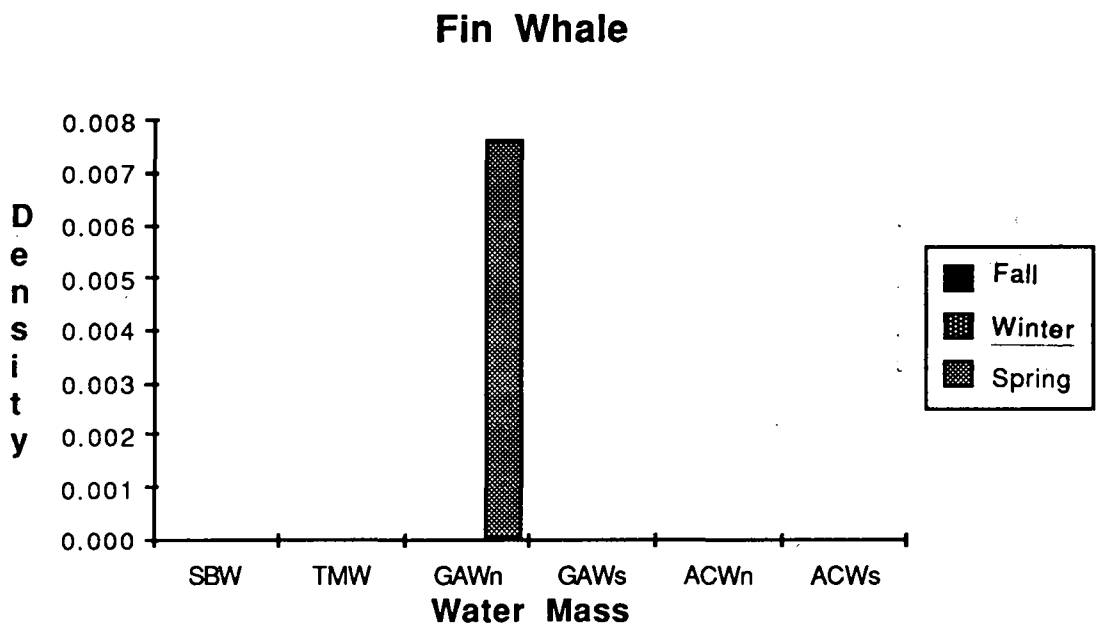



Figure 6. Summary of densities of fin whale by water mass during the three cruises. Water masses are as follows: SBW=Shelf Break Water; TMW=Tidally Mixed Water; GAWn=Gulf of Alaska Water northern (Bering Sea) portion; GAWs=Gulf of Alaska Water south; ACWn=Alaska Coastal Water north (Bering Sea); and ACWs= Alaska Coastal Water south.

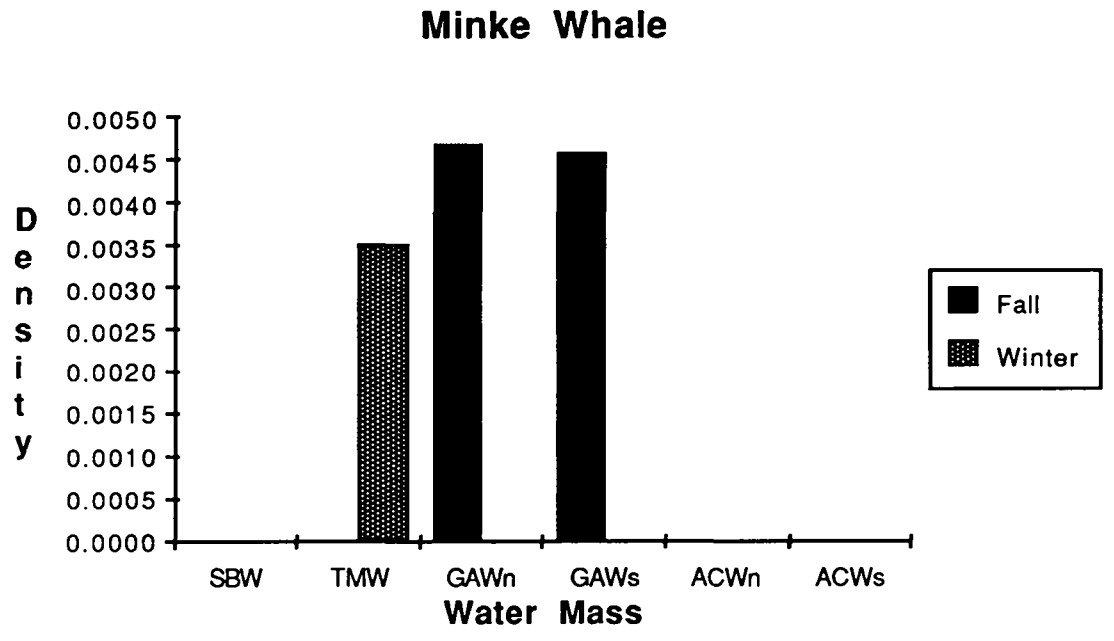



Figure 7. Summary of densities of minke whale by water mass during the fall and winter cruises. Water masses are as follows: SBW=Shelf Break Water; TMW=Tidally Mixed Water; GAWn=Gulf of Alaska Water northern (Bering Sea) portion; GAWs=Gulf of Alaska Water south; ACWn=Alaska Coastal Water north (Bering Sea); and ACWs= Alaska Coastal Water south.

variation seemed to be north-to-south movement in GAW masses. During the fall porpoise numbers were relatively high in the SBW.

The Tidally Mixed Water had the most distinctive fauna. Minke whales seemed to be associated with the TMW, at least seasonally; other species more clearly associated with the TMW were Steller sea lion and killer whale (Fig. 8). Note that none of these were particularly numerous species in the areas covered by shipboard surveys, but both were restricted to TMW.

Harbor seal, sea otter, and gray whale were found primarily in the Alaska Coastal Water (Figs. 9 and 10). Harbor seals were recorded only during the fall cruise, when they were most numerous in the ACWn. Large numbers are known to frequent the waters near the Alaska Peninsula so this result is not surprising. Considering the coastal nature of this species we did not expect to encounter very many, which was the case; the occurrence of this species in the SBW was surprising. Sea otters were found in water masses near coasts, as would be expected. They were most reliably found in the TWM and ACWn, but the highest density recorded was in the ACWs during spring. Gray whales were also recorded where they would be expected, i.e., only within the ACW.

## RECOMMENDED FURTHER RESEARCH

Despite relatively intensive sampling, we saw few northern fur seals and endangered whales. There could be two reasons--either the Unimak Pass area does not support many of these species or we were sampling at inappropriate times. To some degree both of these are probably true.

With respect to temporal coverage, we failed to sample in the summer season, the period when past surveys in neighboring areas such as NAS have indicated the highest use by many marine mammals. Further, the periods of spring and fall migration are long and the brief three-week periods of our surveys probably did not adequately sample migration use of the study area by all species. The best use of the spring and fall surveys probably was to document the presence of species and clarify general habitat associations.

Our failure to find any or many marine mammals also may indicate that they were truly absent or scarce. We expected to encounter few endangered whales in any case, but the historical evidence indicates that many of the areas of concentration for them were at the periphery of our study area, i.e., north of Unalaska Island and south of our study area, e.g. Davidson Bank.

In terms of the potential impacts of OCS development, the Davidson Bank area may be rather remote from potential sea traffic through Unimak Pass and thus removed from immediate concern. However, the areas immediately to the west of the Unimak Pass study area are probably of more interest because they seem to support higher concentrations of marine

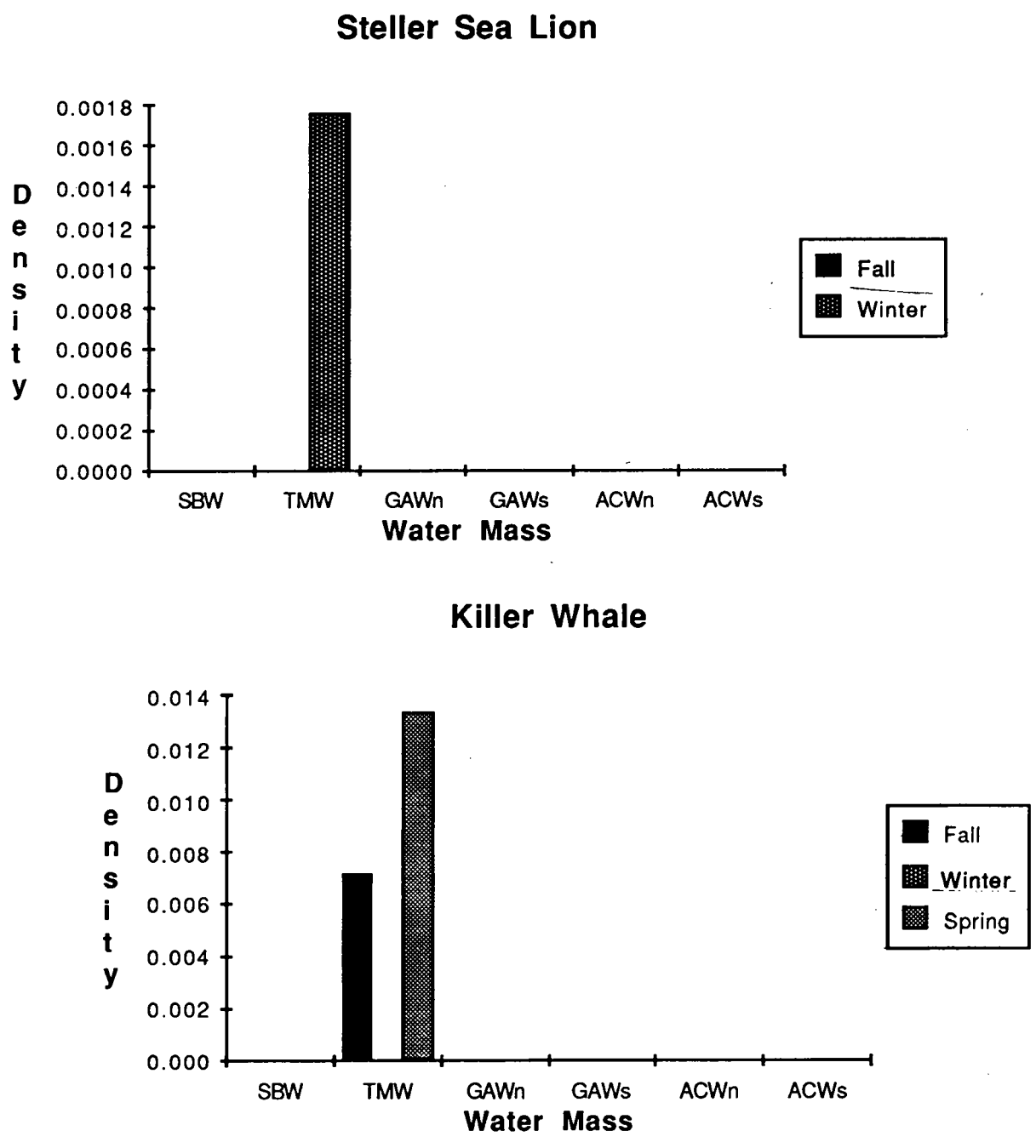



Figure 8. Summary of densities of Steller sea lion and killer whale by water mass during the three cruises. Water masses are as follows: SBW=Shelf Break Water; TMW=Tidally Mixed Water; GAWn=Gulf of Alaska Water northern (Bering Sea) portion; GAWs=Gulf of Alaska Water south; ACWn=Alaska Coastal Water north (Bering Sea); and ACWs= Alaska Coastal Water south.

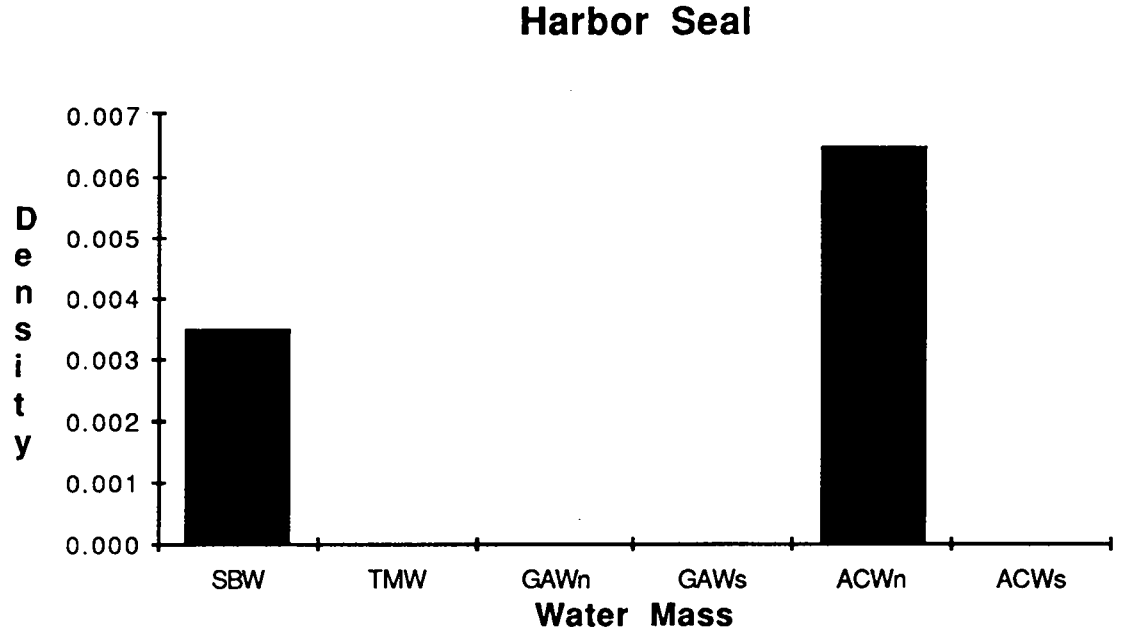



Figure 9. Summary of densities of harbor seal by water mass during the fall cruises. Water masses are as follows: SBW=Shelf Break Water; TMW=Tidally Mixed Water; GAWn=Gulf of Alaska Water northern (Bering Sea) portion; GAWs=Gulf of Alaska Water south; ACWn=Alaska Coastal Water north (Bering Sea); and ACWs= Alaska Coastal Water south.

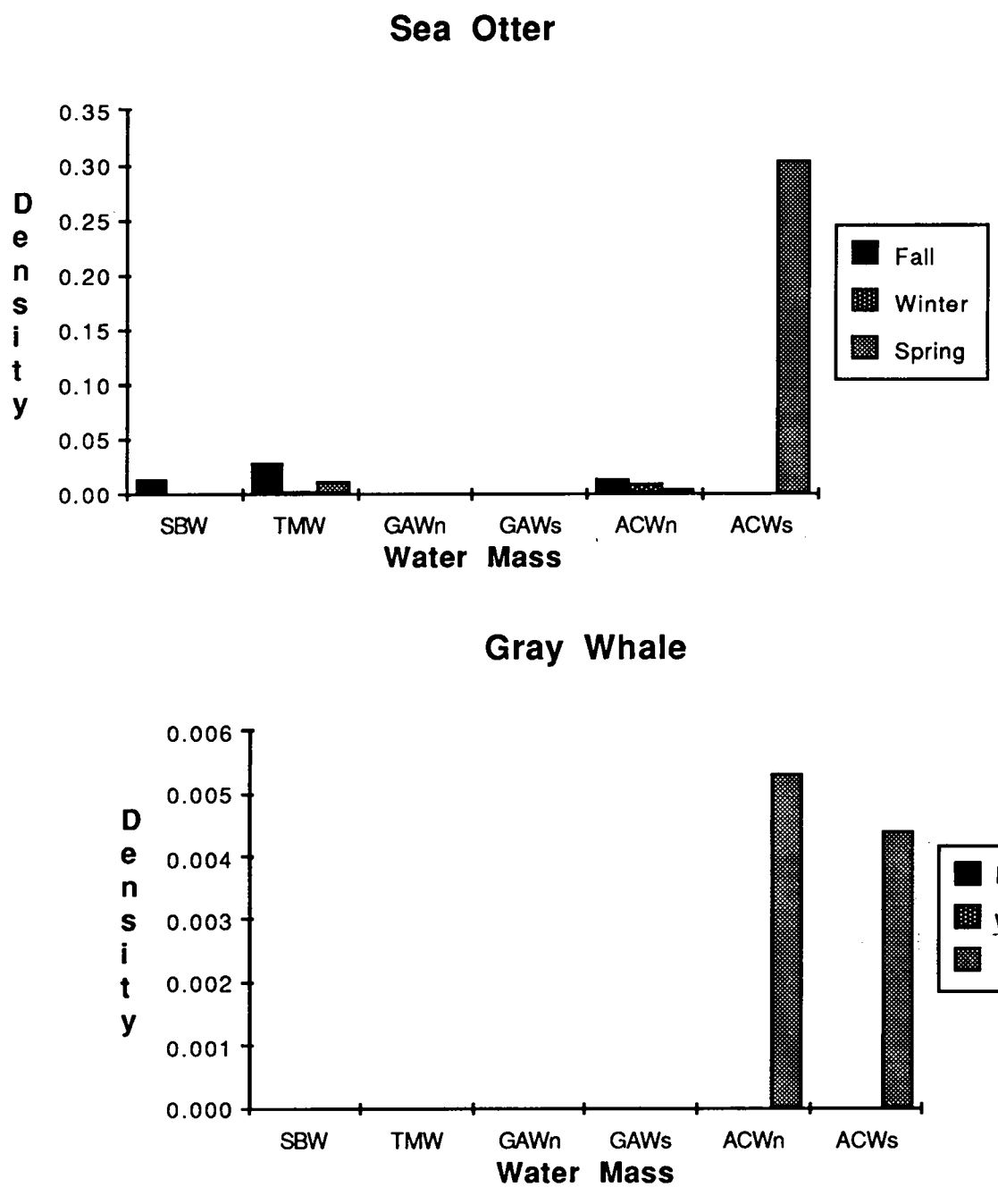



Figure 10. Summary of densities of sea otter and gray whale by water mass during the three cruises. Water masses are as follows: SBW=Shelf Break Water; TMW=Tidally Mixed Water; GAWn=Gulf of Alaska Water northern (Bering Sea) portion; GAWs=Gulf of Alaska Water south; ACWn=Alaska Coastal Water north (Bering Sea); and ACWs= Alaska Coastal Water south.

mammals and to be near potential oil-development activities as well. Our studies indicate that the areas of marine mammal and other biological concentrations in the Unimak Pass area are the result of nutrient flow from the west and are thus functionally linked to areas of upwelling outside of our study area.

The main areas of research that would benefit from continued effort and would complement what we have done thus far are:

(1) Conduct an additional cruise similar to the ones described in this report but during the summer season, perhaps in late June and early-July .

(2) Conduct a study similar to the Unimak Pass investigation but shift the study area to extend coverage as far west as Samalga Pass.

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The assistance provided by a few individuals deserves special mention. CDR Taguchi found ways to accommodate our innumerable trips through all passable passes in the Krenitzin Islands. LT Brian Hayden (FOO) accommodated all our requests and last minute changes in plans, allowing us to obtain all our samples where and when we wanted them. He also prepared a chart overlay detailing our accomplishments.

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