Section 6

MARINE BIRDS

by

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6.1 SUMMARY

6.1.1 Distribution and Abundance

Marine birds common in the North Aleutian Shelf (NAS) nearshore zone include shearwaters, gulls, kittiwakes, murres, auklets, sea ducks, and cormorants. Abundance of the various species groups varies seasonally, with shearwaters and kittiwakes most abundant in summer and sea ducks and auklets often more abundant in winter.

Shipboard surveys conducted seaward of about the 20-m depth contour show that some birds were unevenly distributed by water depth. In spring, shearwaters appeared to concentrate between 30- and 60-m depths; murres were most abundant in 30- to 40-m depths. Cormorants, gulls, and ducks were most abundant in shallow waters <30 m deep. In September, the two most common species groups, Short-tailed Shearwater and phalaropes, appeared clumped in the 40- to 50-m zone; murres peaked beyond 60-m depths. In January, the two most common species groups, Crested Auklet and murres, were highly concentrated in the 50- to 60-m zone; sea ducks and cormorants were largely restricted to waters <40 m deep.

6.1.2 Feeding Studies

In shallow (< 50 m deep) nearshore waters of the NAS, diets of the four dominant species of surface-feeding birds (Black-legged Kittiwake, Short-tailed Shearwater, Aleutian Tern, Glaucous-winged Gull) changed radically between spring (May) and summer-fall (July-September) sampling periods. During May, diets were composed largely of euphausiid crustaceans and secondarily of fish (mainly sand lance in 1985). By July, and continuing into September, all surface-feeding birds that we collected had switched to fish, primarily sand lance.

These results are surprising for two reasons. First, they contrast in some ways with the results of others studying seabirds, many of the same species, at other southeastern Bering Sea locations that were primarily deeper and farther offshore; in these studies walleye pollock was the dominant fish prey. Second, we found virtually no salmonid prey in the diets of surface-feeding birds, even though very large numbers of the smolts of salmonids are reported to pulse through our study area annually .

Diets of the three dominant species of water-column-feeding birds (Thick-billed Murre, Common Murre, and Red-faced Cormorant) were composed almost entirely of fish, with sand lance comprising well over 95% of the identifiable prey from samples collected in waters shallower than 50 m. Similarly to diets of surface-feeding birds, these results contrast with those of others studying seabird food habits in deeper waters of the southeastern Bering Sea (in the middle domain near St. George Island and close to the shelf break community), where walleye pollock was the dominant fish prey. Walleye pollock otoliths were abundant (over 2000) only in stomachs of birds (8 murres) taken at a relatively deep station (70 m).

Diets of the six species of sea ducks (Steller's and King eiders, White-winged and Black scoters, Oldsquaw, Harlequin Duck) that feed on benthos were largely bivalve molluscs, but amphipod crustaceans and echinoderms also were strongly represented during some periods. Sever al species appeared to specialize in preying on specific taxa (e.g., Harlequin Duck on gastropod molluscs and scoters on bivalve molluscs). Other species appeared to feed on several different taxa (e.g., Oldsquaw on crustaceans, fish, and molluscs; King and Steller's eiders on bivalve molluaes during the molt period in September and on molluscs and crustaceans during May and July).

6 .2 INTRODUCTION

The Bering Sea supports a bird community of immense proportions that iaoludes large numbers of pelagic birds (an estimated 40 million; Hunt et al. 1981b), major seabird breeding colonies (see Fig. 6.1), and concentrations of migrant , staging, and molting waterfowl (King and Dau 1981) and shorebirds (Gill et al. 1981). The region is of ornithological importance not only because of the large numbers of individual birds involved, but because these concentrations represent at times the entire Alaskan or even world populations of several taxa (e.g., Short-tailed

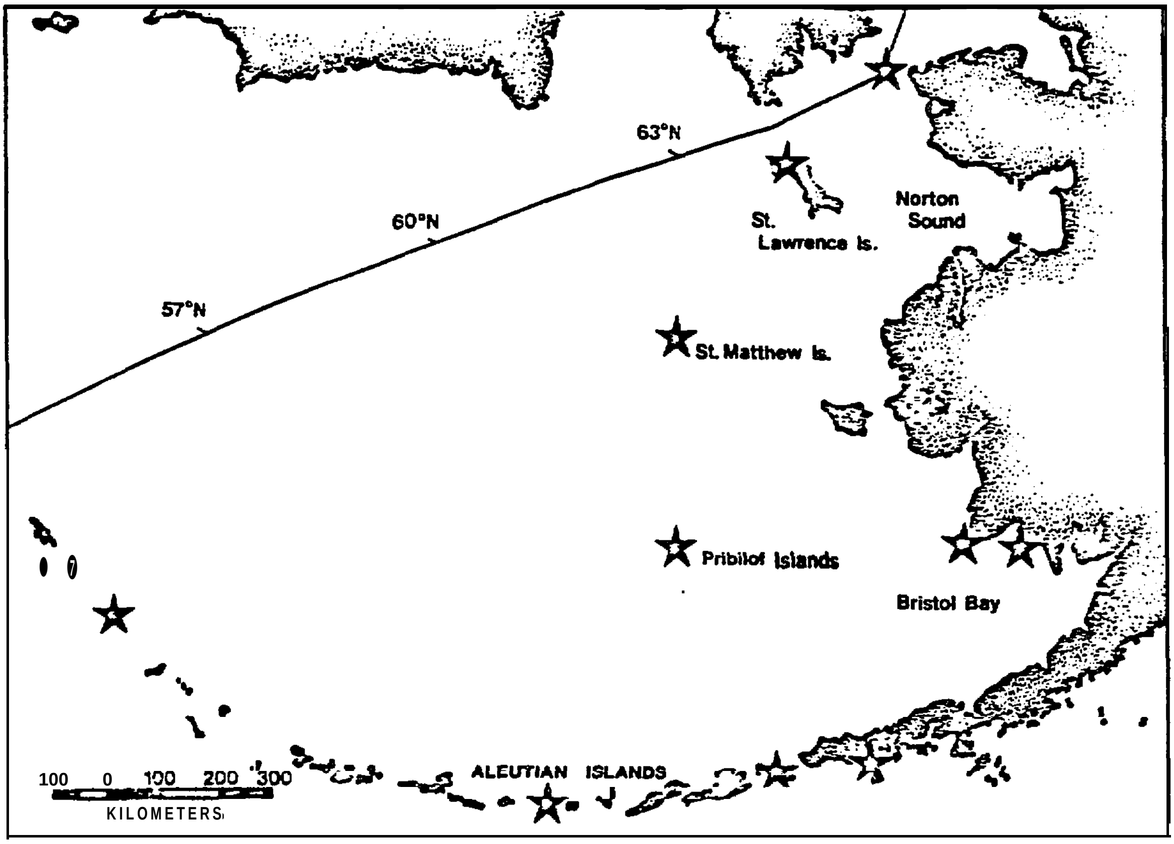


Figure 6.1. Major breeding concentrations (more than 500,000) of seabirds in the Bering Sea. From Lewbel (1983).

Shearwater, Western Sandpiper, pacifica Dunlin, nigricans Brant, Emperor Goose, and Bar-tailed Godwit). Gill and Handel (1981) considered the northern coast of the Alaska Peninsula to be the most extensive and diverse expanse of intertidal shorebird habitat along the Pacific coast of the Americas. Feeding seabirds (especially shearwaters, kittiwakes, and murres) rely on the nearshore zone (<50 m) of Bristol Bay and the Alaska Peninsula, and on the oceanic front associated with the shelf break (Pace 1984).

A considerable volume of research, much of it sponsored through the OCSEAP program, has described the distribution and abundance of birds in the southwestern Bering Sea as a whole. Locally detailed study has been made of the lagoon systems along the north side of the Alaska Peninsula, most notably Izembek and Nelson lagoons. These lagoons are both known to be quite important to birds, especially Brant, Steller's Eider, scoters, and shorebirds, though the specific use of the two lagoons differs. The

Table 6.1. Seabird colonies of the North Aleutian Shelf study area. Values listed are the most representative estimates as listed in the FWS seabird colony data base (USFWS 1986). Asterisks denote possible nesting species or unknown population size.

Colony Number	29-001	29-002	29-003	29-005	28-041	28-042	28-043	28-044	28-045
Colony Location	N. Isanotski Island	Amak Island	Sealion Rock	Birdsall Island	Dowilcher Island	Lagoon Point	Unnamed Is. e. of Lagoon Pt.	Walrus Island	Gull island
Fork-tailed Storm Petrel		*							
Cormorant									
Double-crested Cormorant							20		
Pelagic Cormorant		2							
Red-faced Cormorant		2952							
Common Eider							400		
Glaucous-winged Gull	191	150					12600		100
Mew Gull					300				
Black-legged Kittiwake		3570	74						50
Arctic Tern				.		1000		80	
Aleutian Tern				•					
unidentified murre		6536	2300						
Common Murre		•	•						
Thick-billed Murre		•	•						
Pigeon Guillemot		10							50
Horned Puffin		150							50
Tufted Puffin	1600	3	50				30		
TOTAL	1791	13373	2424	0	300	1600	13050	80	250

offshore waters of the Bering Sea have been the focus of considerable research, both through OCSEAP-sponsored reconnaissance programs and integrated multidisciplinary studies such as PROBES.

The following discussions focus on theabundances,distributions, trophic interactions, and population limiting factors of common species in marine habitats within the 50-m isobath. In keeping with the objectives of this project, birds largely restricted to bays and lagoons, or to waters beyond the 50-m isobath, will not be addressed.

Abundances of seabirds at colonies within the study area are summariied in Table 6.1. Although major colonies exist in coastal areas

Table 6.1. (Continued)

SPECIES/LOCATION	28-046 Entrance Point	28-047 Left Triangle	28-049 Unnamed Island	28-051 Cannery Islands	28-052 Kudobin Islands	30-002 Cape Seniavin	30-003 Unnamed Cape	TOTAL
Fork-tailed Storm Petrel								0
Cormorant						1700	100	1800
Double-crested Cormorant			60					80
Pelagic Cormorant						'		2
Red-faced Cormorant						.		2952
Common Eider					*			400
Glaucous-winged Gull		50	200	400	.			13691
Mew Gull								300
Black-legged Kittiwake						3500	100	7294
Arctic Tern	400			0-1000	*			1480
Aleutian Tern	600							600
unidentified murre								8836
Common Murre						500	100	600
Thick-billed Murre								0
Pigeon Guillemot								60
Horned Puffin								200
Tufted Puffin		100						1783
								0
TOTAL	1000	150	260	400	0	5700	300	40078

of the southern Bering Sea (e.g., Cape Newenham), few colonies of appreciable size are found within the area in which sampling was conducted for this study. The major breeding seabirds in the area are Glaucous-winged Gull, murres (both species but presumably Common Murres predominate), Blaok-legged Kittiwake, Red-faced Cormorant, and Tufted Puffin. The most numerous breeding species in the study area, with approximately 14,000 nesting birds, is Glaucous-winged Gull. Cliff-nesting species such as murres and Black-legged Kittiwakes are relatively uncommon, with total breeding populations on the order of 7,000-9,000 birds. The major cliff colonies are at Amak Island and Cape Seniavin.

Marine birds common in the NAB study area include representatives of five major taxonomic groups: (1) shearwaters and fulmars (family Procellariidae), (2) cormorants (family Phalacrocoracidae), (3) seaducks (family Anatidae), (4) gulls and terns (family Laridae), and (5) murres, murrelets, auklets, and puffins (family Alcidae).

Very little work on seabird feeding ecology has been done in the waters offshore from the bays and lagoons of the Alaska Peninsula but nearshore from the 50-m depth contour. Most of the published information on marine bird feeding in the southeastern Bering sea is based on OCSEAP and PROBES studies conducted near the Pribilof Islands and along transects well north of our NAS study area (see references in Hunt et al. 1981a,d and Schneider et al. 1986). Much of the seabird sampling conducted during those investigations was directed towards pelagic species; nevertheless, systematic sampling was also conducted in the inner domain waters south of Cape Newenham. Other work (see references in King and Dau 1981, Gill and Handel 1981, and Petersen 1981) was focused on the bays and lagoons along the north side of the Alaska Peninsula. Arneson (1980) flew several surveys the length of the Alaska Peninsula. He found large concentrations of birds (mostly geese and ducks) in the estuaries during spring and fall, and seaducks in protected areas (estuaries and lagoons ?) during winter. His only mention of bird concentrations in our area of interest were of shearwaters during summer off the southern end of the peninsula and gulls along exposed beaches during winter.

6.3 CURRENT STATE OF KNOWLEDGE

6.3.1 Northern Fulmar (Fulmarus nlacialis)

The Northern Fulmar occurs year-round in the study area. The eastern Bering Sea population is estimated to be near one million and is highly concentrated at a few breeding locations (Sowls et al. 1978). All but a few thousand breed in three areas: Chagulak Island in the Aleutians, the Pribilof Islands, and St. Matthew/Hall islands. No Northern Fulmars nest in the North Aleutian Shelf study area. Northern Fulmars at sea during the summer are concentrated along the shelfbreak and outer shelf near the Pribilof Islands and south to Unimak Pass (Fig. 6.2), often in close

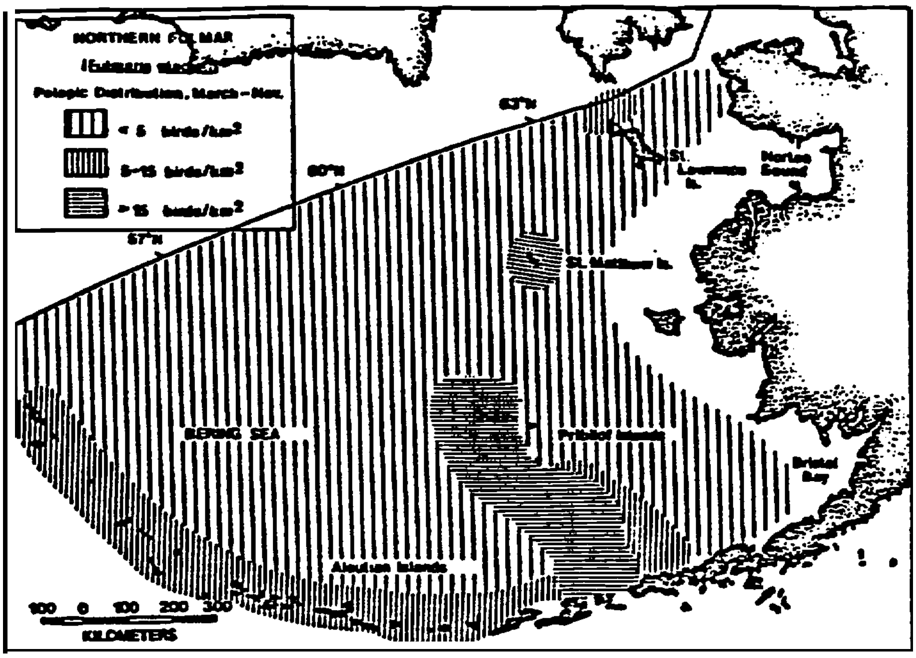


Figure 6.2. Pelagic distribution of Northern Fulmars in the Bering Sea, March-November. From Lewbel (1983).

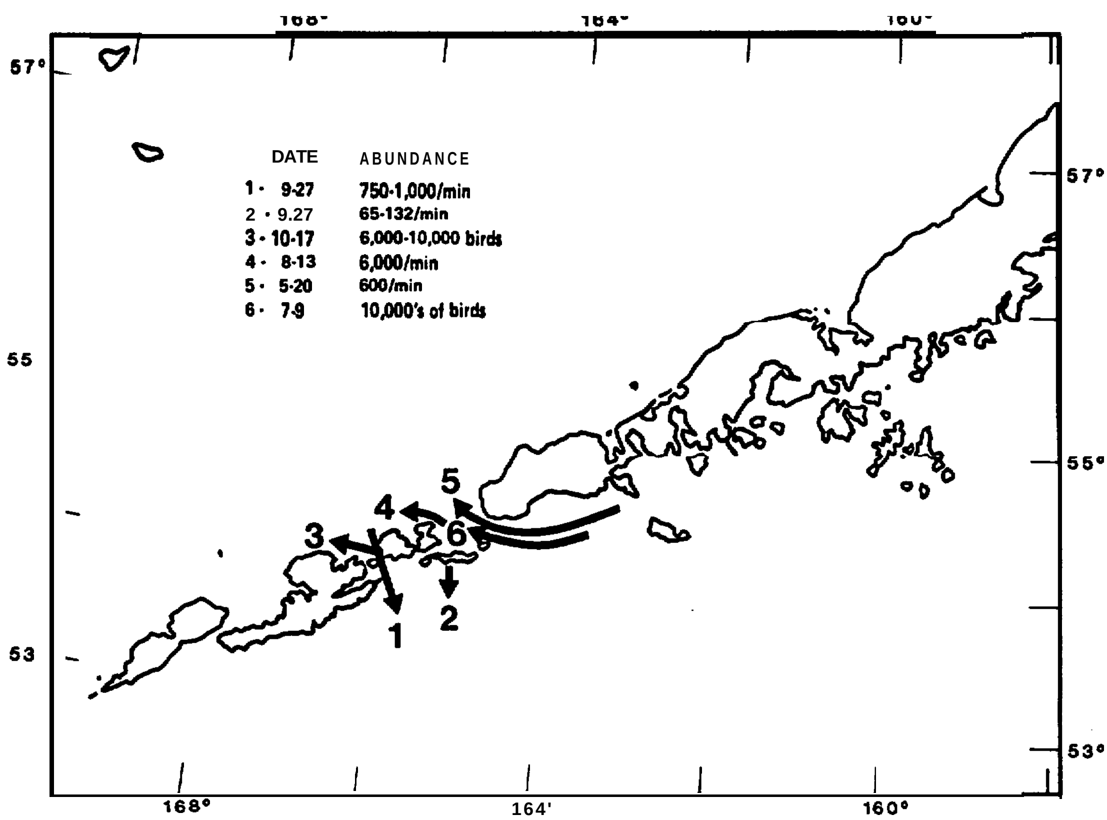


Figure 6.3. Distribution of flying flocks of 10,000 or more shearwaters observed in the eastern Aleutian Islands. From Strauch and Hunt (1982).

association with fishing fleets. They are markedly less common in the shallow waters of Bristol Bay and the inner shelf (Hunt et al. 1981d). In winter, most Northern Fulmars leave the Bering Sea for the North Pacific; however, some are still present in ice-free waters north and west of the Pribilof Islands and towards Unimak Pass.

Northern Fulmars feed by surface-seizing (Ashmole 197 1). They prey on cephalopods, crustaceans, and fish. Northern Fulmars have become habituated to scavenging fish offal from fishing vessels as a -major food source (Hunt et al.1981d).

6.3.2 Short-tailed Shear-water (Puffinus tenuirostris)

Both the Short-tailed and Sooty shearwaters (P. griseus) occur in the study area but the former is much more numerous (perhaps 90% of the total in the Bering Sea as a whole). The two species are not always differentiated during pelagic surveys and thus specific areas of abundance of each species are dlffioult to delineate. In general it appears that Sooty Shearwaters are' most abundant in the Gulf of Alaska whereas Short-tailed Shearwaters predominate within the Bering Sea. There is a zone of overlap in the southern Bering Sea and both species are known to occur in our area of interest. Reported densities and distributions of "pelagic shearwaters" in the Bering Sea, in which species are not named, are assumed to refer mostly to the Short-tailed Shearwater.

From June through September the Short-tailed Shearwater is the most abundant species in the Bering Sea; at this time approximately 8-10 million are thought to occur in the area (Hunt et al. 1981a). Large aggregations of this species (over 10,000) have been found in Unimak Pass from mid-May through late October (Jaques 1930, Gould 1982). They are typically found over the continental shelf, with only moderate numbers occurring over the shelf break. They are concentrated in the coastal domain, near and within the 50-m isobath. Concentrations of over 1,000,000 shear-waters have been recorded feeding in Unimak Pass in July. Large movements have been recorded through Unimak Pass, Baby Pass and Derbin Strait (Trapp 1975) (Fig. 6.3). Passage of Short-tailed Shearwaters between the Pacific Ocean and Bering Sea is widespread; however, the area between Akutan Pass and Amak Island appears to be the moat heavily visited region in Alaskan waters [Guzman 1981, Guzman and Myrea 1982). Really high numbers of Short-tailed Shearwaters (up to 1 ,000,000) have been reported only from the Unimak Pass area and the waters. northeast of Unimak Island (Byrd 1973, Guzman and Myres 1982). Late summer concentrations occur in northeastern Unimak Pass/Akun Bay. The Akun Bay area was also found to harbor large numbers of shearwaters on 20 October 1981, with estimates ranging from 8-84 million (USFWS memorandum, 12 January 1982).

Shear-waters feed mainly by pursuit diving but also by surface seizing (Hunt et al. 1981a). They probably feed entirely within the upper 5 m of the water column (Sanger 1972). In the Kodiak Island area, Short-tailed Shearwaters feed mostly on euphausiida, fish (capelin and osmerids), and squid (Sanger et al. 1978). In the Bering Sea euphauaiida are important prey in summer (70%), while in fall the hyperiid amphipod Parathemiato libellula is taken extensively (60%), with cephalopods and fish used both seasons (Hunt et al, 1981a). Sooty Shearwaters appear to depend more heavily on fish and squid at all times during their stay in Alaska (Sanger et al. 1978). As la probably the oaae with many seabirds, shearwaters can be opportunistic. In the Kodiak area in spring and summer 1977, Sanger et al. (1978) found both species eating capelin, which were. apparently extremely abundant in the area.

A striking feature of shearwater distribution in the Bering Sea is its patchiness; flocks of *over* 100,000 birds are often reported (Hunt et al. 1981 a). Schneider (1982) and Hunt et al. (1982) found shearwaters to concentrate along the inner front of the southeastern Bering Sea, presumably in response to prey concentrations. Brown (1980) points out that it is characteristic of many aeabirda elsewhere to congregate on shoals to feed on euphauaiida. The implications of this are that places where prey (euphausiids and perhaps fish or squid) concentrate are also apt to be areas of concentration for shearwaters on the NAS. Little investigation of this phenomenon has taken place.

It is not known what regulates populations of shearwaters. Straty and Haight (1979) note that people harvest shearwaters in the southern hemisphere. Large-scale mortalities (of uncertain magnitude) of shearwaters in the Bering Sea have recently been reported. Major die-offs of first-year shearwaters have occurred as they pass Japan on their first northbound migration. Another souroe of mortality has been entanglement in nets of North Pacific fisheries. This latter source may take hundreds of thousands of birds annually.

6.3.3 Red-faced Cormorant (Phalacrocorax urile)

Red-faced Cormorant, Pelagic Cormorant (P. pelagicus), and Double-crested Cormorant (P. aurftus) all occur in the area of interest, but Red-faced Cormorant predominates. Nelson (1976) estimated that the three species occurred in a 6:2:1 ratio at Unimak Island during the fall. The seabird colony catalogue (Table 6.1) shows the ratio in the NAS to be 1476: 1:40; however, many nesting cormorants are unidentified to species. Red-faced Cormorants nest on cliffs; in the Pribilofs they are restricted to portions of cliffs less than 200' (Hickey 1976, Troy and Baker 1985). Virtually all cliffs in the NAS fall within this range.

Red-faced Cormorants are probably year-round residents through most of their range. Cormorants are generally found within a few kilometers of their colonies, especially in summer but also in winter if open water remains available (Hunt et al. 1981a), as it usually does in the NAS study area. Two main nesting concentrations of cormorants exist in the study area--one near Cape Seniavin and the largest on Amak Island (Table 6.1)--and it is near these locations that the birds are likely to forage in nearshore marine waters. A southward movement of cormorants, predominantly Red-faced, was recorded through Unimak Pass from 7 April to 26 May 1976 (Nelson and Taber, FWS, unpubl. data). Gill et al. (1979) thought it unlikely that this was the result of cormorants wintering In the Bering Sea, but our surveys (this report) suggest that cormorant densities in northern Unimak Pass may peak during mid-winter.

Cormorants feed near shore and are most numerous within a few km of their breeding colonies during the nesting season. A few are seen in small numbers in the open ocean during spring and fall (Hunt et al. 1981d). Their feeding method is pursuit-diving (Ashmole 1971). Fish are the primary prey, but decapods (shrimp and crab) and amphipods are also eaten. Sculpins appear to be the most frequently taken fish. The cormorants appear to be restricted to foraging near the bottom (Hunt et al. 1981a) and consequently are generally close to land.

The numerous incidental observations of cormorants have not been pieced together to form a reasonable overview as to what controls their populations. It is known that the Red-faced Cormorant invaded Prince William Sound in the Gulf of Alaska and became the dominant breeding cormorant between 1959 and 1976, indicating that some controlling factor was altered.

6.3.4 King Eider (*Somateria spectabilis*)

At least 90% of the estimated two million King Eiders in North America utilize habitats within the Bering Sea at some time of the year (King and Dau 1981). The greatest numbers of King Eiders occur in the Bering Sea during spring and fall migrations, when they migrate through the area. The primary nesting areas are located along the arctic slopes of North America, Europe, and Asia. None nest near the study area (Bellrose 1976) (Fig. 6.41.

Adult males move to salt water molting areas soon after egg-laying, as do the subadults. Molting congregations for many North American and Siberian birds probably occur in the Chukchi Sea in late summer. In fall and winter there are gradual movements of the birds south into the Bering Sea in association with the movements of pack ice (Palmer 1976).

In spring, large rafts of King Eiders congregate in bays and lagoons along the western end of the Alaska Peninsula. For example, between late March and May 1964, the refuge manager from Izembek NWR counted 50,000 King Eiders at Ugashik Bay, large rafts from Moffett Lagoon to Nelson Lagoon, 20,000 in Kululak Bay, 22,000 in Port Moller, 10,000 at Cinder River Lagoon, and 10,000 in Port Heiden (Palmer 1976). From here they pass northward, following leads in the ice pack and the coastline of western Alaska.

Except during the nesting season, King Eiders are found in marine habitats. They occur in shallow coastal waters wherever their main food item, mollusks, occur. Bivalve mollusks, along with crustaceans and echinoderms, provide the bulk of the diet in marine waters (Cottam 1939).

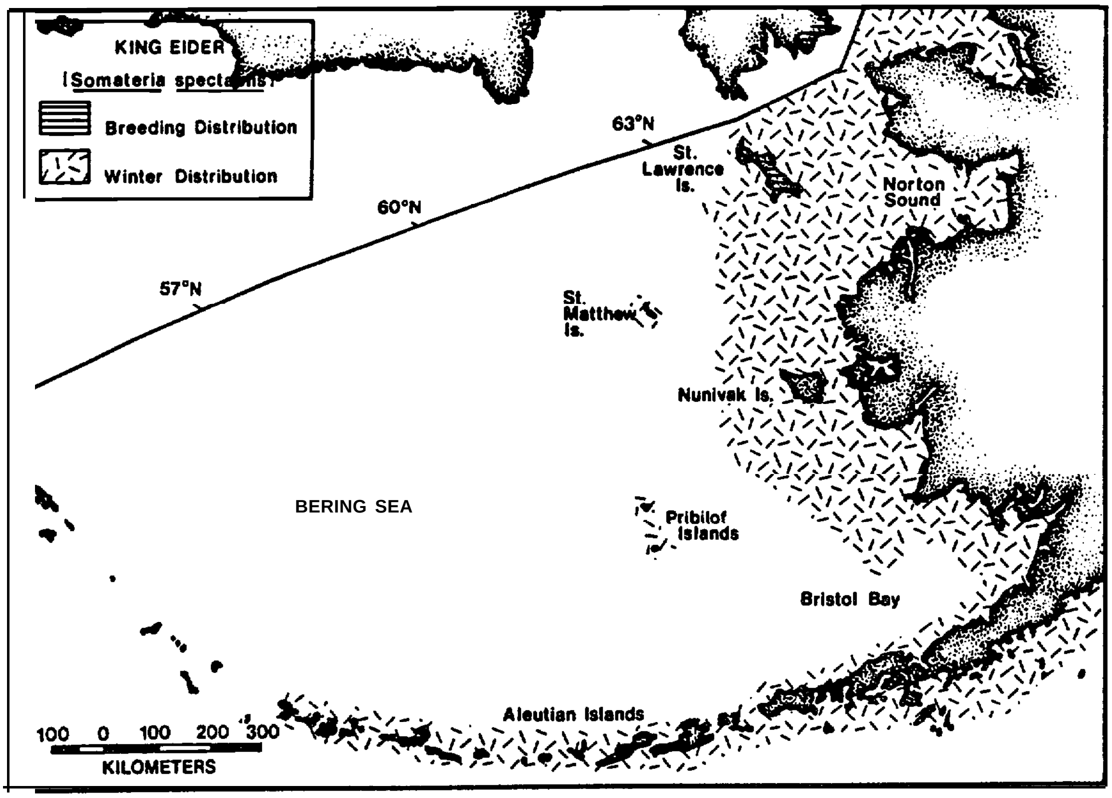


Figure 6.4. Breeding areas and winter distribution of King Eiders in the Bering Sea region. From Lewbel (1983).

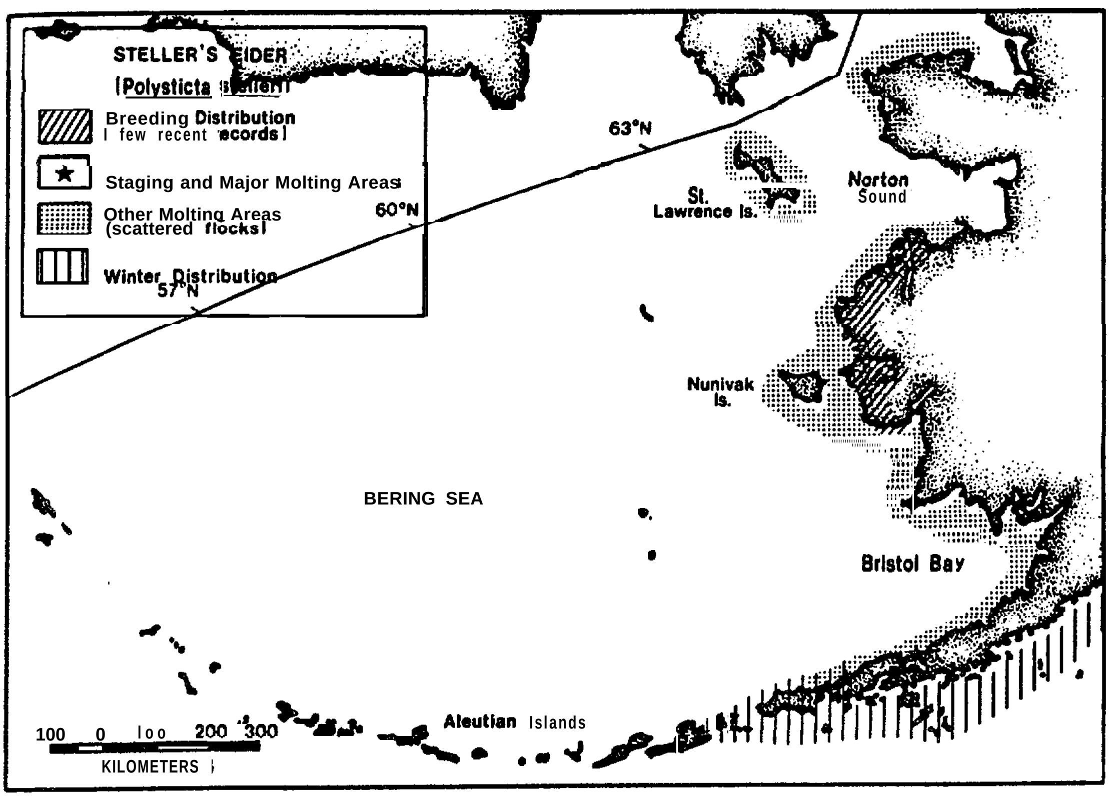


Figure 6.5. Former breeding area, molting areas, and winter distribution of Steller's Eiders in the eastern Bering Sea region. From Lewbel (1983).

6.3.5 Steller's Eider (*Polysticta stelleri*)

Steller's Eiders are most commonly sighted in the Bering Sea during the fall and winter months. The historical breeding range included the Yukon-Kuskokwim Delta and St. Lawrence Island (Fay and Cade 1959, Gabrielson and Lincoln 1959), but the primary nesting areas are now restricted to northern Siberia (Kistchinski 1973). Some Steller's Eiders still nest in widely scattered locations along the coast of northern Alaska.

Steller's Eiders occur in huge flocks during the spring and fall in the lagoons of Bristol Bay and the Alaska Peninsula (Fig. 6.5) (King and Dau 1981). The greatest concentrations occur at Izembek and Nelson lagoons (Petersen 1980). Up to 100,000 Steller's Eiders, mainly subadult and adult males, occur in Nelson Lagoon between early August and late September. Adult females molt primarily in Izembek Lagoon, but in lesser numbers than the males and subadults molting elsewhere (Petersen 1981). Following the molt, Steller's Eiders move to wintering areas along the Alaska Peninsula (to Kodiak Island), in the eastern Aleutian Islands, and in lower Cook Inlet (Jones 1965, King and Dau 1981). In the spring, concentrations again occur in bays and lagoons along the north side of the Alaska Peninsula and along coasts of Bristol Bay, before the major movements to northern nesting areas occur.

Off the breeding grounds, Steller's Eiders are found in marine areas, inhabiting shallow water areas along coasts. They feed primarily on bivalves (especially the blue mussel *Mytilus edulis*) and other invertebrates; including amphipods, polychaete worms, pycnogonids, and nudibranchs (Peterson 1980).

6.3.6 Scoters

All three species of scoters are common seaducks in the Bering Sea. Black Scoters (*Melanitta nigra*) nest on tundra ponds and lakes, primarily in coastal areas from Unlmak Island to the Bering Strait region. Surf (*M. perspicillata*) and White-winged (*M. fusca*) scoters breed on boreal lakes and ponds in the interior of Alaska (Fig. 6.6). All three species migrate through, and molt in, coastal areas In the Bering Sea. In the winter,

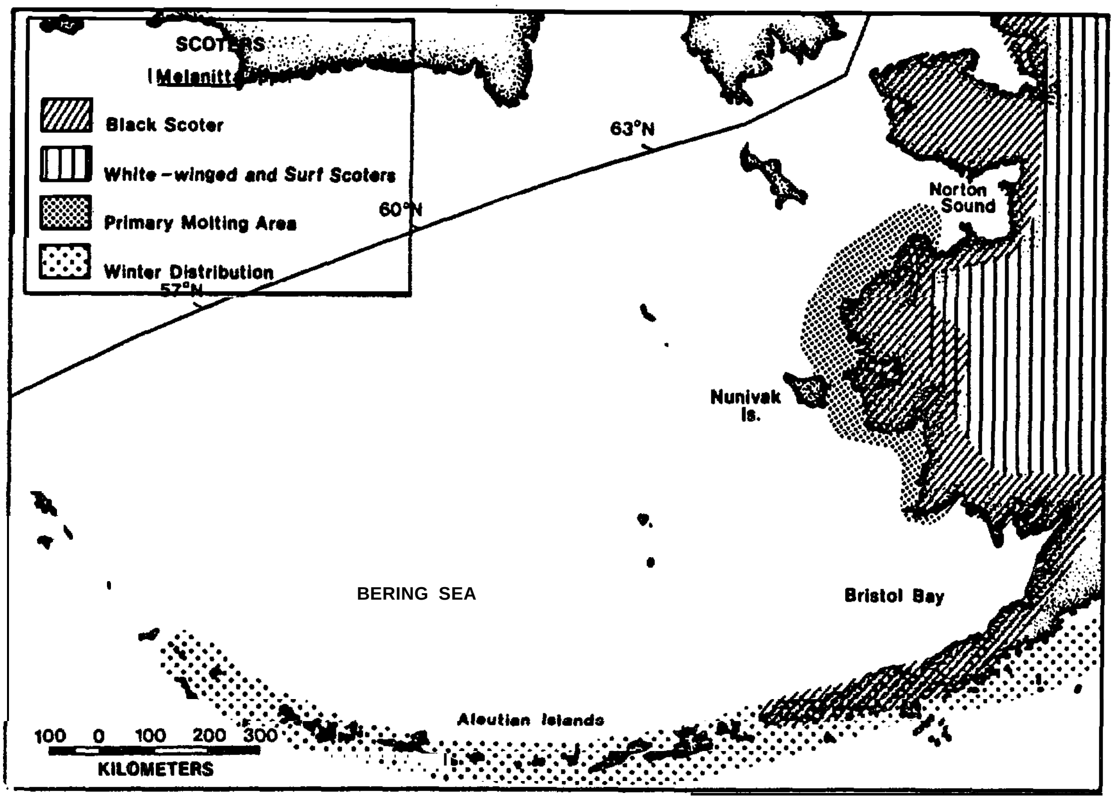


Figure 6.6. Distribution of scoters in the eastern Bering Sea region. From Lewbel (1983).

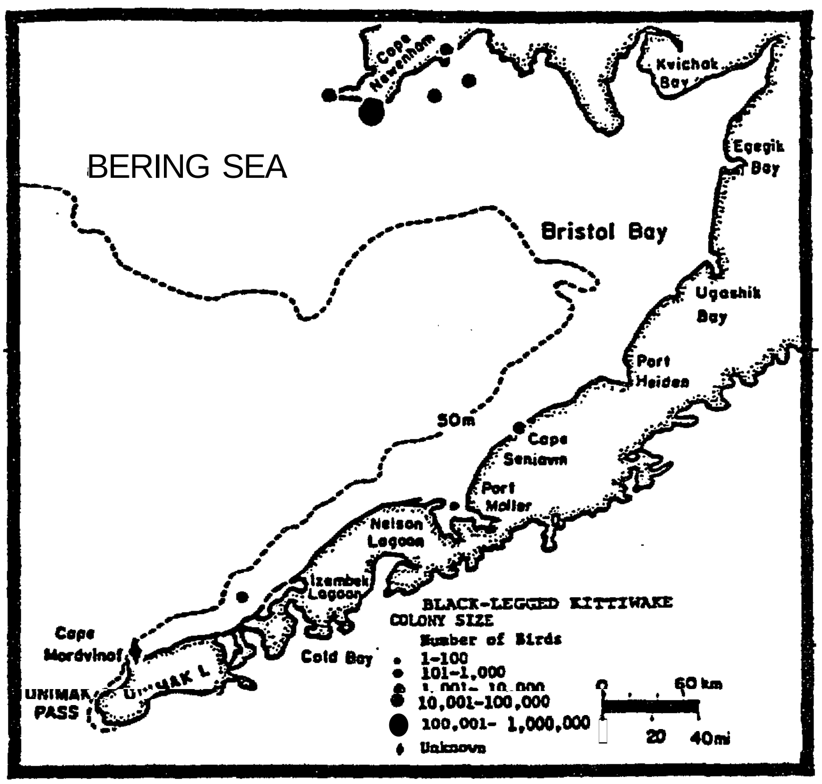


Figure 6.7. Black-legged Kittiwake colonies in the southeastern Bering Sea. From Hunt et al. (1981c).

most scoters retreat to more southern areas along the Pacific coast, but several hundred thousand winter in the eastern Aleutian Islands and along the southern Alaska Peninsula (Murie 1959).

Scoter numbers are inprecisely known due to their dispersed and/or remote breeding and wintering areas. Numbers in the Bering Sea, and the percent that represents of the total North American populations, are estimated at 488,000 (50%) for Black Scoters, 116,000 (25%) for Surf Scoters, and 401,000 *(33%)* for White-winged Scoters (King and Dau 1981).

Little is known about the nesting biology of Black ***Scoters*** because nests are very difficult to locate and are often not initiated until late June or July, when other waterfowl young are hatching. As a result, few field biologists searching for waterfowl nests encounter those of this species. Black Scoters usually lay ***5-8*** eggs which hatch in late July or early August (Shepherd 1955, Dick and Dick 1971, Gill et al. 1981). Little information exists on brood dispersal, but ducklings are likely raised on lakes, rivers, and estuaries near their natal ponds. Molting areas of scoters in the Bering Sea have only recently been identified (though incompletely) by C.P. Dau (presentation to Alaska Migratory Bird Conference, Anchorage, 15-18 March 1982). Surveys in nearshore waters off the Yukon-Kuskokwim Delta indicated tens of thousands of molting scoters, primarily Surf Scoters from mid-July to mid-August, and Black Scoters from mid-August to mid-September. White-winged Scoters were found in consistently lower numbers throughout the molting period. Waters off the Yukon-Kuskokwim Delta thus appear to be a major molting area of scoters. Molt migration of scoters westward past Cape Peirce in July and August indicate that birds breeding in areas other than the Yukon-Kuskokwim Delta also move there to undergo molt (Dick and Dick 1971). Migration routes are little known; however, birds molting in the Bering Sea probably make the relatively short flight to and from wintering areas in the Aleutians and adjacent Pacific coast on a gradual basis.

Scoters, like most seaducks, are bottom-feeders, and although they have phenomenal diving abilities, most birds feed in shallow waters (<25 m) (Palmer 1976). Foods of scoters at sea consist mainly of mollusks (clams and mussels), crustaceans, echinoderms, other marine Invertebrates, some marine algae, and other plants (Cottam 1939, Palmer 1976).

6.3.7 Glaucous-winged Gull (Larua glaucescens)

The summary in Table 6.1 shows Glaucous-winged Gull to be one of the moat numerous aeabirds encountered in the study area. Their abundance varies seasonally; peak densities occur in summer and fall, at least in coastal areas. About 13% of the Alaska population of nesting Glaucous-winged Gulls occurs between Cape Newenham and Unimak Pass. Glaucous-winged Gulls are important in the NAS study area because the largest colony in Alaska is located at Nelson Lagoon, where 13,000 gulls neat. This and several smaller colonies make Glaucous-winged Gull the moat numerous breeding colonial bird in the study area.

Glaucous-winged Gulls are omnivorous and are opportunistic foragers. Their diet includes a variety of intertidal organisms, fish, garbage, offal, and other prey. Moat foraging occurs in nearshore habitats, especially during the breeding season, but this species is often encountered quite far offshore, well beyond the limits of our study area. Because of its opportunistic foraging behavior, the Glaucous-winged Gull is prone to great geographic variability in its diet. In the western Aleutians, Glaucous-winged Gulls specialized on whatever species was abundant and vulnerable; prey selection varied among invertebrates (sea urchins), fish, and seabirds, depending on the location, tide state, and (presumably in the case of seabirds) the season (Trapp 1979, Irons et al. 1986). The relative use between fish and invertebrates was partially dependent on whether sea otter populations were sufficiently large that they reduced macroinvertebrate numbers and made them leas available to the gulls.

Gulls tend to be quite adaptable to variations in their environment but this does not imply that extrinsic factors do not regulate their populations. Gull colonies vary markedly in their productivity and a large colony such as exists in Nelson Lagoon would need a close, abundant source of food to fledge very many chicks. Further, Hatch et al. (1978) found egging activity by humans to reduce hatching success at the Nelson Lagoon colony to 3.9%. Many gull populations have increased markedly in size in recent decades, indicating that some previously limiting factor has been relaxed. [Gull populations have not been monitored in Alaska or on the NAS to document such a population growth, but expanding populations have been noted in many other areas of North America]. Presumably the greater availability of food associated with municipal dumps, canneries, and fishing fleets have aided gulls but how this affects their populations--e.g., enhanced winter survivorship or greater reproductive output--is unknown. Part of the initial increase in gull populations this century was probably due to reduced mortality of adults oaused by the termination of gull harvests that were conducted to provide feathers for the millinery trade.

6.3.8 Black-legged Kittiwake (*Rissa tridactyla*)

Black-legged Kittiwakes are circumpolar in distribution and are numerous in the eastern Bering Sea, with a minimum breeding population estimated at 750,000 (Sowls et al. 1978). From Unimak Pass to Cape Newenham, the breeding population is estimated to be in excess of 490,000 birds. Most of these cluster near Cape Newenham (Hunt et al. 1981c). In the NAS study area, the Black-legged Kittiwake has a population estimated to be in excess of 7100 birds; it is the third most numerous breeding marine bird in the area.

The breeding distribution of Black-legged Kittiwakes in the Bering Sea is depicted in Fig. 6.7, The pelagic distribution during all seasons may be characterized as low-density and dispersed. In the southern sector of the Bering Sea, Hunt et al. (1982) described a tendency for higher densities between the 100-m isobath and deeper waters of the shelfbreak, and for lower densities between the 50- and 100- m isobaths. Despite the low densities, the vast area occupied by klttiwakes translates into large numbers of birds. Population indices derived from aerial and shipboard censuses indicate the presence of 1-3 million kittiwakes in summer and 3-4.5 million in fall over the eastern Bering Sea (Gould et al. 1982). In summer, kittiwakes seem no more abundant nearshore than offshore, despite the coastal locations of their nesting colonies (Bartonek and Gibson 1972); in fall they are apparently more abundant in the middle and outer domains of the Bering Sea (Hunt et al. 1981d).

In winter, most Black-legged Kittiwakes leave the Bering Sea (Armstrong et al. 1984), although they still occur in low densities north of the Aleutians, on the shelfbreak, and in oceanic waters north of the

Pribilof s. Kenyon (1949) reported few in the Gulf of Alaska and northeastern Pacific in winter, but they become more common in winter along the California coast and over a broad zone of deep oceanic water south of the Aleutians. Gould et al. (1982) described kittiwakes as virtually absent from shallow waters of Bristol Bay in winter, but present in "fair numbers" over shelfbreak and oceanic waters. Probably most of the kittiwakes breeding in colonies in the Bering Sea concentrate in the western portion of their major wintering area south of the Aleutians.

Northward displacement of kittiwakes begins in mid-March, with intensive movements occurring through straits of the eastern Aleutian ridge in April. Fall migration through Unimak Pass occurs. from the middle of September and into late October (Nelson 1976), at which time there is a broad and gradual movement of the eastern Bering Sea population from breeding colonies to wintering areas south of the Aleutians.

Kittiwakes feed on or near the water surface (Hunt et al. 1981b), primarily by dipping; however, surface-seizing and occasionally shallow pursuit-diving are also employed (Hunt et al. 1981a). Fish are the primary prey, but crustaceans (euphausiids , amphipods) and cephalopods are also consumed. Off the Pribilof Islands, the most important prey species is apparently walleye pollock, but capelin, sand lance, and myctophids are also preyed upon. In other regions sand lance and capelin predominate over pollock as principal prey items (Hunt et al. 1981a).

The breeding distribution of kittiwakes is restricted by the availability of suitable nesting cliffs. Productivity and the capacity of populations to expand is apparently influenced by short- and long-term changes in weather and oceanographic conditions that in turn regulate the availability of food to the kittiwakes. Unusually cold waters in foraging areas seem to depress reproduction (Springer et al. 1982). During years when prey availability is poor, productivity at the nesting cliffs may be very low, because of fewer nests, smaller clutch sizes, and greater egg mortality (Hunt et al. 1981c). Even though adults are long-lived, several successive years of poor food supply and reproductive failure may cause significant population reductions.

6.3.9 Murres

Both species of murre, Common (*Uria aalge*) and Thick-billed (*U. lomvia*), are abundant and widespread in the southeastern Bering Sea. Both occur in the study area throughout the year, and both nest there in summer. Common Murres appear to predominate in the NAS. The two species differ in many aspects of their biology and distribution; it is unfortunate that a great many studies could not, or did not, use methods that would distinguish between them. In this discussion we have to treat them as a group.

The eastern Bering Sea supports a minimum of 5.3 million breeding murres (Sowls et al. 1978). In general, Common Murres predominate at the mainland colonies of the Bering Sea, and Thick-billed Murres predominate in the Aleutian, Pribilof, and other offshore Islands (Fig. 6.8). Between Cape Newenham and Unimak Pass, the breeding population of murres exceeds 1,300,000 birds, of which more than 1 ,OOO,OOO are Common Murres; most are clustered at Cape Newenham colonies and are thus outside the NAS study area. Within the NAS study area the known breeding population is approximately 9300 birds. Most of these birds occupy the colonies at Amak Island and Sea Lion Rock (over 8800 birds). Although both species are known to be present, estimates of their relative abundance have not been made.

Murres are most common over the continental shelf. In the spring they occur in areas of open water, but begin to aggregate on waters near the colonies in late March and April (Hunt et al. 1981b). In the summer they are concentrated around the major breeding colonies. In the fall they again disperse over the continental shelf from the Gulf of Anadyr to Bristol Bay. Their numbers appeartoincreaseinthe eastern Aleutians and Unimak Pass during the fall. They may remain in northerly areas of the Bering Sea until forced south by advancing ice. They are the most abundant seabirds wintering in the Bering Sea. The pelagic distribution of murres in winter is shown in Fig. 6.9.

A substantial number of the Bering Sea breeders migrates through Unimak Pass in spring and fall between the Bering Sea and the Gulf of Alaska (Nelson 1976). The spring migration through Unimak Pass into the Bering Sea commences in late March, peaks in late April, and continues

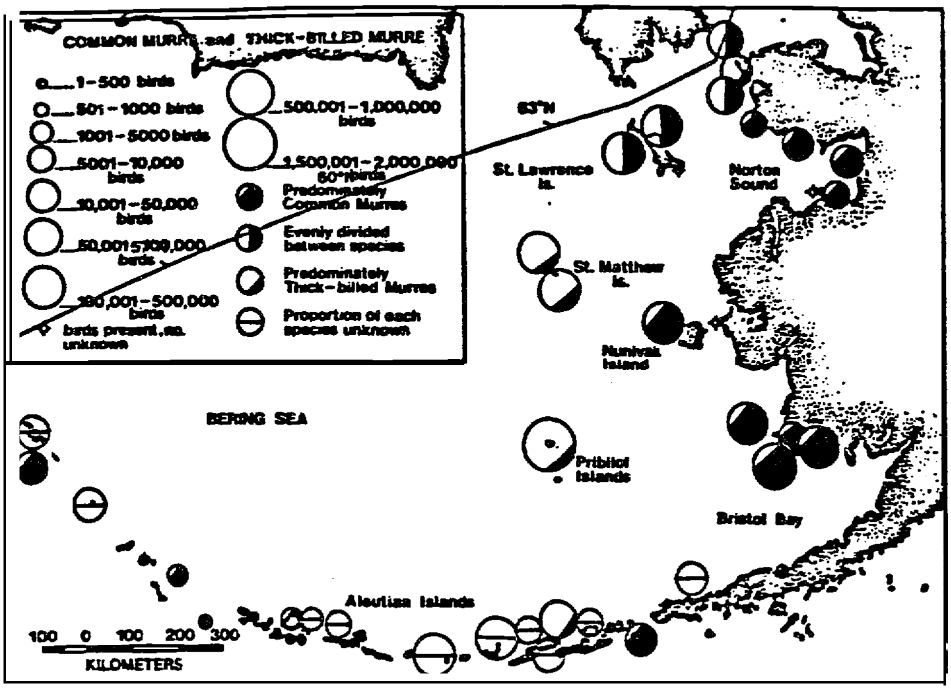


Figure 6.8. Breeding distribution of Common and Thick-billed murres in the Bering Sea. From Lewbel (1983).

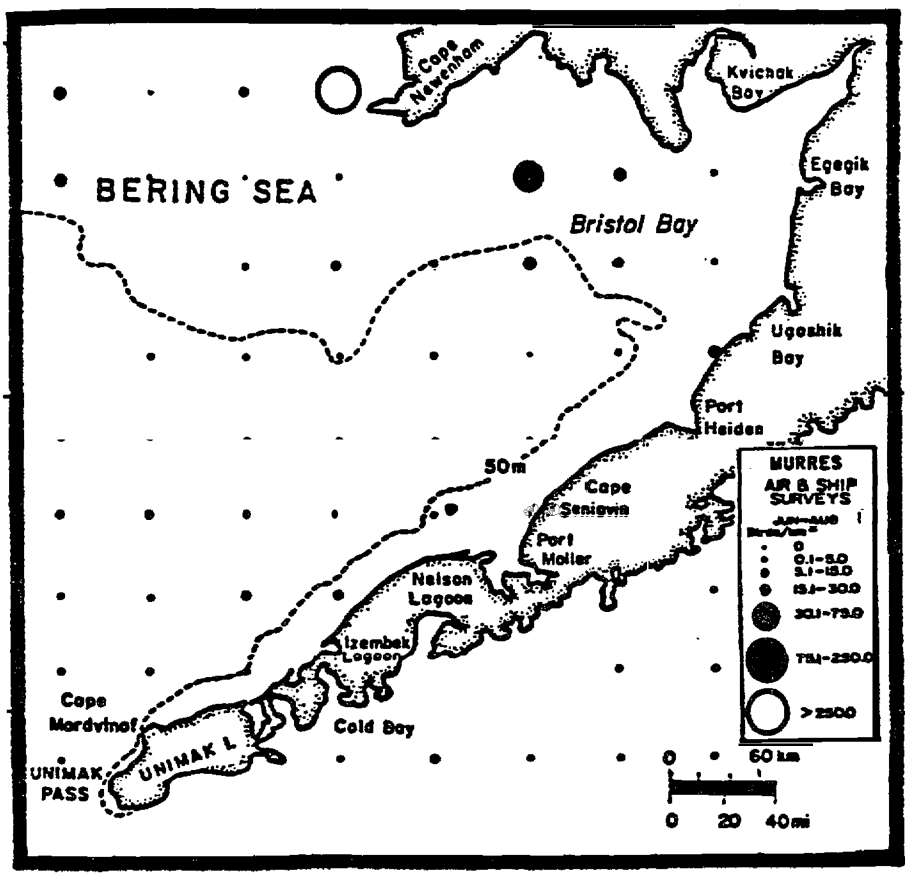


Figure 6.9. Pelagic distribution of murres determined by air and ship surveys in July and August, southeastern Bering Sea. From Hunt et al. (1981a).

Into May. Phillips (1 976) estimated 20,000 murres swimming in Unimak Pass off Cape Sarichef on 14 May. Gould (1982) reported mean at-sea densities of 10-28 murres/km^2 in Unlmak Pass during spring. Autumn migration through Unimak Pass is also quite protracted, extending from late July through October. Peak movements have been recorded during the last week of August and again during October (Nelson 1976).

Aerial and shipboard survey data (Bartonek and Gibson 1972, Hunt et al. 1981 a) show murres to be moderately common in late spring and summer in the vicinity of the NAS study area even though the NAS breeding population is not large. This could indicate that many subadult murres summer here. Murres remain common in the study area during winter when birds breeding to the north are forced south by sea ice.

Both species of murres feed by diving, often attaining depths of 110-130 m (Forsell and Gould 1980). Fish are the principal prey, but invertebrates are often an important constituent of the diet. Common Murres tend to feed within a few km of shore in water 50 m or less in depth; Thick-billed Murres may feed tens of kilometers to sea in deep water (Roseneau and Springer 1982). Correspondingly, Common Murres are dependent on nearshore mid-water fishes, whereas Thick-billed Murres use demersal fishes. Thick-billed Murres also take a greater variety of prey (with a greater proportion of invertebrates in the diet) than Common Murres.

Common Murres in the Bering Sea feed on a variety of fish including cod, sand lance, capelin and pricklebacks (Stichaeidae); the latter is used principally as food for the chicks. Thick-billed Murres frequently prey on all the above fish (except pricklebacks) and also take sculpins, which occur near the seabottom (Roseneau and Springer 1982). Invertebrates consumed by both species (but mostly by Thick-billed Murre) include, in approximate order of importance, shrimps, amphipods, euphausiids, cephalopods, and polychaetes (Roseneau and Springer 1982). There is considerable regional variability in diet; murres on the Pribilof Islands take walleye pollock extensively (Bradstreet 1985), whereas murres in Norton Sound are dependent on sand lance and arctic cod (Hunt et al. 1981a).

Habitat factors to which murres respond include availability of suitable nesting cliffs and perhaps concentrations of food. Pelagic distributions of murres in summer reflect distributions of nesting colonies. Schneider (1982) found feeding aggregations of murres (Common and Thick-billed together) associated with the inner front (about the 50-m isobath) southwest of Cape Newenham in late spring, 1981, presumably in response to *prey* concentrations. Factors important in limiting murre populations are not known for sure, though food availability appears to play a significant role. Bourne (1976) suspected that food shortages caused an observed instance of mass mortality of Common Murres in the Irish *Sea.* Bailey and Davenport (1972) thought that a massive die-off of Common Murres they observed in April 1970 on the north side of Unimak Island and the Alaska Peninsula resulted from starvation. The starvation was apparently precipitated by severe weather that prevented normal access to food.

6.3.10 Crested Auklet (Aethia oristatella)

Four species of auklet--Parakeet (Cyclorrhynchus psittacula), Least (Aethia pusilla), Whiskered (A. pygmaea), and Crested--occur in the study area, but the Crested Auklet is more numerous than all the others combined. The Crested Auklet has its population center in the Bering Sea, where an estimated two million nest in Alaskan waters. This species is not known to nest in our area of interest although large colonies are found to the west in the Aleutian chain. Insufficient data are available to accurately describe the wintering distribution of this species. Most small auklets may leave the Bering Sea in fall, wintering along the Aleutian chain and in the North Pacific. Kodiak Island is a known wintering area for Crested Auklets (Gould et al. 1982). *Arneson* (1977) reports rafts of this species during winter in both Unimak and Akutan passes. A minimum of 150,000 Crested Auklets in several large *rafts* was observed 2-5 mi off Swanson Lagoon, Unimak Island, Feb. 23, 1984 by C. Dau (Gibson 1984).

Crested Auklets feed by pursuit diving (Ashmole 1971) and specialize in preying on zooplankton at moderate depths (Hunt et al. 1981d). At the Pribilof Islands Crested Auklets take mostly euphausiids, with secondary reliance on copepods and amphipods (Hunt et al. 1981d). Searing (1977)

Indicated that Crested Auklets at St. Lawrence Island were foraging almost completely on calanoids, at least as food for their young.

6.4 METHODS

Distribution and abundance of marine birds was assessed using two types of platforms: 1) fixed-wing aircraft surveys, and 2) shipboard surveys. The methods employed and purpose of each type of survey are described below.

The two survey methods used complement each other and in concert permit a better evaluation of bird (and marine mammal) distribution and abundance than would either alone. Each has advantages and disadvantages. The aerial surveys are a much more efficient and reliable means of enumerating the study organisms, because these surveys rapidly cover very large areas, providing almost synoptic documentation of the distribution of animals in the study area. Shipboard counts suffer from the problem that the organisms being censused can move much more rapidly than the counter; this fact alone makes reliable density estimation impossible (Burnham et al. 1980). Many ad hoc methods of minimizing this inherent bias have been employed but the accuracy of them all is unverifiable. Surveys near shore are impossible using ship board surveys alone since the minimum sampling depth from the ship is approximately 20 m. On the other hand, the ship permits more detailed study of the smaller organisms that are missed or cannot be identified from the air. The ship allows more precise documentation of certain important behaviors that cannot be ascertained from the air. For example,the use of the area by molting murres and loons was determined during the cruises, but molting individuals could never be verified from aircraft. Most importantly, the ship permits concurrent measurements of prey availability and oceanographic conditions, information that is critical to trying to determine correlative and/or probable causative factors for bird and marine mammal distributions.

6.4.1 Aerial Surveys

Aerial surveys were conducted from a Dehaviland Twin Otter. During most surveys the aircraft was equipped with bubble windows to provide maximum visibility for the observers. Two biologists surveyed, one on each side of the aircraft. Fixed transects were censused during each sample session.

The initial survey design consisted of four survey lines, each approximately 200 miles long and parallel to the coast (Fig. 6.10, Table 6.2). Each line was divided into eight transects. The rationale of this design was to provide samples (transects) at a variety of water depths and along a gradient of distances away from the lagoon entrances.

In November 1984 our survey lines were extended to the west approximately 50 miles (two transects) to provide coverage to the west side of Unimak Pass. This decision was made in response to the observation that densities of several species of birds appeared to increase dramatically at the western extreme of the study area. Results of the other disciplines appeared to corroborate our suspicion of higher productivity/richness in this area, and consequently other research efforts (ship-based) shifted westward beginning in January 1985. Thus, the final study design consisted of four parallel lines with a total of 40 transects, resulting in the surveying of approximately 1000 miles per survey period.

Surveys were flown at 150 m above sea level. This height was a compromise between heights that were optimal for observing birds and those best for observing marine mammals. A greater height would be more efficient for whales, a lower height would permit more accurate detection of the smaller birds. However, for the most numerous species in the study area; i.e., large birds (gulls, waterfowl) and small marine mammals (sea otters), the survey height has proved satisfactory.

Surveys were flown at a ground speed of 100 knots. Transect endpoints were identified by means of LORAN. The effective survey strip was set at 200 m on either side of the aircraft and each observer used an inclinometer to ensure that a constant transect boundary was maintained. Observations, pertinent environmental and weather information, as well as the behavior of the animals sighted were recorded using tape recorders.

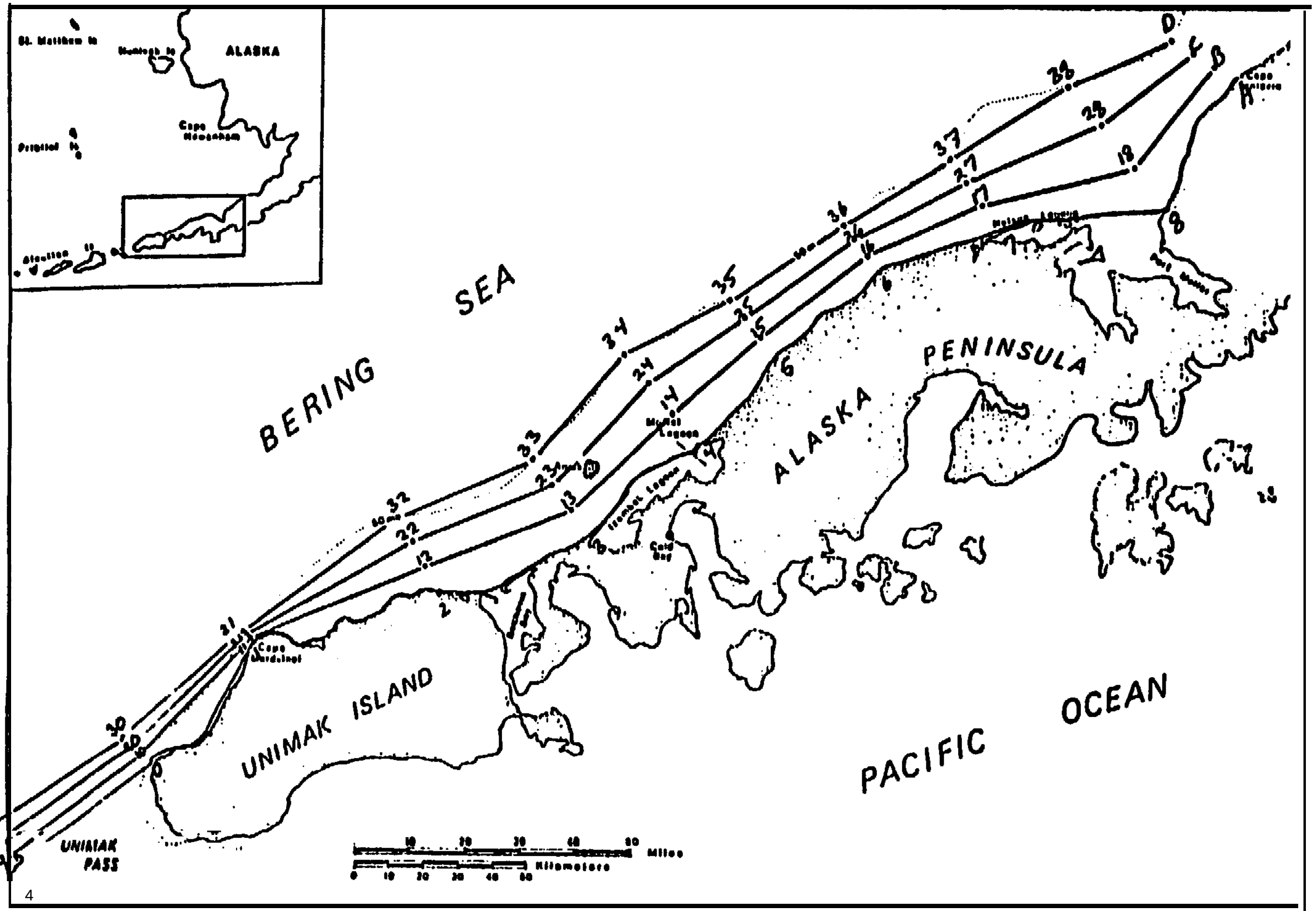


Figure 6.10. Aerial survey transects for bird and marine mammal distribution and abundance, North Aleutian Shelf, Alaska.

Table 6.2. Coordinates for ends of aerial survey transects.

TRANSECT	LAT	LONG	TRANSECT	LAT	LONG
9	54°17'.8	165°30'.0	29	54°24'.4	165°37'.0
0	54°35'.4	164°55'.2	20	54°45'.1	165°07'.1
1	54°55'.3	164°28'.4	21	54°59'.6	164°32'.0
2	55°02'.2	163°53'.6	22	55°11'.9	164°03'.2
3	55°08'.4	163°17'.0	23	55°24'.1	163°32'.1
4	55°23'.6	162°46'.3	24	55°39'.8	163°03'.9
5	55°39'.1	162°16'.7	25	55°53'.6	162°33'.4
6	55°54'.4	161°43'.3	26	56°06'.8	161°56'.8
7	56°01'.2	161°03'.4	27	56°15'.3	161°18'.6
8	56°05'.9	160°27'.0	28	56°20'.8	160°42'.1
A	56°23'.8	160°08'.2	C	56°31'.6	160°16'.7
19	54°21'.1	165°33'.7	39	54°27'.0	165°39'.9
10	54°39'.3	165°00'.2	30	54°50'.0	165°15'.0
11	54°57'.2	164°31'.2	31	55°02'.7	164°37'.8
12	55°07'.2	163°58'.4	32	55°15'.3	164°06'.6
13	55°16'.1	163°24'.0	33	55°31'.7	163°39'.4
14	55°28'.0	162°51'.1	34	55°48'.0	163°12'.8
15	55°45'.5	162°24'.0	35	56°01'.5	162°41'.4
16	56°00'.5	161°49'.9	36	56°13'.0	162°05'.5
17	56°08'.2	161°11'.2	37	56°22'.2	161°26'.6
18	56°13'.4	160°35'.7	38	56°28'.5	160°49'.2
B	56°27'.6	160°12'.4	D	56°35'.5	160°21'.3

Systematic records of 2-minute time increments are identified along each line. These time markers permitted a fine-scale means of mapping bird and marine mammal location within each transect and aided in making inferences about the importance of lagoons and seabird colonies in determining distribution trends.

The survey schedule is summarized below.

MONTH	YEAR 1984	YEAR 1985	YEAR 1986
January			X
February			X
March		X	
April		X	
May	X		
June		X	
July	X		
August		X	
September	X		
October		X	
November	X		
December		X	

All of the original 32 transects were successfully censused during all surveys. The Unimak Pass lines were not surveyed during the first three flights and some of these lines were missed due to fog problems since they were first included in the study in November 1984.

6.4.2 Shipboard Transects

Counts of marine birds and mammals were made also during the multidisciplinary cruises of the Miller Freeman. Surveys were made when the ship was at or near full steam. Some surveys were made on predetermined lines where samples for other disciplines were collected (Fig. 1.2), but the majority were made while the ship was ferrying between sample locations. Transects were defined as lo-minute intervals, as **is** the customary protocol for marine bird surveys in Alaska. The biologist **censused** from the flying bridge, using either a 90^{o} or 180^{o} arc depending on the viewing conditions and on the occurrence of small birds in the area. For example, if the observer thought using a 180^{o} arc would result in birds being missed, a 90^{o} arc was used, and this was usually the case.

Birds were recorded as being in one of four distance increments parallel to the course of the boat: O-100 m, 100-200 m, **200-300** m, and **>300 m.** Calculations of densities are based on the first three bands only; the fourth zone was used to record off-transect sightings of major **seabird** concentrations and/or whales. Although not practiced in the analyses used in this study, if less biased density estimates are required, the effective zone used for the calculation of densities can be varied depending on the species. For example the sightability of **storm-**petrels may be too low for reliable **censusing** beyond **100** m, whereas Northern Fulmars can easily be **censused** to **300** m.

At the time **of** each transect, location and environmental conditions were recorded. The most important characteristics were time, coordinates of starting and endpoints, observer speed, and water depth. Weather information including temperature, cloud cover, sea state, precipitation, wind speed, and temperature (air and sea surface), were obtained hourly from the ship's log. During most survey periods the ship echosounders were run to provide a qualitative record of prey availability. Both 100 **kHz** (invertebrate) and 38 **kHz** (fish) recorders were used.

6.4.3 Sampling for Prey Analysis

The primary purpose **of** the bird feeding study was to determine which organisms comprised the important proportions of the diets **of** species of birds most widely distributed and most abundant in the study area. Samples of birds **were** collected on an opportunistic -basis, e.g., at times and locations when and where other sampling activities were least compromised. Thus, samples were not collected systematically along predefined transects or at predefined stations, but at locations (usually nearshore) where other disciplinary tasks and sea surface conditions allowed the use of small boats. As a consequence, few birds were collected at offshore locations where some species (e.g., shear-waters, murres, puffins, and auklets) were typically most abundant. In this report , we base most of our discussion of seabird food habits on the samples we collected on an opportunistic basis in waters less than 50 m deep.

6.4.3 .1 Bird Collection Methods

Collections were made from one of two pneumatic boats (Avon or Zodiac) carried aboard the R/V Miller Freeman. The small boats were equipped with high-powered outboard motors that could propel them over relatively calm water at speeds up to about 35 kts. Once birds were located, and in most instances observed to be feeding, they were approached at high speed from the boat and a sample was collected using a 12 ga. shotgun. Birds were retrieved rapidly and their guts (proventriculus and ventriculus) were injected with absolute isopropyl alcohol to preserve food items; the esophagus was plugged with a paper wad to prevent food from spilling out. Each bird was labeled and packed in a bag with all other birds collected at that location. The location and number of the collection was marked on a hydrographic chart of the area so the approximate depth category of the collection location could be estimated.

Food availability was estimated from results of the invertebrate sampling program (see Section 4.0 INVERTEBRATES, this report). Systematic samples of invertebrates (zooplankton, epibenthos, infauna) were taken in nearshore waters similar to those where birds were collected; this allowed some cursory comparisons to be made between food availability and food eaten by the birds (see Section 8.0 Patterns of Energy Flow, this report).

6.4.3.2 Laboratory Analysis of Bird Specimens and Stomach Contents

Within 24 hours of collection, all birds were dissected and food items found in the esophagi and guts were preserved. The esophagus and gut were removed as a single unit from each bird. These organs were slit lengthwise, and an arbitrary measure of fullness (Hynes 1950, see Johnson and Richardson 1981) was assigned to the total unit in the field laboratory (aboard the Miller Freeman), and a cursory and tentative description of the contents was recorded. The intact esophagus and gut of each specimen were washed, stored in absolute isopropanol, and labelled for future analyses.

More detailed laboratory analyses of the stomach contents of each bird were conducted at LGL's laboratory. The preserved stomach contents were sorted into major taxa (most often taxonomic class, but sometimes family or species), counted and weighed (g wet weight). Fish otoliths found in bird stomachs were identified to major taxa (family or species), counted, weighed, and sorted into separate vials. A separate analysis of the number of otoliths found in the stomach of each bird helped in the identification of well-digested fish eaten by those birds.

In order to determine the origin of carbon consumed by birds in the NAS study area, samples of breast muscle tissue were extracted from several individuals of each important bird species for carbon analysis (see Section 3.0 this report). These results give insights into the importance of nearby lagoons as sources of carbon for nearshore primary and secondary consumers.

6.5 RESULTS AND DISCUSSION

6.5.1 Distribution and Abundance

6.5.1 .1 Species Composition by Season

Aerial Surveys. A summary of relative densities of marine birds observed during aerial surveys is provided for each month in Table 6.3. Overall bird use of the survey area was highest during summer when shearwaters were abundant and during late winter/early spring (February-April) when Crested Auklets occurred in large aggregations north of Unimak Island. The lowest counts of birds also occurred during early spring (March). Arenson (1981) also found bird use of the area to peak during summer, but in his study the other seasons ranked, in order of importance, fall, spring, and winter. The difference in importance of the seasons in our study compared with Arneson's is likely due to his surveys being more restricted to the coast (except during summer). This also results in his

Table 6.3. Average densities of marine birds (birds/km²) on aerial survey transects between Cape Mordvinof and Cape Seniavin, North Aleutian Shelf, Alaska. All species listed occurred during the surveys but some were so infrequent that their density appears as 0.0 d-ring all months. Highest densities are shown in bold-face, lowest in italics.

SPECIES	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Red-throated Loon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Pacific Loon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Loon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grebe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern Fulmar	0.1	0.1	0.1	0.0	0.1	0.1	1.0	0.2	0.2	0.5	0.0
Shearwater-dark	*0.0*	0.0	0.0	*0.0*	50.3	48.4	30.7	3.3	0.2	0.2	0.0
Fork-tailed Storm-Petrel	0.0	0.0	0.0	0.0	0.0	0.2	*0.0*	0.0	0.0	0.1	0.0
Cormorant	1.3	0.2	1.6	0.4	0.9	0.6	0.7	0.9	0.4	1.4	0.4
Emperor Goose	0.0	0.0	0.0	0.1	OR	*0.0*	*0.0*	0.0	1.1	0.5	*0.0*
Brant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.0
Mallard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Eider	0.1	0.2	0.0	0.0	0.9	0.0	*0.0*	0.0	0.0	0.0	0.0
King Eider	4.1	5.4	2.3	4.1	0.1	0.5	0.1	0.9	0.9	0.3	0.1
Steller's Eider	1.4	4.6	0.2	1.9	0.1	0.0	*0.0*	0.3	0.1	0.7	5.4
Harlequin Duck	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Oldsquaw	0.5	1.3	0.2	1.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3
Scoter	4.1	2.3	5.4	13.6	2.6	5.0	0.0	1.4	5.0	3.4	9.5
Red-breasted Merganser	0.0	0.1	0.0	0.1	0.1	0.3	0.0	*0.0*	0.0	0.0	0.0
duck	0.1	0.0	0.0	0.1	1.4	0.5	0.2	0.6	1.1	0.0	1.1
Bald Eagle	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rock Sandpiper	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	1.2
small Sandpiper	0.0	0.0	0.0	0.0	0.0	*0.0*	0.1	*0.0*	0.0	0.0	0.0
Phalarope	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.3	0.0	0.0
shorebird	0.0	0.0	0.0	0.0	0.1	0.8	0.1	0.0	0.2	0.0	0.0
Jaeger	0.0	0.0	0.0	0.0	0.0	*0.0*	0.3	0.1	0.0	0.0	0.0
Bonaparte's Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mew Gull	0.2	0.1	0.0	0.0	0.0	0.1	*0.0*	*0.0*	0.0	0.5	0.0
Herring Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glaucous-winged Gull	3.6	3.6	4.1	14.6	21.3	50.0	23.5	15.7	20.3	12.0	4.4
Glaucous Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Black-legged Kittiwake	0.0	0.0	0.1	2.4	3.4	14.4	32.6	30.5	9.5	1.1	0.1
Sabine's Gull	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tern	0.0	0.0	0.0	0.0	0.3	0.3	0.1	0.3	0.0	0.0	0.0
Murre	0.3	6.4	1.5	3.5	0.3	0.2	0.5	0.2	0.9	0.1	0.2
Pigeon Guillemot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Murrelet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Auklet	32.0	91.5	1.4	91.8	1.6	*0.0*	0.1	0.1	0.3	0.1	0.3
Tufted Puffin	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.1	0.2	0.1
Horned Puffin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alcid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Raven	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snow Bunting	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
passerine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
TOTAL	48.0	116.2	17.1	133.8	83.6	121.7	90.6	56.5	40.9	25.6	23.1

recording relatively fewer seabirds but more waterfowl than we recorded. Based on earlier work (Guzman 1981, Arneson 1981), high densities of shearwaters were expected to occur during the summer. Arneson recorded no tubenoses (the group including shearwaters) during his May surveys but his July density of tubenoses (~330 birds/km2) was higher than densities he recorded for any other species group during any season.

In our study, Crested Auklets were by far the most numerous bird in the area during the late-winter period, and the wide fluctuations in bird abundance were caused mainly by fluctuations in the number of auklets we encountered. The auklets were reoorded in a rather small portion of the study area north of Unimak Island. Their absence during the March survey may indicate either a minor movement to deeper waters to the west, or their departure from the area, perhaps into or through Unimak Pass.

In addition to the shearwaters and auklets, common species in the area included seaducks, especially scoters and eiders. Among the scoters, White-winged was the most numerous, Black Scoters were locally common, and Surf Scoters were relatively infrequent. Both King and Steller's eiders were numerous but Common Eiders were never more than a small proportion of the ducks (although they are probably the most numerous breeding seaduck in the area). Seaducks were largely restricted to the coastal transects, being quite scarce on the other lines. Their abundance peaked during the winter months, generally November through April. But there were seaducks present year-round, and they were quite numerous within the lagoons adjacent to our study area during late summer and early fall.

Glaucous-winged Gull was the most consistently common species. We counted peak numbers during the summer, perhaps reflecting their littoral distribution during the nesting season. (Recall the major colony near Nelson Lagoon.) Abundance reached a minimum during winter (December) but even then this species was the fifth most numerous bird counted. Another larid, the Black-legged Kittiwake, was also an abundant bird in the area. Its seasonal trend in abundance was more pronounced than that of Glaucous-winged Gull; it was essentially absent for virtually half the year.

Murres were present year-round in the study area but their seasonal abundance varied markedly. Numbers peaked during late winter, probably when murres from northern breeding areas reached the NAS. Lowest counts were recorded in fall when local breeding birds had left the colonies.

Incidental observations suggested that the successful breeding birds swam offshore with their chicks after "fledging."

Cormorants, predominantly Red-faced, were present year-round. Highest counts were in fall and winter, indicating an influx of birds from other breeding areas. There are no major breeding areas to the north or northeast (small numbers nest in Bristol Bay outside the NAS), so the wintering birds may have been from the Pribilofs or Aleutians.

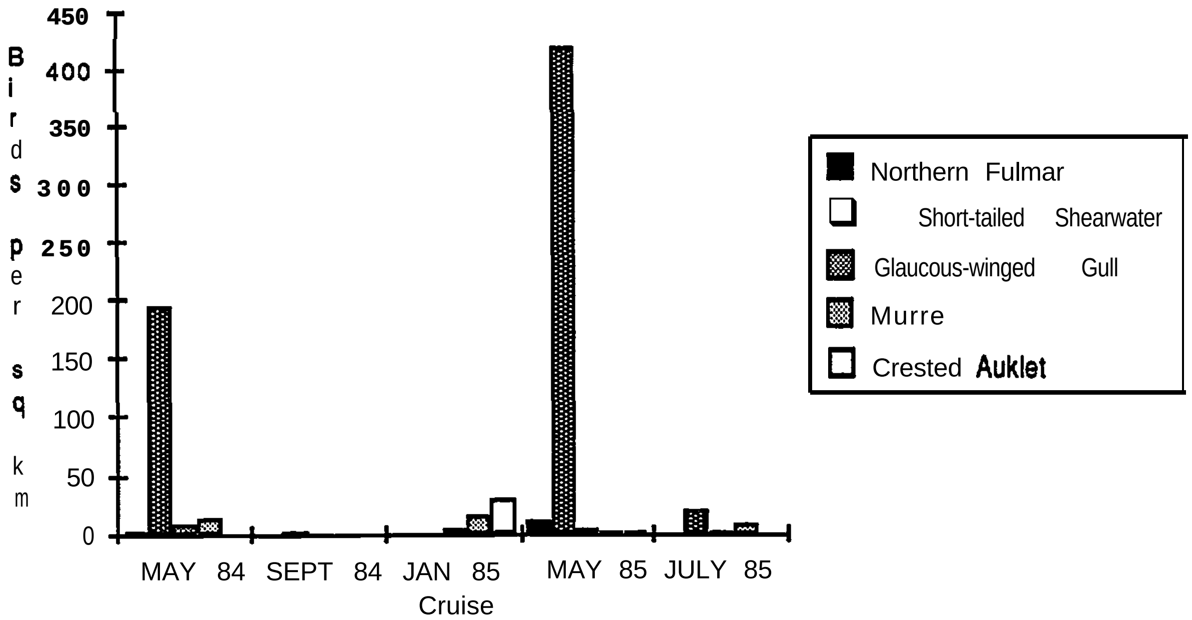
During fall migration two shorebirds, phalaropes and Rock Sandpipers, were among the most numerous birds. The Rock Sandpipers were restricted to shorelines along the Alaska Peninsula and thus made use of the nearshore zone only at the water's edge. Their occurrence on our surveys is a reminder of the Importance of littoral areas and lagoons of this area to migrating shorebirds. In contrast, phalaropes are pelagic; during the August survey this species group was one of the most common encountered seaward from the coastal transects.

Shipboard *Surveys.* The results of the five cruises are shown in Table 6.4; densities of the more common species are summarized in Fig. 6.11. The species composition differs in many respects from that described for the aerial surveys. This reflects sampling coverage. One-quarter of the aerial survey lines were along the shoreline of the Alaska Peninsula, but it was rare for the ship to enter waters less than 20'm deep. Thus coastal species such as seaducks, cormorants, and many marine mammals (see Section 7.0, this report) are poorly represented in the shipboard survey summaries.

&--During the May 1984 cruise, overall densities were high but the vast majority of sightings were of Short-tailed Shearwaters (almost 200/km^2). (Sooty Shearwaters were also encountered during some of our cruises; however our observations and specimen collections both indicate that this species makes up a very small proportion of the dark shearwaters in the study area. For tabulation purposes all have been pooled as Short-tailed Shearwaters.) The next most common species group was murres with approximately 1 5/km^2. Although all murres are pooled in the summary tables, the vast majority of murres identified during the surveys were Common Murres. Thick-billed Murres also occur, especially in the deeper

Table 6.4. Densities of marine birds (#/km^2) by cruise, North Aleutian Shelf, Alaska. Highest densities are shown in boldface, lowest in italics.

SPECIES	MAY 84	SEPT 84	JAN 85	MAY 85	JULY 85
Loon	0.0	0.2	0.0	0.0	0.0
Red-necked Grebe	0.0	0.0	0.0	0.0	0.0
Northern Fulmar	1.5	0.2	0.0	10.8	0.8
Sooty Shearwater	0.0	0.0	0.0	0.0	0.0
Short-tailed Shearwater	193.7	2.4	0.0	418.9	21.4
Fork-tailed Storm-Petrel	0.0	0.0	0.0	0.4	0.0
Leach's Storm-Petrel	0.0	0.0	0.0	0.0	0.0
Red-faced Cormorant	0.0	0.0	2.0	0.0	0.1
Cormorant	0.3	0.1	0.3	0.1	0.0
Brant	0.0	0.0	0.0	0.3	0.0
dark goose	0.0	0.0	0.0	0.0	0.0
King Eider	0.2	0.0	2.4	0.0	0.0
Eider	1.2	0.0	0.1	0.0	0.0
Harlequin Duck	0.0	0.0	0.0	0.0	0.0
Oldsquaw	0.0	0.0	0.1	0.0	0.0
Black Scoter	0.0	0.0	0.0	0.0	0.0
White-winged Scoter	0.0	0.0	0.1	0.0	0.0
Merganser	0.0	0.0	0.0	0.0	0.0
duck	0.1	0.0	0.4	0.0	0.0
Lesser Golden-Plover	0.0	0.0	0.0	0.0	0.0
Least Sandpiper	0.0	0.0	0.0	0.0	0.0
Phalarope	0.0	1.8	0.0	0.0	0.0
Jaeger	0.1	0.0	0.0	0.1	0.5
Bonaparte's Gull	0.0	0.0	0.0	0.0	0.0
Mew Gull	0.0	0.0	0.1	0.0	0.0
Herring Gull	0.0	0.0	0.0	0.0	0.0
Glaucous-winged Gull	9.8	1.0	5.5	4.2	2.0
Glaucous Gull	0.0	0.0	0.0	0.0	0.0
Black-legged Kittiwake	2.1	0.9	0.4	10.0	5.2
Sabine's Gull	0.0	0.0	0.0	0.0	0.0
Gull	0.0	0.0	0.0	0.0	0.0
Arctic Tern	0.0	0.0	0.0	0.0	0.0
Aleutian Tern	0.0	0.0	0.0	0.0	0.2
Murre	14.7	0.7	16.5	3.0	9.5
Pigeon Guillemot	0.0	0.0	0.4	0.0	0.0
Murrelet	0.0	0.0	0.1	0.1	0.7
Crested Auklet	0.2	0.0	30.0	1.9	0.0
Auklet	0.1	0.0	0.0	1.1	0.0
Tufted Puffin	0.7	0.1	0.0	0.8	1.3
Horned Puffin	0.0	0.1	0.0	0.1	0.3
alcid	0.1	0.1	0.0	0.0	0.0
Lapland Longspur	0.0	0.0	0.0	0.0	0.0
TOTAL	224.9	7.3	58.6	451.9	42.1



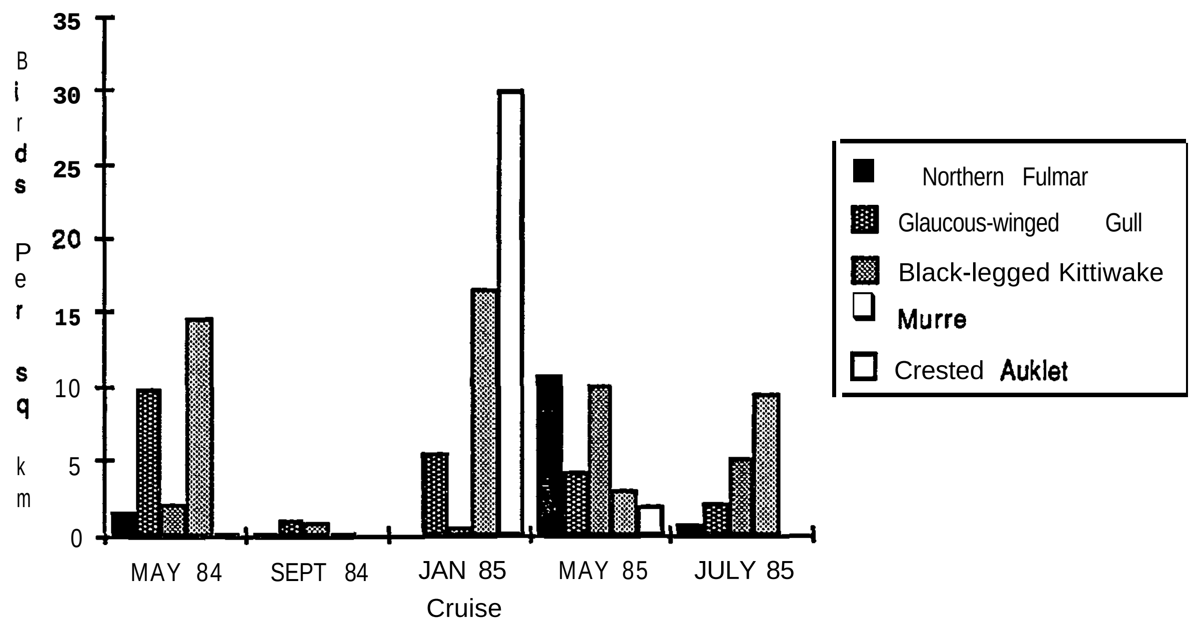


Figure 6.11. Densities of the most common birds recorded during North Aleutian Shelf, Alaska cruises on the Miller Freeman. Short-tailed Shearwaters, shown to reach very high densities in the top graph, are omitted from the lower figure to show trends in the other species.

areas, and both species nest at Amak Island. Glaucous-winged Gull was the only other bird species occurring In appreciable numbers (approaching 10 birds/km*).

During May 1985 another cruise was made that provided the opportunity to collect additional Information during this dynamic portion of the year. Again the area was found to have exceptionally high densities of marine birds. Overall densities in 1985 were substantially higher than in 1984, but the abundance of birds in general and the overwhelming number of shearwaters was similar.

Care must be taken in estimating the number of shearwaters because, as mentioned earlier, it is not possible to accurately census objects that move fast relative to the observer. Streams of migrating shearwaters are an extreme case. The numbers for this species are difficult to interpret beyond indicating that there were a lot of shearwaters. The aerial survey results give a more useful index of shearwater abundance.

Some other important contrasts between the two May surveys include differences in the abundances of Northern Fulmars, Glaucous-winged Gulls, Black-legged Kittiwakes, and murres. The increased abundance of Northern Fulmars in 1985 was likely merely a function of more sampling in deep water relative to 1984; this species favors deep areas. A valid interpretation of the other differences is not possible without further examination of the sampling distribution and intensity. Despite the between-year differences, If the densities of these species are ranked by cruise, the two May samples always group together relative to the other samples.

<u>September</u>--In contrast with May surveys, September counts on the NAS showed the area to be virtually devoid of birds. The most numerous species was still Short-tailed Shearwater; however, its density had decreased by two orders of magnitude. Even gulls were virtually absent. One “positive” change In September was that the greatest species richness occurred at this time (Le., there were more species, but all were rare). Also, phalaropes reached their peak abundance in September; both Red and Red-necked phalaropes were recorded using the study area.

January--Birds were again numerous in January; however, the species composition differed considerably from that of May. The most numerous bird in January was Crested Auklet at approximately $30/km^2$. The only other widely-encountered species group was murres, which were found at densities very similar to those reoorded in May 1984. Species that peaked in abundance during this cruise were Red-faced Cormorant and King Eider, but neither could be considered very common on the transects.

July--In many respects counts of marine birds during July 1985 were intermediate between counts made in May and those made in September. The surface-feeding species, birds that typically reach the highest abundances in the Bering Sea during the summer months, all had intermediate densities between counts in May and oounts in September. Alcids, especially murres, Tufted Puffins, and murrelets, peaked in July. This contrast is not as apparent in the aerial survey data; indeed, only the July peak of Tufted Puffins and the intermediate abundance of Short-tailed Shearwaters was common to the two sets of summaries. As will be noted later when bird use of depth zones is discussed, the July cruise occurred during a period when the inner front was located unusually close to shore and this may have greatly affected bird use of the area. The aerial survey data for July were collected during 1984 (as opposed to in 1985 when the cruise took place) and, although no oceanographic measurements are available to ascertain the location of the front in 1984, it is possible that it was closer to the 50-m isobath with which it is customarily associated.

Species reaching their peak abundance during the July cruise were jaegers, Aleutian Terns, murrelets, and Horned and Tufted puffins. Among the jaegers, Pomarine Jaeger was the most numerous; it appeared to be migrating "south" at this time. Aleutian Terns nest along the Alaska Peninsula and are resident in the area *only* during the nesting season. The abundance of mu-relets and puffins is more difficult to explain. None is a particularly common breeding species in the area. As mentioned above, part of the cause for their abundance may be oceanographic events (i.e, intrusion of the middle domain into the study area) that caused middle-domain seabirds to move nearer to shore. In the case of murrelets and Horned Puffins the numbers recorded using the area was relatively small and it may be premature to attach much significance to their presence.

Summary. Comparison of the cruise results shows that the study area supports seasonally high densities of marine birds. Species that reach peak densities do so only for portions of the year. Species that exhibited highest peaks in abundance are Short-tailed Shearwater and Crested Auklet. Both of these species use the NAS during their "wintering" seasons (the shearwaters nest in the southern hemisphere and "winter" in the north Pacific during May-August). The cruise summary is misleading in that some important attributes of bird use of the area are poorly represented by the data. Most importantly, seaduck use was greatly underestimated in cruise censuses because these groups are probably most widespread in areas shallower than those surveyed from the ship. The use of the extreme nearshore areas by several species of ducks and gulls is more apparent when the aerial survey results are considered.

In summary the nearshore zone (at least the portions > 20m deep) receives widespread use by birds in spring and winter. Early fall finds the area relatively devoid of these organisms.

6.5.1.2 Segregation By Depth

The transect data were compiled by water depth to see if bird abundance was influenced by this variable. Selection of depth as a criterion was inspired by its use as the delimiting character of the nearshore zone for this study, and because PROBES researchers found that a regularly occurring front that influenced bird distribution was found near the 50-m isobath in the southern Bering Sea.

Aerial Surveys. The data are summarized by the four major tracks along which the transects were aligned (the westernmost lines added midway through the program are compiled separately). The transect groups are thus named and characterized as follows:

- Unimak--The eight transects added midway through the project, all located to the west of Cape Mordvinof. All four of the major lines were extended by two transect lengths to achieve this coverage. This group is quite heterogenous in terms of water depths and oceanographic regions it covers. Habitats sampled extended from shoreline (Unimak Island) to almost 200-m depths.

- o Coast--The shoreline transects from Cape Mordvinof to Cape Seniavin. The exact depths sampled are hard to ascertain due to different depth profiles adjacent to the coast and the poor bathymetry information on nautical charts for this part of the coast. Near Cape Mordvinof some areas surveyed may have been in the vicinity of 30 m but on average the coastal transects probably sampled to water depths of about 13 m. Along most portions of the coast the transect width included the beach, but off Port Moller the transect included some deeper waters. This line includes the portions of the study area not surveyed from the Miller Freeman.

- o Teens--The first track line off the coast. The "teens" includes transect numbers 11 though 18. The average depth sampled by these transects was estimated to be 35 m. These transects characterize use of the coastal domain beyond the shoreline areas.

- o Twenties--The second track line off the coast. The "twenties" includes transect numbers 21 through 28. The average depth sampled by these transects was estimated to be 53 m. This set of transects thus sampled the area where the "inner front" was usually expected to be, although the percent of the time that the inner front was within the area sampled is not known.

- o Offshore--The outermost line of transects. The offshore group comprised transect numbers 31 though 38. The average depth sampled by these transects was thought to be 70 m. These transects should characterize bird use of the middle domain.

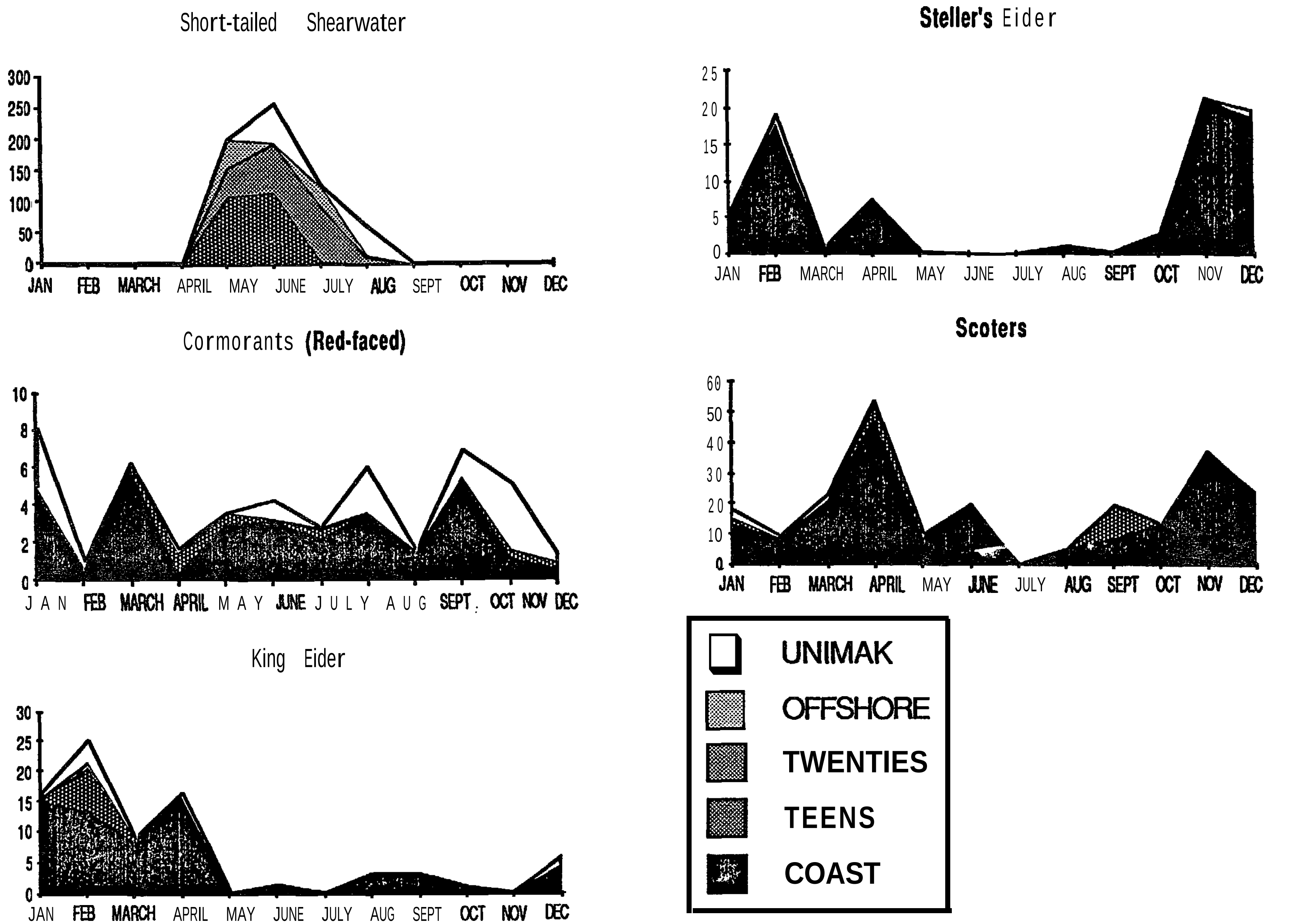


Figure 6.12. Monthly trends in abundance ($\#/km^2$) of marine birds by transect group (depth class) in the North Aleutian Shelf. "Unimak" was not sampled during the May, July, and September surveys.

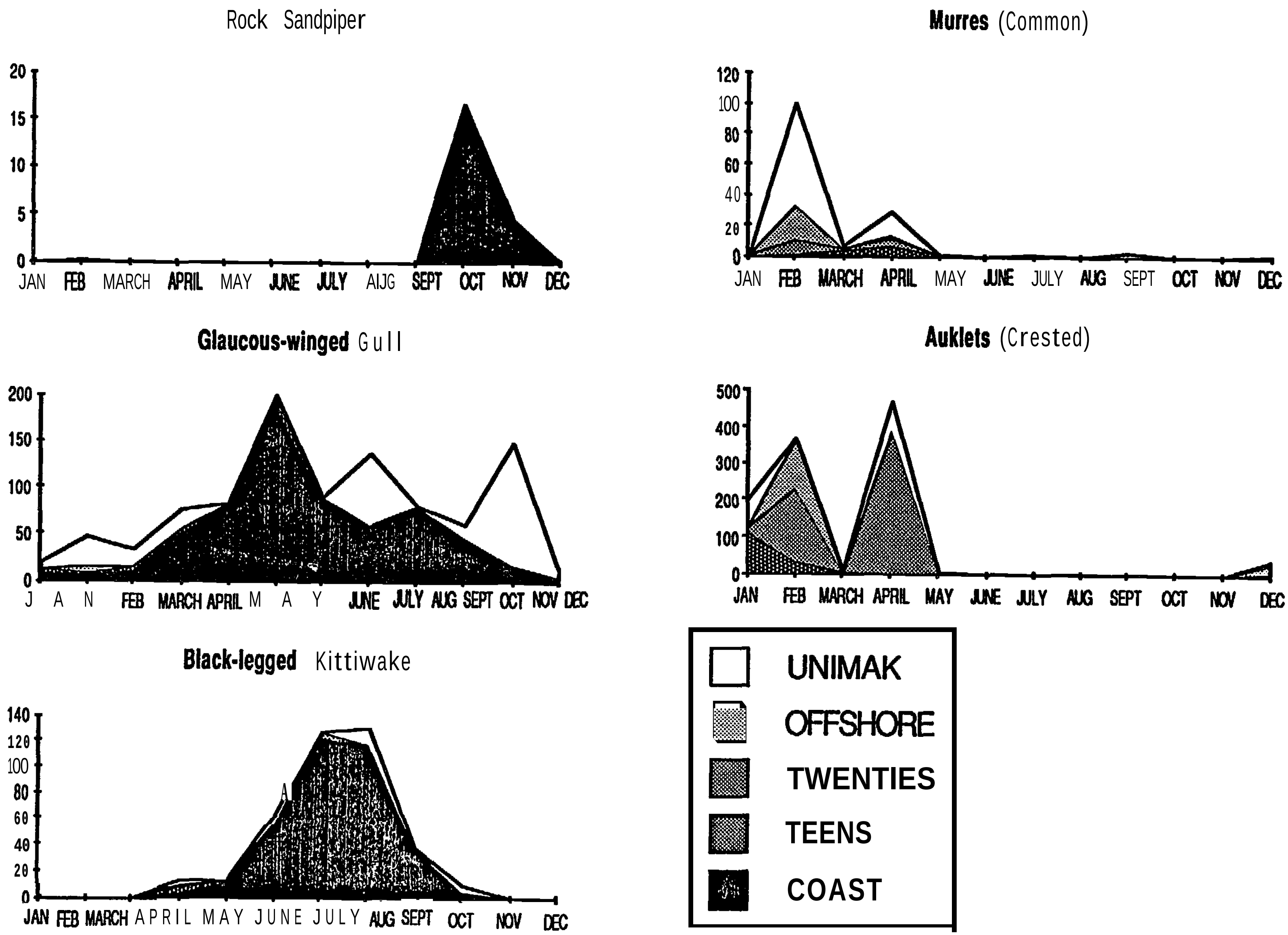


Figure 6.12 (cont 'd)

Use of the above zones by marine birds is summarized in Figure 6.12. Both seasonal (monthly) and spatial (depth) information is included in these charts. Short-tailed Shearwaters are shown to occur only during the summer months and to shift their areas of use from the coastal domain (teens) to farther offshore areas as the summer progressed. By the end of the summer shearwaters were found only in Unimak Pass. Although Figure 6.12 shows shearwater use ending by September, it should be noted that our September aerial survey was done prior to the extension of the study area to include northern Unimak Pass. Studies of Unimak Pass in progress (LGL for NOAA) show this species to be numerous in that area through at least early Oct ober. Most of the remaining species (all the ducks, gulls, cormorants, and Rock Sandpiper) are shown to have predominately strictly coastal peaks in abundance within the NAS. The absolute numbers of some, especially Glaucous-winged Gull and Black-legged Kittiwake, are higher in the coastal domain waters (teens and twenties) than in the littoral band (coast) by virtue of the former's much greater areal extent (portions of the study area < 10 m 557 km^2, 10-50 m ~7740 km^2); however, the seaducks were observed to be quite infrequent seaward of 10-m depths. Two remaining groups--murres and Crested Auklets--were characteristic of the nearshore waters (< 50 m but not along the shoreline), not being encountered along the strictly coastal transects. The murres were found in the coastal domain during the breeding season but tended to be in deeper waters, at or beyond the inner front, during the winter months when they were most numerous in the NAS area. Crested Auklets were generally most numerous along the "twenties" transects, generally close to the inner front.

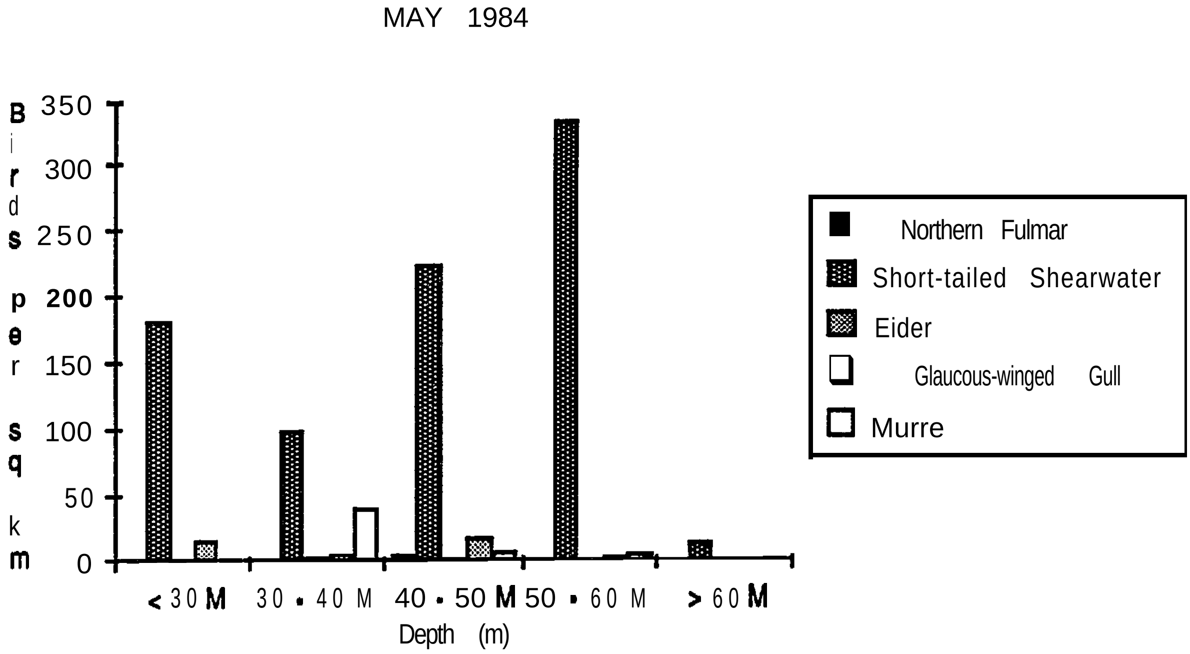
Shipboard Surveys. Densities of marine birds were determined for five depth classes: < 30 m, 30-40 m, CO-50 m, 50-60 m, and >60 m. The analyses were repeated for each cruise.

&--Densities by depth class for the May 1984 cruise are summarized in Table 6.5 and Figure 6.13; results for May 1985 are in Table 6.6 and Figure 6.14.

In May 1984 the predominant species were Short-tailed Shearwater and murres. The shearwaters were the most common species at all depths but

Table 6.5. Densities of marine birds (#/km²) by water depth classes on the North Aleutian Shelf, Alaska during May 1984. Highest densities are shown in boldface, lowest in italics.

SPECIES	< 30 M	30 - 40 M	40 - 50 M	50 - 60 M	> 60 M
Loon	0.05	0.02	0.06	0.00	0.00
Northern Fulmar	*0.00*	0.00	5.37	0.59	0.75
Short-tailed Shearwater	170.88	96.71	243.56	329.21	14.38
Red-faced Cormorant	0.02	0.00	0.00	0.00	0.00
Cormorant	0.70	0.54	0.06	0.02	0.11
dark goose	0.00	0.10	0.00	0.00	0.00
King Eider	0.00	0.58	0.00	0.00	0.00
Eider	0.09	4.02	0.06	0.00	0.00
Harlequin Duck	0.00	0.60	0.00	0.02	0.00
duck	0.37	0.00	0.00	0.00	0.00
Jaeger	0.02	0.03	0.09	0.07	0.11
Glaucous-winged Gull	15.33	4.40	19.08	2.62	1.93
Black-legged Kittiwake	2.46	1.52	1.41	3.92	0.54
Aleutian Tern	0.02	0.03	0.00	0.00	0.00
Murre	1.33	38.28	8.64	4.56	0.32
Pigeon Guillemot	0.02	0.00	0.02	0.00	0.00
Murrelet	0.00	0.05	0.00	0.00	0.00
Crested Auklet	0.05	0.02	0.85	0.00	0.11
Auklet	0.00	0.11	0.11	0.00	0.00
small alcid	0.30	0.11	0.04	0.00	0.21
Tufted Puffin	0.00	0.05	1.59	0.88	2.25
Horned Puffin	0.00	0.00	0.00	0.02	0.00
Phalarope	*0.00*	0.00	0.00	0.00	0.11
TOTAL	191.66	146.56	280.94	341.91	20.83



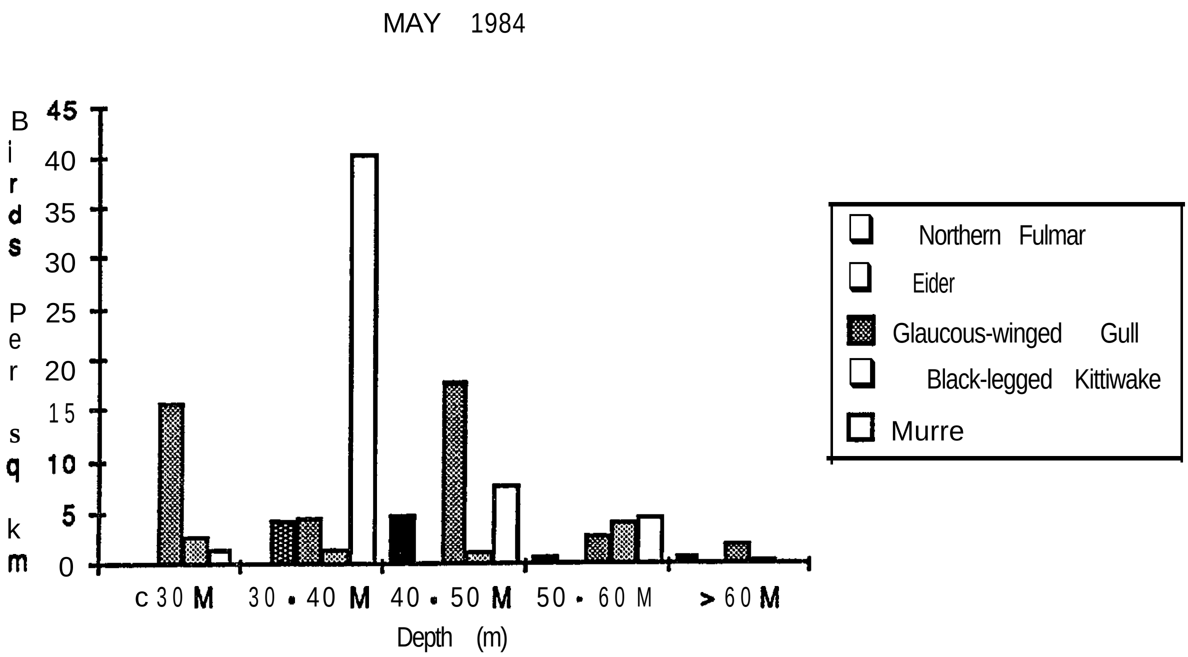
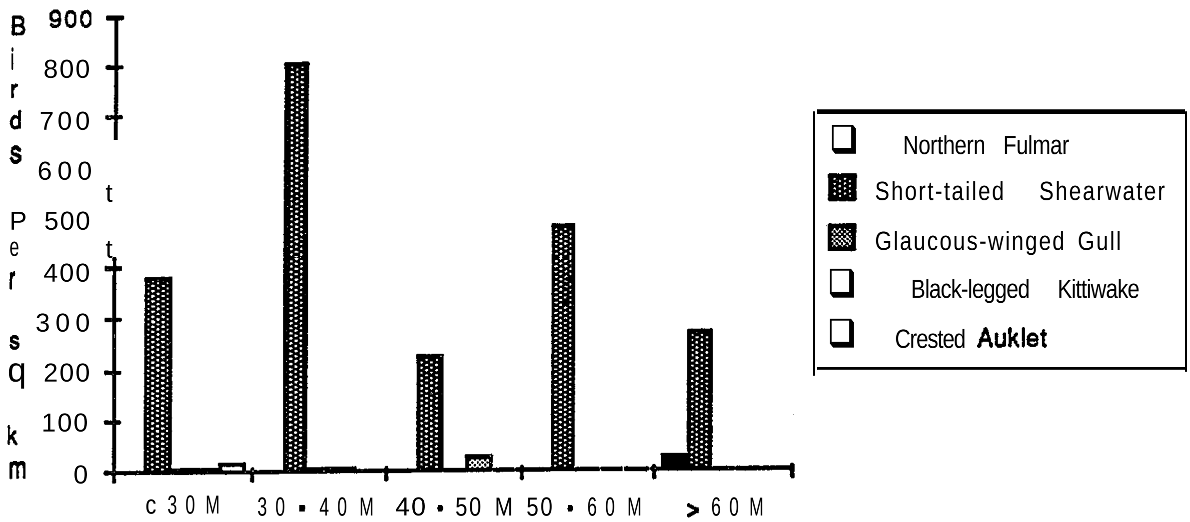


Figure 6.13. Densities of marine birds by depth as recorded during the May 1984 cruise, North Aleutian Shelf, Alaska. Short-tailed Shearwaters, shown in the top graph to reach very high densities, are omitted from the lower graph to show trends in the other species.

Table 6.6. Densities of marine birds (#/km^2) by water depth classes on the North Aleutian Shelf, Alaska during May 1985. Highest densities are shown in boldface, lowest in italics.

SPECIES	< 30 M	30 - 40 M	40 - 50 M	50 - 60 M	> 60 M
Loon	0.1	0.2	0.0	0.0	0.0
Northern Fulmar	0.2	2.1	2.0	6.3	27.9
Short-tailed Shearwater	384.2	807.6	224.0	483.7	271.0
Fork-tailed Storm-Petrel	*0.0*	0.0	0.0	0.6	0.9
Red-faced Cormorant	0.0	0.0	0.1	0.0	0.1
Cormorant	0.1	0.3	0.0	0.0	0.0
Brant	0.0	0.7	*0.0*	0.0	0.5
King Eider	0.2	0.0	0.0	0.0	0.1
Oldsquaw	0.1	0.0	0.0	0.0	0.0
Black Scoter	0.0	0.0	0.0	0.0	0.0
White-winged Scoter	0.0	0.0	0.0	0.0	0.0
Least Sandpiper	0.0	0.0	0.0	0.0	0.0
Parasitic Jaeger-light ph	0.0	0.0	0.0	0.0	0.0
Jaeger	0.1	0.1	0.1	0.1	0.0
Herring Gull	0.0	0.0	0.0	0.0	0.0
Glaucous-winged Gull	7.5	8.9	3.7	2.8	2.1
Glaucous Gull	0.0	0.0	0.0	0.0	0.0
Black-legged Kittiwake	10.8	8.4	28.8	4.0	*1.5*
Sabine's Gull	0.0	0.0	0.0	0.0	*0.0*
Aleutian Tern	0.1	0.1	0.1	0.0	*0.0*
Murre	3.6	4.0	4.2	2.6	1.7
Pigeon Guillemot	0.5	0.0	0.0	0.0	0.0
Murrelet	0.5	0.2	0.1	0.1	0.0
Crested Auklet	17.1	0.3	1.7	1.7	*0.1*
Auklet	0.2	0.1	0.1	0.3	3.0
Tufted Puffin	0.4	0.4	0.9	1.3	0.7
Horned Puffin	0.0	0.1	0.0	0.1	0.0
Lapland Longspur	0.0	0.0	0.0	0.0	0.0
Gull	0.0	0.0	0.0	0.0	0.0
alcid	0.2	0.0	0.0	0.0	0.0
TOTAL	426.0	833.4	265.9	503.6	309.6

MAY 1985



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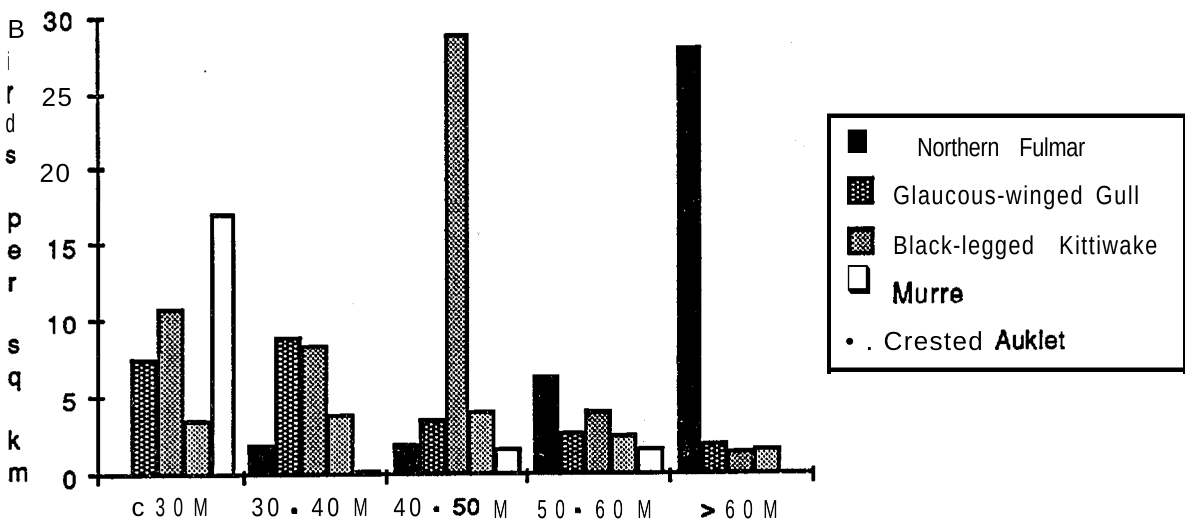


Figure 6.14. Densities of marine birds encountered by depth zone on the North Aleutian Shelf, Alaska, May 1985. Short-tailed Shearwaters, shown in the top graph to reach very high densities, are omitted from the lower graph to show trends in the other species.

they were not evenly distributed. The highest densities occurred at 50-60 m; high densities were found in the 40-50 m zone as well. The lowest densities of shearwaters were found in waters deeper than 60 m. Murres in contrast appeared to exhibit a marked affinity to the 30-40 m zone. Among the less common species, cormorants and seaducks were largely restricted to the shallow zones; i.e., < 30 m and 30-40 m. Northern Fulmars peaked quite markedly in the 40-50 m zone. Puffins were most numerous (but still very uncommon> in the deeper waters.

Oceanographic measurements *In* May 1984 indicated that the inner front was probably seaward of, and at least in a **few** cases, very near the 50-m lsobath. The distribution of Short-tailed Shearwaters is consistent with the idea that greater bird densities occur near this front, but no marked concentrating ef fect was evident.

The results of the May 1985 cruise are not entirely congruent with those of the preceding year. Short-tailed Shearwaters continued to be the most abundant bird in every depth class; however, they peaked in abundance in shallower water (30-40 m) and were markedly **more** abundant in the > 60 m class then during the preceding year. Murres were not as abundant in May 1985 as they were during the preceding **May** and **were** *more* evenly distributed across all depths. Northern Fulmars were more numerous in 1985 and appeared to exhibit a pronounced tendency to occur in deeper waters, especially > 60 m. Other species that were common In May 1985 were Glaucous-winged Gull, Black-legged Klttiwake and Crested Auklet. These species were all predominant in shallow waters although the actual peak *in* abundance of kittiwakes was in the 40-50 m zone. The location of the inner front appeared to be similar to the situation in **1984**, i.e, generally seaward of 50 m. The bird distribution did not reveal any concentrating or boundary effects of this front. Surprising was the occurrence of Short-tailed Shearwaters in deeper waters than in 1984, concurrent with the presence of Northern Fulmar (a typically offshore species) in shallower waters than in 1984.

September--So few birds *were* present in September that the occurrence of distinct trends is difficult to detect (Table 6.7, Fig. 6.15). However, the limited data suggest that the two most common species, Short-tailed Shearwater and phalaropes, were decidedly clumped within the 40-50

Table 6.7. Densities of marine birds (#/km*) by water depth classes during September 1984. Highest densities are shown in boldface, lowest in italics.

SPECIES	< 30M	30 - 40 M	40 - 50 M	50 - 60 M	> 60 M
Loon	0.3	0.3	0.2	0.2	0.0
Northern Fulmar	*0.0*	0.2	0.4	0.2	0.3
Short-tailed Shearwater	1.2	1.4	6.6	*0.3*	0.3
Fork-tailed Storm-Petrel	*0.0*	0.0	0.0	0.1	*0.0*
Leach's Storm-Petrel	0.0	0.0	.0.0	0.0	0.0
Red-faced Cormorant	0.0	0.1	0.0	0.0	0.0
Cormorant	0.1	0.1	0.0	0.0	0.0
King Eider	0.1	0.0	0.0	0.0	0.0
Harlequin Duck	0.0	0.0	0.0	0.0	0.0
Oldsquaw	0.0	0.0	0.0	0.1	0.0
White-winged Scoter	0.2	0.0	0.0	0.0	0.0
Merganser	0.0	0.0	0.0	0.0	0.0
duck	0.0	0.0	0.0	0.0	0.0
Lesser Golden-Plover	0.1	0.0	0.0	0.0	0.0
Jaeger	0.0	0.0	0.0	0.0	0.0
Bonaparte's Gull	0.2	0.0	0.0	0.0	0.0
Mew Gull	0.0	0.0	0.0	0.0	0.0
Glaucous-winged Gull	1.7	1.1	0.7	0.5	0.8
Glaucous Gull	0.0	0.0	0.0	0.0	0.0
Black-legged Kittiwake	1.9	0.8	0.4	0.8	1.3
Murre	*0.0*	*0.0*	0.2	0.0	0.3
Pigeon Guillemot	0.2	0.0	0.0	0.0	0.0
Murrelet	0.0	0.0	0.0	0.0	0.0
Auklet	0.0	0.0	0.0	0.0	0.0
small alcid	0.0	0.0	0.0	0.0	0.0
Tufted Puffin	0.1	0.1	0.0	0.0	0.0
Horned Puffin	*0.0*	0.2	0.1	*0.0*	0.1
large alcid	0.0	0.0	0.1	0.1	0.0
Phalarope	0.0	1.1	5.6	0.1	0.0
TOTAL	6.2	5.6	14.5	2.3	3.2

SEPTEMBER 1984

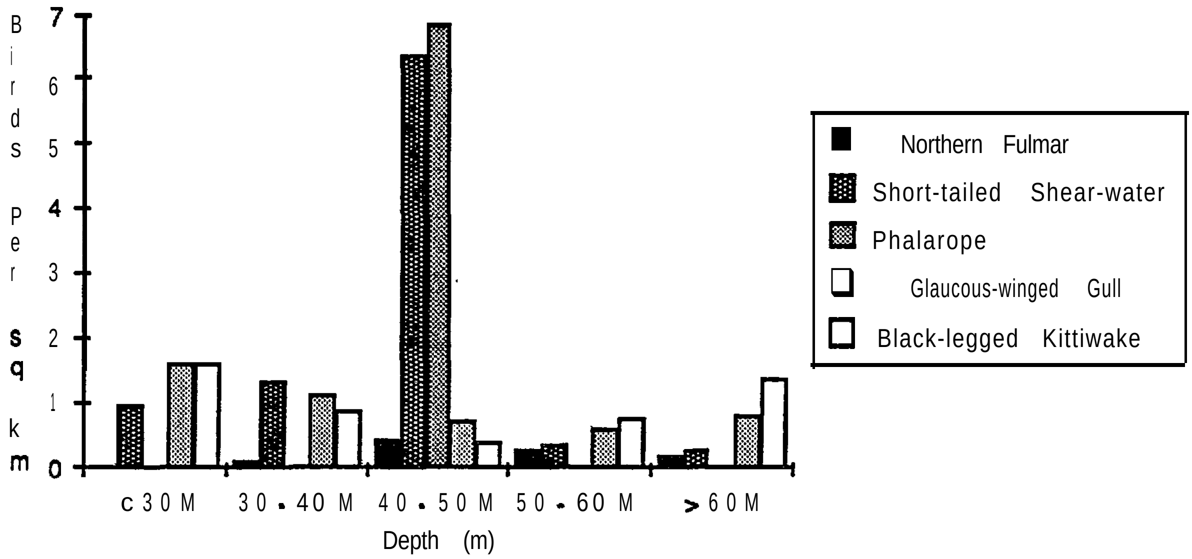


Figure 6.15. Densities of marine birds encountered by the depth zone during the September 1984 cruise on the North Aleutian Shelf, Alaska.

JANUARY 1985

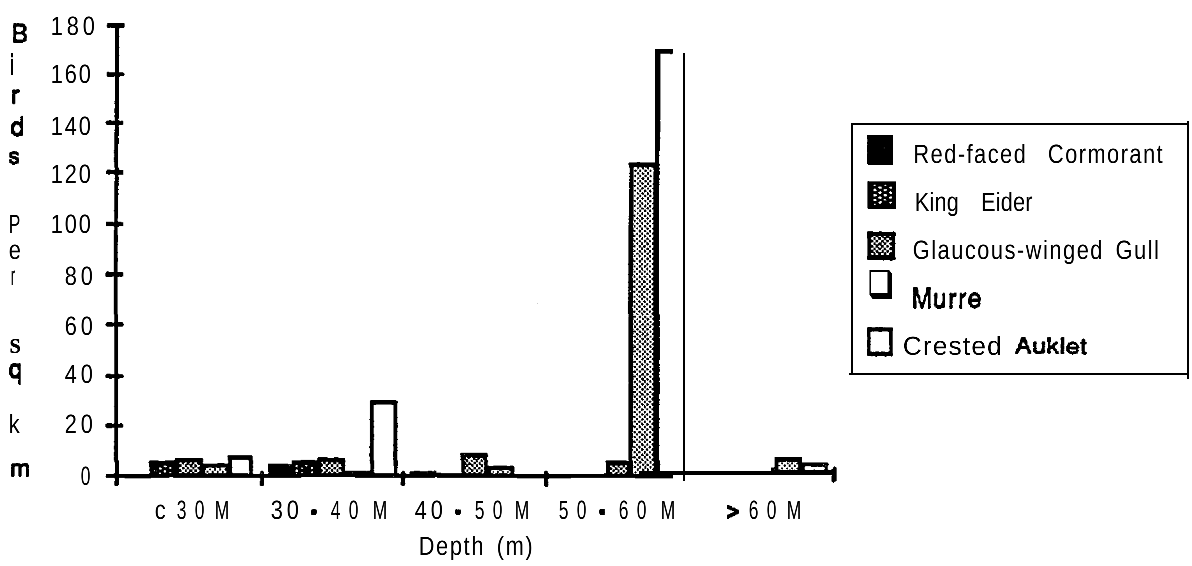


Figure 6.16. Densities of marine birds encountered by depth zone during January, 1985 on the North Aleutian Shelf, Alaska.

m zone. Murres, which were quite rare, peaked in the > 60 m zone, suggesting that post-breeding murres (which nest in summer within the study area) disperse offshore. Although the oceanographic measurements did not provide strong indication of the presence of the inner front within the study area, the birds, at least phalaropes and Short-tailed Shearwaters, were decidedly aggregated in the 40-50 m depth classes, suggesting that some important attractant was present in the area. Phalaropes in particular are well known for their affinity for convergences where the small zooplankters they prey upon are concentrated.

January--Several interesting patterns in bird abundance by depth are evident in the January results (Table 6.8, Fig. 6.16). The two most common species, Crested Auklet and murres, were very concentrated in the 50-60 *m* zone where they occurred in densities exceeding 100 /km^2. The auklet was also relatively common in shallower areas, especially in the 30-40 m zone, but was conspicuously absent from 40-50 m. Murres were the most abundant group in water >60 m. Glaucous-winged Gulls were moderately common in all zones except the deepest *waters*, and peaked from 40-50 m. Ducks (eiders and Oldsquaws) and cormorants (especially Red-faced Cormorant) were at their greatest abundance of any cruise and were largely restricted to waters <40m.

Oceanographic measurements showed no evidence of inner front or middle domain conditions within the study area. But evidence that a distinct front should exist at all in winter is ambiguous (see Section 2.0, this report). The marked concentration of birds in the 50-60 m depth class may indicate that the front existed just outside our main sampling area. *Or* conversely, Unimak Pass *or* the shelf break, rather than the inner front , might have been responsible for the observed concentrations, because concentrations of Crested Auklets, whose numbers were a large proportion of the total bird numbers, were limited to the Umimak Pass-shelf break vicinity.

The January results are intriguing in the apparent zonation of several species and the extremely high densities that occurred in some depth classes. Unfortunately this is also the cruise for which we have the least data (short cruise and limitations on daylight). The sampling intensity is very low for some of these depth classes, (i.e, one transect

Table 6.8. Densities of marine birds (#/km^2) by water -depth classes during January 1985, on the North Aleutian Shelf, Alaska. Highest densities are shown in boldface, lowest in italics.

SPECIES	< 30 M	30 - 40 M	40 - 50 M	50 - 60 M	> 60 M
Loon	*0.0*	0.0	**0.1**	*0.0*	0.0
Red-necked Grebe	0.0	0.0	**0.1**	*0.0*	0.0
Northern Fulmar	0.0	0.0	**0.0**	**0.0**	0.0
Red-faced Cormorant	0.0	4.2	2.1	0.4	0.0
Cormorant	0.0	0.4	0.1	0.1	0.3
King Eider	2.8	6.1	0.4	0.0	0.0
Eider	2.0	0.3	0.0	0.0	0.0
Oldsquaw	5.7	0.0	0.0	0.0	0.0
White-winged Scoter	0.0	0.2	0.0	0.0	0.0
duck	0.0	0.0	0.0	0.0	**1.1**
Mew Gull	0.0	0.3	0.0	0.0	**0.0**
Herring Gull	0.0	0.0	0.0	0.1	**0.0**
Glaucous-winged Gull	6.6	6.6	9.5	5.6	2.0
Black-legged Kittiwake	0.0	0.2	0.7	0.6	0.6
Murre	4.7	2.3	3.5	123.9	6.2
Pigeon Guillemot	0.0	0.8	0.3	0.0	0.2
Murrelet	0.0	0.2	0.0	0.3	0.0
Crested Auklet	8.5	29.3	**0.0**	**169.5**	3.7
Tufted Puffin	0.0	0.0	**0.1**	**0.0**	0.0
TOTAL	31.3	50.8	16.8	300.5	14.4

in the < 30 m zone, and very little in the apparently important 50-60 m zone).

m--During the July cruise all common species peaked in abundance in waters less than 40m deep; many peaked in waters less than 30m (Table 6.9, Fig. 6.17). Tufted Puffins were unusually numerous during this cruise. This compression of seabirds shoreward of their depth distributions on other cruises was coincident with a tendency of the inner front to be well shoreward of the 50-m isobath. Oceanographic data revealed that many of the stations, including some of the shallower stations, **were** apparently located in the middle domain (see Section 2.0 PHYSICAL OCEANOGRAPHY, this volume).

6.5.1.3 Population Estimates

Estimates of the number of marine birds using the study area are presented in Table 6.10. These estimates, determined **for** use in the energy flow model (Section 8.0, this report), were calculated using the following formula:

$$N_i = \Sigma a_j t_{ij}$$

where

N_i = estimated population of species "i" in the NAS study area

a_j = the total area (km^2) in depth class "j" in the study area

and

t_{ij} = the average density of species "i" on all transects in depth class "j"

Six depth classes were used: (1) the 100-m band directly along the shoreline; i.e., the area censused from the nearshore side of the plane on the coastal transects. (This area, "66 km^2, was sampled in its entirety.) (2) coastal waters seaward of zone 1 but less than 10 m deep, total area "557 km^2; (3) waters 10 -20 m deep, total area "1133 km^2; (4) waters 20-30 m deep, total area "1543 km^2; (5) 30-40 m deep, total area "2471 km^2; and (6) waters 40-50 m deep, total area "2593 km^2.

Table 6.9. Densities of marine birds (#/km*) by water depth classes during July 1985 on the North Aleutian Shelf, Alaska. Highest densities are shown in boldface, lowest in italics.

SPECIES	< 30 M	30 - 40 M	40 - 50 M	50 - 60 M	> 60 M
Loon	0.0	0.0	0.0	0.0	0.0
Northern Fulmar	0.4	0.0	0.1	0.8	2.6
Sooty Shearwater	0.0	0.0	0.0	0.0	0.0
Short-tailed Shearwater	32.0	42.8	7.0	7.3	4.7
Fork-tailed Storm-Petrel	*0.0*	0.0	**0.1**	0.0	0.0
Red-faced Cormorant	0.0	0.0	**0.0**	0.3	0.0
Cormorant	0.0	0.0	**0.0**	0.0	0.0
P halarope	0.0	0.0	**0.0**	0.0	0.0
Parasitic Jaeger-light ph	0.1	**0.1**	**0.0**	0.0	0.0
Long-tailed Jaeger	0.0	*0.0*	**0.1**	0.0	0.0
Jaeger	0.8	0.7	0.3	0.2	0.1
Glaucous-winged Gull	4.1	2.3	1.1	0.5	0.4
Black-legged Kittiwake	12.9	2.7	0.9	1.7	0.6
Sabine's Gull	0.0	0.0	**0.1**	0.0	0.0
Arctic Tern	0.0	0.0	**0.0**	0.0	0.0
Aleutian Tern	0.6	0.0	0.1	0.0	0.0
Murre	23.7	5.0	1.7	4.2	0.3
Murrelet	1.7	0.2	0.4	0.2	0.0
Auklet	0.0	0.0	0.0	0.0	0.0
small alcid	**0.1**	0.0	0.0	0.0	0.0
Tufted Puffin	0.7	4.5	0.8	0.5	0.4
Horned Puffin	0.6	0.5	0.0	0.0	0.0
alcid	0.0	0.0	0.0	0.0	0.0
TOTAL	77.7	58.8	12.7	15.8	8.6

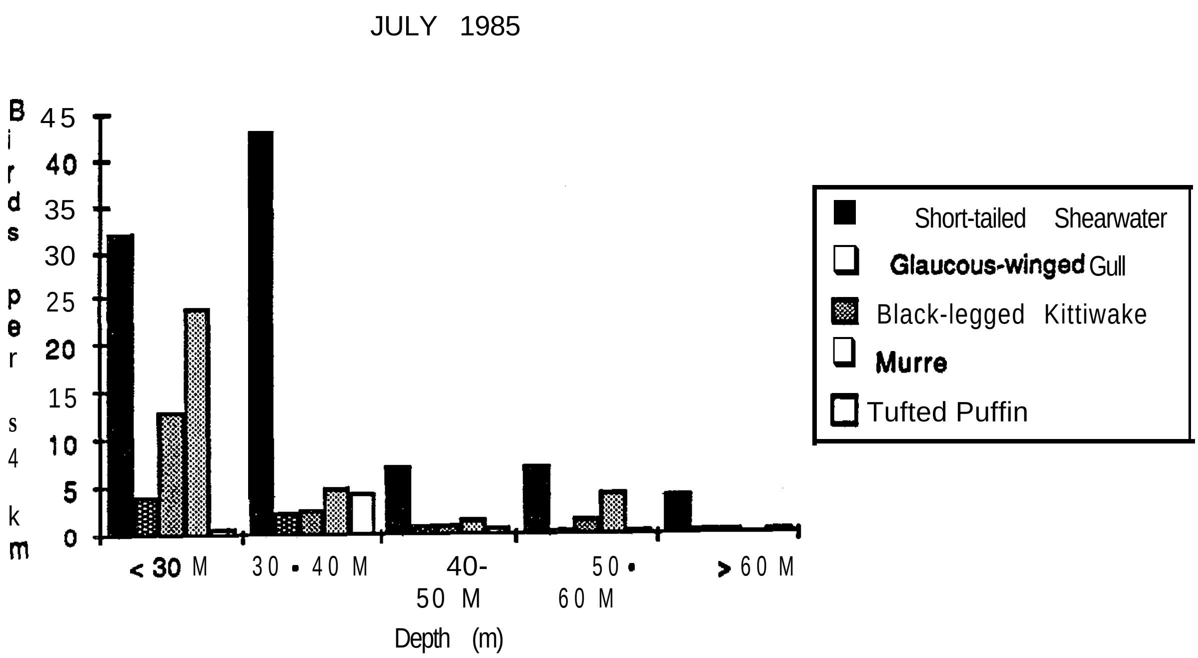


Figure 6.17. Densities of marine birds encountered by depth zone in July, 1985 on the North Aleutian Shelf, Alaska.

Table 6.10. Rough estimates of total bird populations within the North Aleutian Shelf, Alaska study area at the time of each aerial survey. Estimates were derived by extrapolating average density on transects within each 10-m depth class to the total area of each depth class in the study area.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Red-throated Loon	0	0	0	0	20	37	0	0	807	0	0	54
Pacific Loon	0	8	0	0	40	0	0	0	107	41	20	0
Common Loon	0	0	0	21	0	2	0	0	0	0	0	0
Loon	0	435	101	124	56	0	0	64	299	74	0	0
Grebe	0	95	1	0	0	0	0	0	0	156	0	115
Northern Fulmar	383	159	685	20	354	1,513	1,492	1,156	1,100	1,447	20	733
Shearwater-dark	0	0	0	0	318,896	1,278,410	10,773	2,646	1,524	1,404	60	20
Fork-tailed Storm-Petrel	0	0	0	0	0	20	101	121	20	216	0	0
Cormorant	7,633	1,709	6,834	3,378	10,786	4,601	2,037	2,929	2,648	3,327	2,571	1,697
Emperor Goose	0	262	0	49	16	0	0	244	14,014	868	189	0
Brant	0	0	0	0	20	2	0	1,606	30	185	0	0
Mallard	0	0	0	3	0	1	0	0	0	0	0	0
Common Eider	842	2,403	353	96	5,480	2	186	0	447	5	27	1,230
King Eider	32,514	70,508	18,761'	26,058	112	350	811	4,966	9,073	2,863	51	12,126
Steller's Eider	15,130	40,261	1,602	24,751	229	1	0	4.520	1,015	10,196	74,308	54,429
Harlequin Duck	56	117	0	26	520	182	1,143	9	7	90	61	36
Oldsquaw	5,521	12,838	2,264	12,380	58	81	0	0	0	1,369	4,236	3,236
Scoter	41,864	16,888	18,215	161,346	25,594	14,077	461	16,614	95,118	36,371	121,518	31,337
Red-breasted Merganser	2	693	0	426	1,015	348	0	0	0	0	0	170
duck	40	9	92	431	28,459	269	2,377	381	561	171	19,930	234
Bald Eagle	69	102	1	0	28	36	1	0	1	2	0	11
Rock Sandpiper	0	40	0	0	0	0	0	0	0	2,200	600	0
small Sandpiper	0	0	0	0	0	0	50	0	0	0	0	0
Phalarope	0	0	0	0	37	0	0	11,519	1,895	105	0	0
shorebird	3	0	0	0	45	468	61	129	86	77	0	0

Table 6.10 (cont'd)

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Jaeger	0	0	0	0	27	422	3,272	971	60	37	0	0
Bonaparte's Gull	0	0	0	0	0	0	0	0	0	229	80	0
Mew Gull	2,546	676	23	0	30	312	40	0	0	7,617	1	265
Herring Gull	0	0	0	37	1	2	0	0	54	64	0	27
Glaucous-winged Gull	18,258	14,859	17,953	55,065	52,839	110,732	37,386	14,898	62,270	22,032	11,094	6,811
Glaucous Gull	20	27	219	211	0	57	0	0	0	40	0	40
Black-legged Kittiwake	40	179	1,591	28,750	25,379	38,878	45,548	51,287	125,788	13,897	1,480	27
Sabine's Gull	0	0	0	0	27	0	40	0	0	0	0	0
Tern	0	0	0	0	2,920	2,541	559	2,901	0	0	0	0
Murre	2,809	7,832	21,385	48,572	3,372	2,768	7,238	1,127	684	725	844	2,937
Pigeon Guillemot	20	21	27	0	0	1	0	0	20	0	0	0
Murrelet	158	895	0	20	0	0	0	0	0	0	227	53
Auklet	304,822	100,475	17,587	643	5,287	114	527	524	141	221	261	11,886
Tufted Puffin	0	0	94	0	955	168	1,197	1,844	302	0	101	121
Horned Puffin	0	0	20	159	0	89	101	155	181	0	0	222
alcid	0	0	181	134	343	0	222	20	0	SO	0	0
Common Raven	45	0	0	0	1	0	2	0	0	0	0	12
Snow Bunting	134	0	0	0	0	0	0	0	0	0	40	15
passerine	0	0	0	0	0	0	0	0	2,619	0	0	0
TOTAL	432,909	271,292	107,991	360,699	482,945	1,456,484	115,626	120,631	320,871	106,109	237,721	127,844

These calculations indicate that bird use of the NAS peaked during June with almost 1.5 million birds present. Most of these birds were shearwaters. Spring migration (April and May) and mid-winter (January) were the other major periods of bird use. During spring shearwaters were always the predominant species whereas during the winter Crested Auklets were most numerous.

6.5.2 Trophic Relationships

Studies of the trophics of marine birds and mammals provide a link in the interpretation of relationships among physical parameters, biological productivity, and distributions and abundances of key species of marine birds and mammals. In this study, *one* of the major objectives was to test the hypothesis that the organic materials transported from the lagoons along the Alaska Peninsula to the adjacent NAS nearshore zone contribute significantly to the food webs in that zone and cause heightened utilization of the zone by higher trophic level organisms (marine birds, mammals, and fish). Another important objective was to determine the manner in which the dominant birds, mammals, and fish contribute to or utilize the nearshore zone and its organic resources. In terms of birds, these objectives were addressed primarily through sampling programs conducted during five cruises in nearshore waters of the NAS (May and September 1984, and January, May,and July 1985). The sampling programs during each cruise involved collections of key species at different levels in the food chain.

We collected representatives of 18 species of birds in three foraging guilds (Table 6.11): (1) surface feeders (Glaucous-winged Gull, Black-legged Kittiwake, Aleutian and Arctic terns, Short-tailed Shearwater), whose prey is obtained primarily in the top 3 m of water, (2) water column feeders (Common and Thick-billed Murres, Red-faced Cormorant), whose prey is obtained generally in waters deeper than 3 m, and (3) bottom (benthic, epibenthic) feeders (scoters, eiders, Oldsquaw, Harlequin Duck), whose prey is obtained from or slightly above the bottom substrate. In total, 365 individuals were collected at over 30 different locations (Fig. 6.18). Except for 8 birds collected at a 70-m sampling station during the July 1985 cruise, all birds were collected in waters shallower than 50 m

Table 6.11. Summary of bird collections, North Aleutian Shelf, Bering Sea, Alaska, 1984 and 1985.

	Collection Dates											
	1984						1985				ALL DATES	
Feeding Habitat/	16-18 May		26 Sept. -4 October		30 Jan.		19-24 May		20-29 July			
Species	S	D	S	D	S	D	S	D	S	D	S	D
Surface												
BLKI	1	0	19	0			50	0	15	0	85	0
STSH	12	0	4	0			9	0	9	3	34	3
GWGU			12	0	4	0	25	0	3	0	44	0
ALTE							6	0	11	0	17	0
ARTE									1	0	1	0
MEGU					1	0					1	0
Mid-Water												
RFCO			17	0			9	0	7	0	33	0
PECO					3	0	1	0			4	0
TBMU							8	0	3	1	11	1
COMU	1	0					6	0	8	4	15	4
Bottom												
STEI			17	0			5	0			22	0
KIEI			14	0			12	0	5	0	31	0
OLDS					5	0	7	0			12	0
WWSC			20	0			1	0	2	0	23	0
BLSC			7	0	2	0	4	0			13	0
HADU			4	0			5	0			9	0
Subtotals	14	0	115	0	15	0	149	0	64	8	357	8
TOTAL	14		115		15		149		72		365	

*S=Shallow collection location (<50m).
D=Deep collection location (>50m).

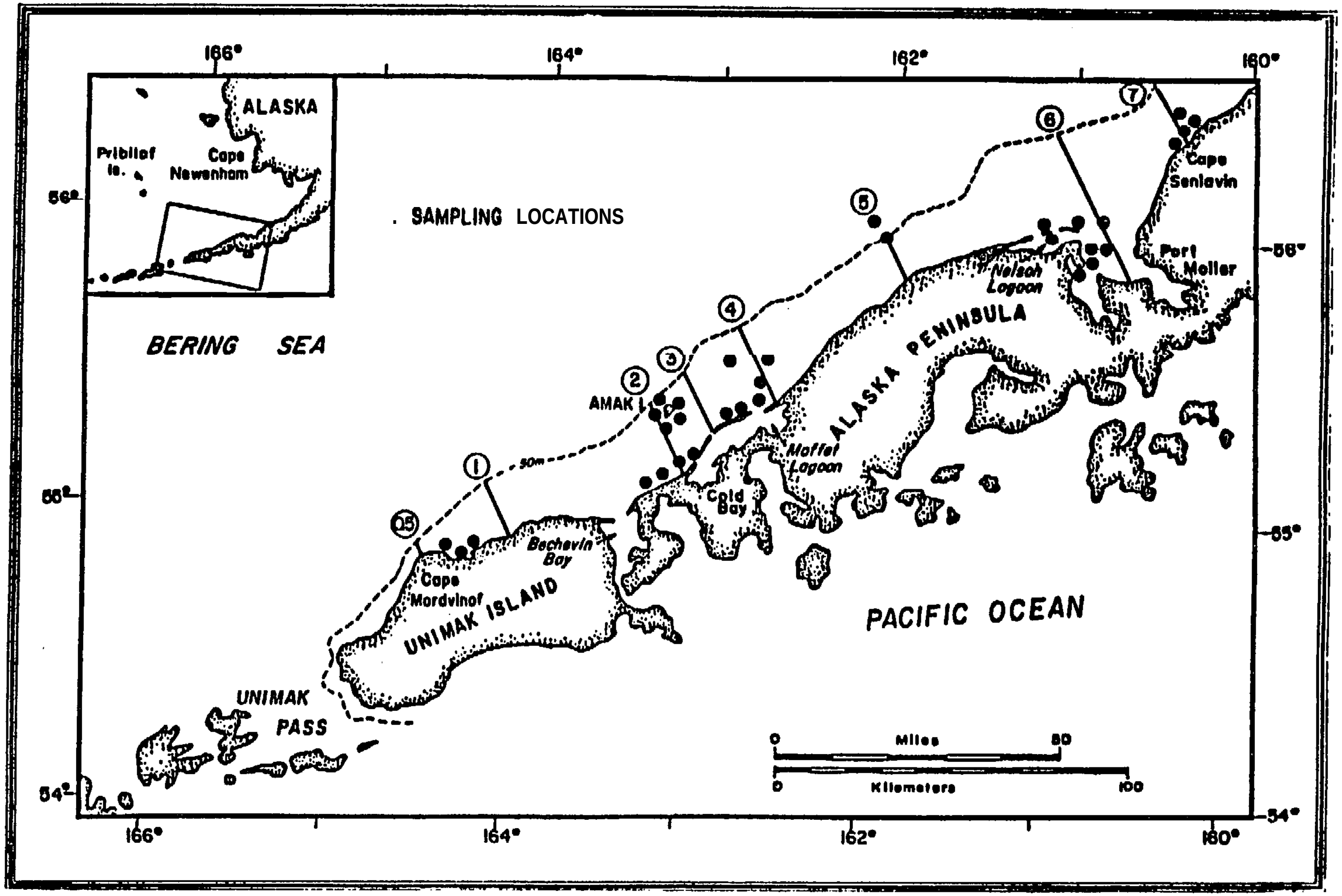


Figure 6. 18. Map of the North Aleutian Shelf study area, showing bird collection locations.

(the primary area of interest in this study). Very small samples of four species (1-4 birds totaling 8 individuals) have not been included in the analyses of food habits because these samples were thought to be too small to be representative.

6.5.2.1 Surface-Feeding Birds

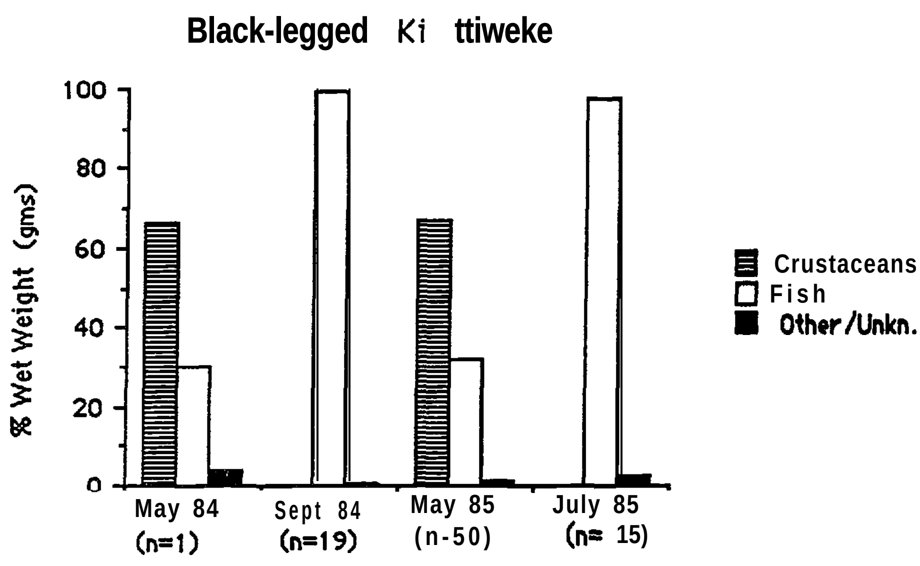
Diets of surface-feeding birds collected in May were mainly euphausiids. Euphausiid crustaceans comprised approximately 66% of the wet weight diets of Black-legged Kittiwakes collected during cruises in May1984 and 1985. Fish (principally sand lance, Ammodytes hexapterus, but also several unidentified species) comprised most of the remainder of the spring diet (see Table 6.12, Fig. 6.19). Figure 6.20 shows the very high proportion of sand lance otoliths taken from the stomachs of kittiwakes during May. Shearwaters, showing an even greater preference for invertebrates, ate exclusively euphausiids in May 1984 (96.7%) and primarily euphausiids and some fish in May 1985 (about 80% and 16%, respectively; see Table 6.13, Fig. 6.19). Although only one shearwater stomach from a spring sample (May 1985) contained otoliths, all otoliths were identified to be from sand lance (Fig. 6.20).

No birds were collected during summer 1984, but those collected in summer 1985 indicated that the diets of Black-legged Kittiwakes and Short-tailed Shearwaters had switched almost entirely to fish by July (Tables 6.12 and 6.13, Fig. 6.19). Although most of the fish were digested and unidentifiable, virtually all otoliths taken from bird stomachs were identified to be from sand lance (see Fig. 6.20). Based on samples collected in 1984, sand lance remained the dominant item in kittiwake and shearwater diets through at least September (Tables 6.12 and 6.13; Fig. 6.20). No winter samples of either kittiwakes or shearwaters were collected during this study (both species are largely absent from the study area). However, Glaucous-winged Gulls, whose spring, summer, and fall diets (see Table 6.14 and Figs.6.21 and 6.22) were similartothose of kittiwakes and shearwaters (euphausiids in spring with a switch to fish, primarily sand lance, during summer and fall), apparently ate no fish during January.

Table 6.12. Organisms consumed by Black-legged Kittiwakes (*Rissa tridactyla*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska.

	1984				1985			
	May (n=1)		Sept. (n-19)		May (n=50)		July (n=15)	
	Wet wt.		Wet wt.		Wet wt.		wet wt.	
Major Taxa	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Euphausiids	1.2	66.5	0.0	0.0	307.0	66.7	0.0	0.0
Mysids	0.0	0.0	tr	tr	1.5	0.3	0.0	0.0
Crustaceans	1.2	66.5	tr	tr	308.5	66.7	0.0	0.0
Sand lance	0.0	0.0	28.1	25.2	67.4	14.6	43.7	45.1
Other fish	0.0	0.0	1.5	1.3	0.0	0.0	1.3	1.3
Unid. fish	0.6	29.7	81.1	72.8	79.1	17.2	49.5	51.0
All fish	0.6	29.7	110.7	99.3	146.5	31.8	94.5	97.4
Other/Unknown	0.1	3.8	0.8	0.7	5.3	1.2	2.5	2.6
Total	1.9	100 .0	111.5	100.0	460.3	100.0	97.0	100.0

*tr = trace amounts (<0.1%) organisms.



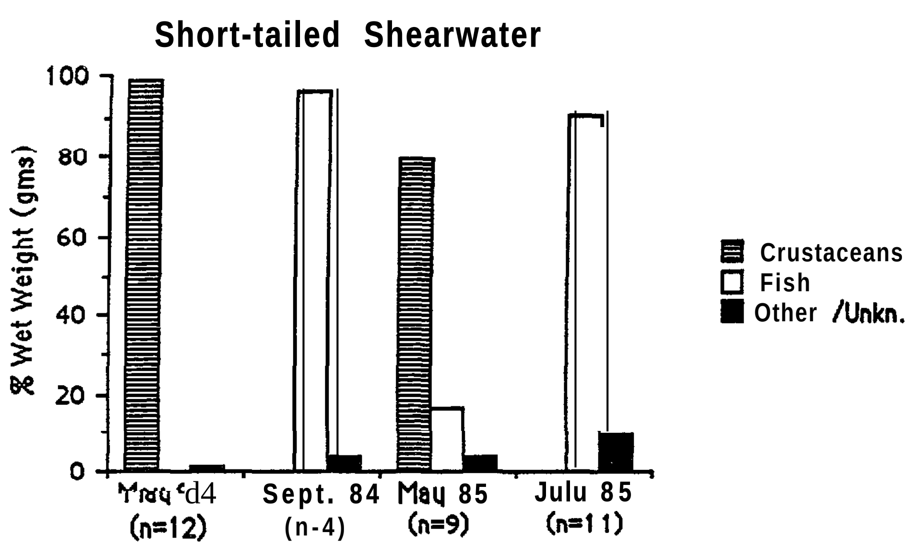
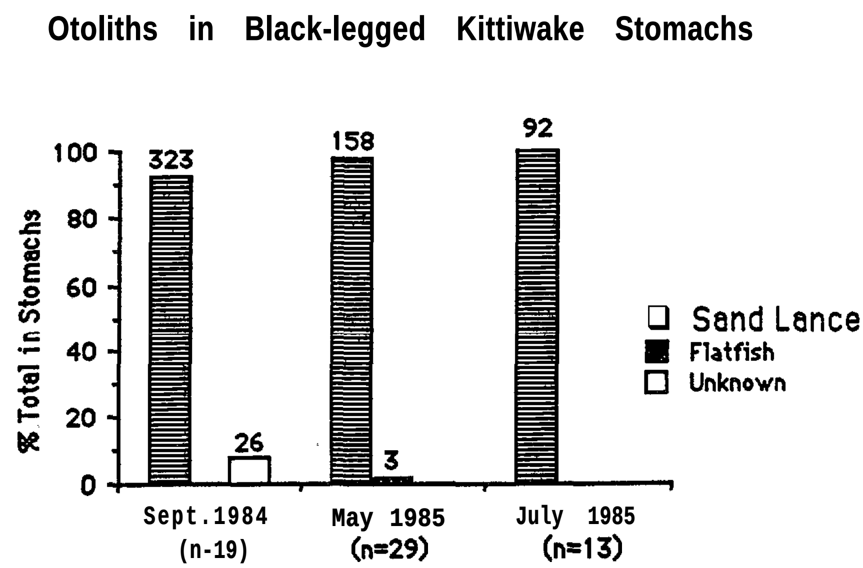


Figure 6 .19. **Diet Composition of Stomach Contents of Black-legged** Kittiwakes and Short-tailed Shearwaters collected in the North Aleutian Shelf area, Bering Sea, Alaska, May 1984 to July 1985.

Table 6.13. Organisms consumed by Short-tailed Shearwaters (*Puffinus tenuirostris*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska.

	1984				1985			
	May (n=12)		Sept. (n=4)		May (n=9)		July (n=11)	
	wet wt.		wet wt.		wet wt.		wet wt.	
Major Taxa	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Decapods	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausiids	379.0	96.7	0.0	0.0	77.0	79.5	tr	tr
Amphipods	0.0	0.0	tr *	tr	0.0	0.0	0.0	0.0
Mysids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustaceans	379.0	96.7	tr	tr	77.0	79.5	tr	tr
Squid	7.5	1.9	tr	tr	0.1	0.1	tr	tr
Jellyfish	tr	tr	0.0	0.0	0.0	0.0	0.0	0.0
Sand lance	0.0	0.0	11.6	23.3	0.0	0.0	0.0	0.0
Other fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unid. fish	tr	tr	36.1	72.6	16.1	16.6	49.8	90.5
All fish	tr	tr	47.7	95.9	16.1	16.6	49.8	90.5
Other/Unknown**	5.5	1.4	2.0	4.1	3.7	3.8	5.2	9.5
Total	392.0	100.0	49.7	100.0	96.9	100.0	55.0	100.0

* tr = trace amounts (<0.1%) of organisms.
** Sludge, blood clots, otoliths, etc.



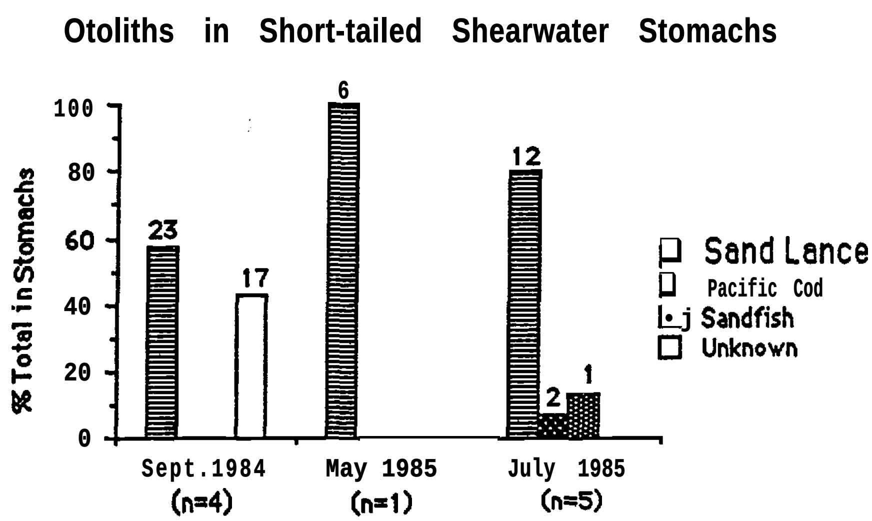
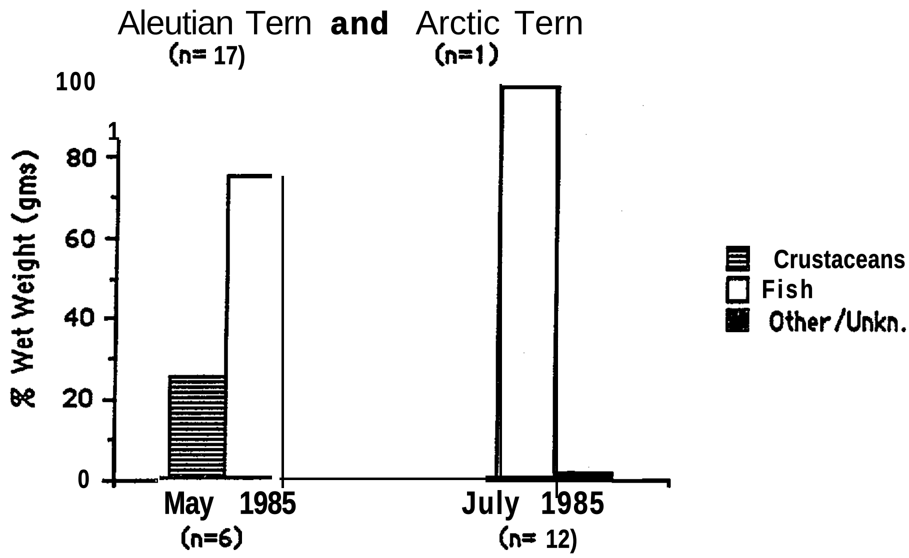


Figure 6.20. Identity of fish otoliths from stomachs of Black-legged Kittiwakes and Short-tailed Shearwaters collected in the North Aleutian Shelf area, Bering Sea, Alaska, September 1984 to July 1985.

Table **6.14. Organisms** eaten by Glaucous-winged Gulls (*Larus glaucescens*) in nearshore waters of the **North** Aleutian Shelf, Bering Sea, Alaska, 1985 .

Major **Taxa**	September 1984 (n-12) wet weight g	%	January 1985 **(n=4)** wet weight g	%	**May** 1985 **(n=25)** wet weight g	%	July 1985 **(n=3)** wet weight g	%
All Fish	7.6	53.3	0.0	0.0	96.0	39.0	4.4	61.1
Decapod	0.0	0.0	0.7	2.1	tr	**tr**	0.0	0.0
Euphausiid	0.0	0.0	0.0	0.0	132.1	53.7	0.0	0.0
Mysid	0.0	0.0	0.0	0.0	0.2	tr	0.0	0.0
Crustaceans	3.6	25.0	2.0	6.0	132.3	53.7	0.0	0.0
Bivalves	0.0	0.0	0.0	0.0	tr	**tr**	0.0	0.0
Gastropods	0.0	0.0	0.0	0.0	1.1	**0.5**	0.0	0.0
Molluscs	0.3	1.8	0.0	0.0	1.1	0.5	0.0	0.0
Echinoderms	0.0	0.0	29.5	88.6	tr	tr	0.0	0.0
Unknown/Other	2.8	19.9	1.8	5.4	16.7	6.8	2.8	38.9
TOTAL	14.19	100.0	33.3	100.0	246.1	100.0	7.2	100.0

***tr** = trace amounts **(<0.1%)** organisms.



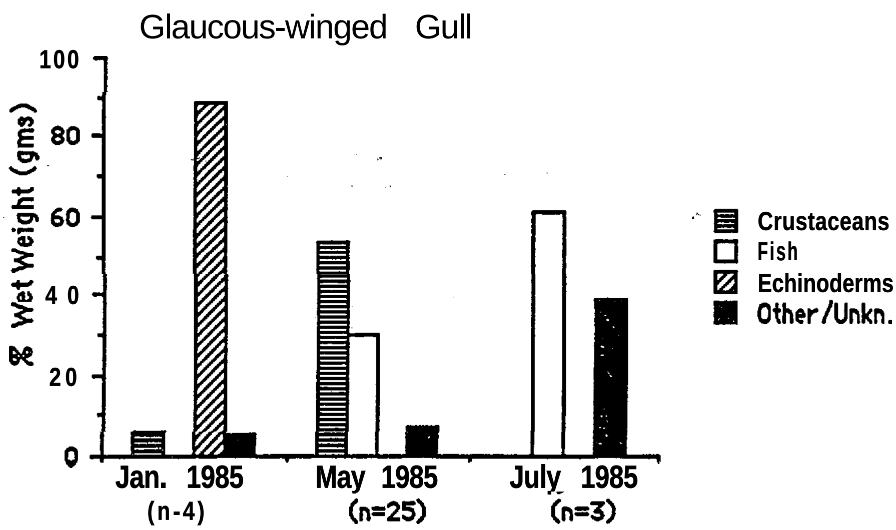
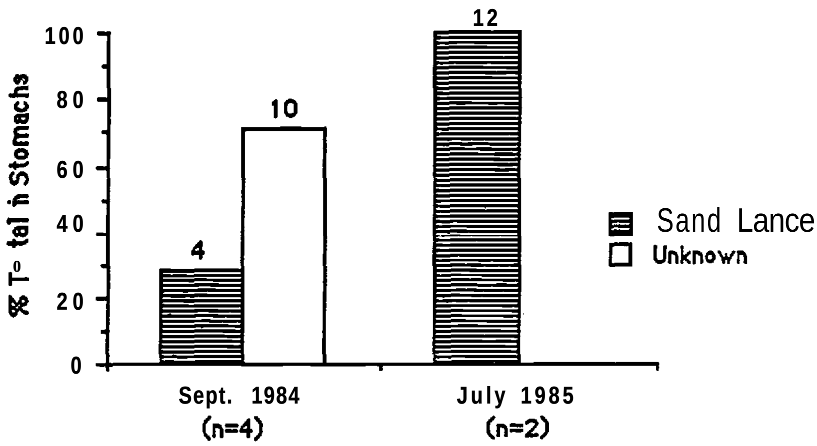


Figure 6.21. Comparisons of stomach' contents of terns and Glaucous-winged Gulls collected in the North Aleutian Shelf area, Bering Sea, Alaska, September 1984 to July 1985.

Otoliths in Glaucous-winged Gull Stomachs



Otoliths in Tern Stomachs

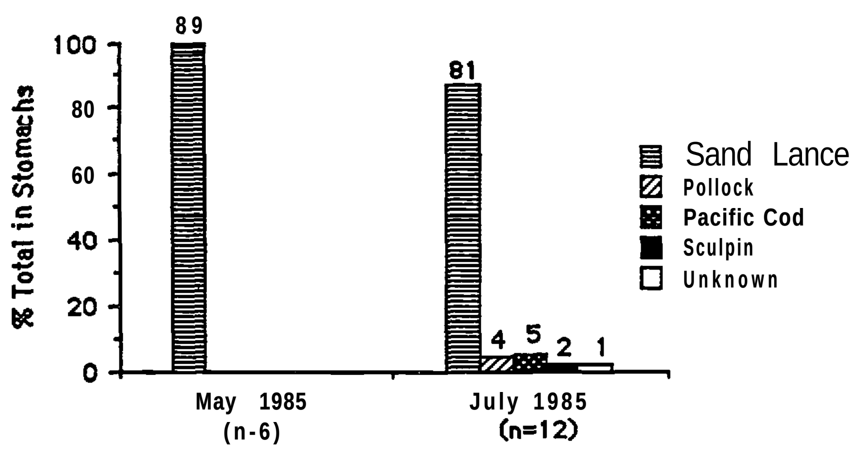


Figure 6.22. Identity of fish otoliths from stomachs of terns and Glaucous-winged Gulls collected in the North Aleutian Shelf area, Bering Sea, Alaska, September 1984 to July 1985.

Samples of terns (primarily Aleutian Terns, see Table 6.11) were collected only during cruises in May and July 1985 (Table 6.15). During those two months, and especially during July, fish (primarily sand lance; Fig. 6.22) comprised the largest proportion of the diet of terns (75% and 98.4%, respectively, of mean wet weight diets for May and July 1985).

Thus, the diets of the four dominant species or species groups of surface-feeding birds using the NAS study area change drastically between spring (May) and summer-fall (July-September) sampling periods (Fig. 6.23). During May, diets were composed largely of euphausiid crustaceans and secondarily of fish (mainly sand lance in May 1985). By July, and continuing into September, all surface feeding birds that we collected had switched to sand lance as their main prey. Correlated with this finding, euphausiids swarm to the surface in late spring and early summer to breed, dispersing thereafter (at least In daylight hours) to water-column and benthic environments (Ponomareva 1966). Further, Craig (see Section 5.0, this report) found that sand lance were most abundant in the NAS study area during mid- to late summer (July and September cruise periods). Their distribution during these periods was very patchy, as illustrated by very erratic catches-per-unit-effort (CPUE): O-180,000 fish hr^{-1} in July.

Our observations of surface-feeding seabirds, especially during the May 1985 cruise, indicated that Black-legged Kittiwakes, Short-tailed Shearwaters, and to a lesser extent Glaucous-winged Gulls, concentrated their feeding on patches of prey when the prey animals were near the surface. On 22 and 24 May especially, very dense concentrations of kittiwakes and shearwaters swarmed over surface concentrations of euphausiids and sand lance. Several birds collected from these feeding flocks had stomachs packed with sand lance and euphausiids; the sand lance in these stomachs were dissected and their stomachs were full of euphausiids. Thus, sand lance are present in the study area during spring (though apparently less abundant than in late summer) and apparently feed heavily on the surface swarms of euphausiids (see also 5.0, this report); they are available to surface-feeding birds when they approach the surface. Nevertheless, euphausiids are the most abundant prey of surface feeding seabirds during spring, as reflected in the diets of the birds. Later, during the summer-fall period, when euphausiids are less abundant

Table 6.15. Organisms eaten by terns (*Sterna aleutica* and *Sterna paradisaea*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska, 1985.

Major Taxa	May 1985 (n=6) Wet Weight (g)	(%)	July 1985 (n=12) Wet Weight (g)	(%)
Sand lance	5.6	42.4	0.0	0.0
Unidentified Fish	4.3	32.6	36.4	98.4
All Fish	9.9	75.0	36.4	98.4
Crustaceans	3.3	25.0	tr	tr
Other/Unknown*	tr	tr	0.6	1.6
TOTAL	13.2	100.0	37.0	100.0

* Blood clots, feathers, parasites, vegetation, sludge, etc.
tr = trace amounts (<0.1 g wet weight) of prey.

Prey of Surface Feeding Birds

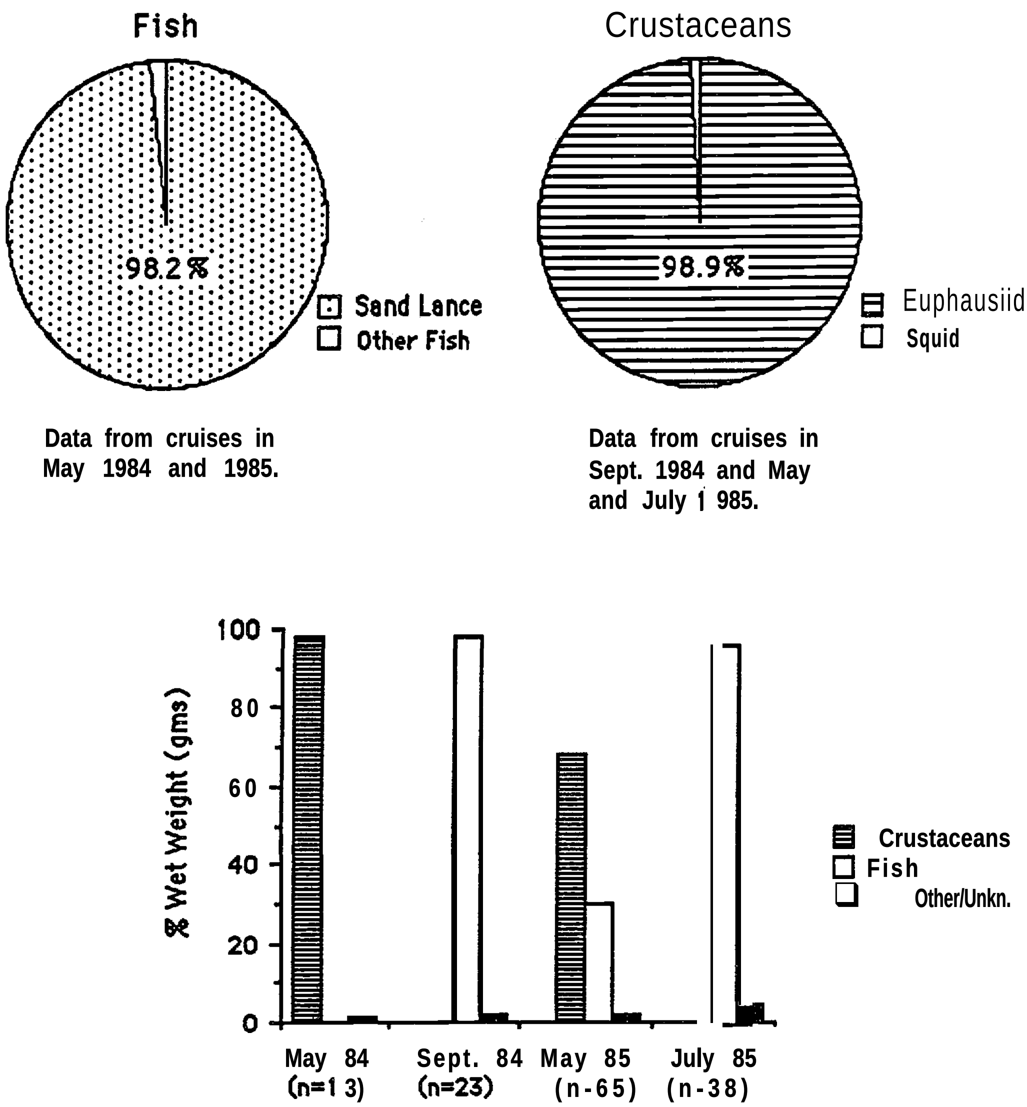


Figure 6.23. Stomach contents of surface-feeding birds (139 individuals of four species) collected during four cruises over the North Aleutian Shelf, Bering Sea, Alaska, May 1984 to July 1985. (Sample sizes of the four species are: 85 Black-legged Kittiwakes, 36 Short-tailed Shearwaters, 17 Aleutian Terns, and 1 Arctic Tern; forty-four Glaucous-winged Gulls were not included in this analysis).

and less available, sand lance are probably more abundant in the area and dominate the diets of surface-feeding seabirds.

These results contrast to some extent with other studies. Schneider et al. (1986) and others found that euphausiids (primarily Thysanoessa raschii) were the principal prey throughout the summer-fall period for important species of seabirds (primarily Short-tailed Shearwater) in the shallow, well-mixed inner domain (waters generally < 50 m deep). Hunt et al. (1981a) and Schneider et al. (1986) found fish (primarily walleye pollock, Theragra chalcogramma) to be the principal prey of seabirds only in outer domain and continental slope waters, close to the shelf-break and near the Pribilof Islands; these authors seldom mention sand lance as an important prey of seabirds near the Prlbilofs. However, feeding studies near the Pribilof Islands by others (e.g., Bradstreet 1985) showed that sand lance formed a significant fraction of the diet of Black-legged Kittiwakes during July and August 1984. This was true especially near St. Paul Island (sand lance were 39% and 44.2% of the wet weight diets in July and August, respectively), which is situated in the middle domain some distance from the shelf break community.

In this study, euphausiids dominated the diets of all surface-feeding seabirds in spring and sand lance dominated their diets throughout the summer-fall period. Walleye pollock were conspicuous in their absence from diets of all surface-feeding seabirds during all cruise periods in the NAS study area.

Another unexpected result from this study was the virtual absence of salmonid prey in the diets of surface-feeding birds, even though very large numbers of the smolts of salmonids are reported to pulse through our study area annually (Straty 1981). However, the timing of our cruises and collections probably did not coincide with the major pulses of salmonids, which occur primarily in June (see Section 5.0, this report).

6.5.2.2 Water-Column-Feeding Birds

Red-faced Cormorants were collected during May and July 1985 and September 1984; the diets of these piscivorous birds were dominated by sand lance (Table 6.16, Fig. 6.24), which again suggests that this was the most abundant species of forage fish present in the study area during

Table 6.16. Organisms eaten by Red-faced Cormorants (*Phalacrocorax urile*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska.

	September 1984 (n=17)		May 1985 (n=9)		July 1985 (n=7)	
	Wet Wt.		Wet Wt.		Wet Wt.	
Major Taxa	(g)	(%)	(g)	(%)	(g)	(%)
Sand lance	154.8	94.8	317.9	93.5	102.4	88.4
All Fish	154.8	94.8	317.9	93.5	102.4	88.4
Crustaceans	0.6	0.4	11.6	3.4	5.1	4.4
Other/Unknown*	7.8	4.8	10.5	3.1	8.4	7.2
Total	163.2	100.0	340.0	100.0	115.9	100.0

* Sludge, rocks, otoliths, nematodes, blood clots, etc.

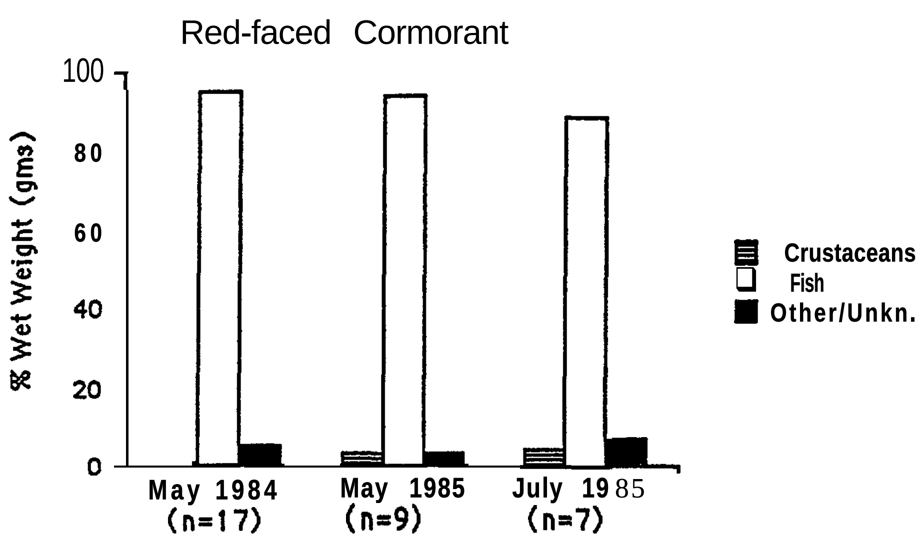
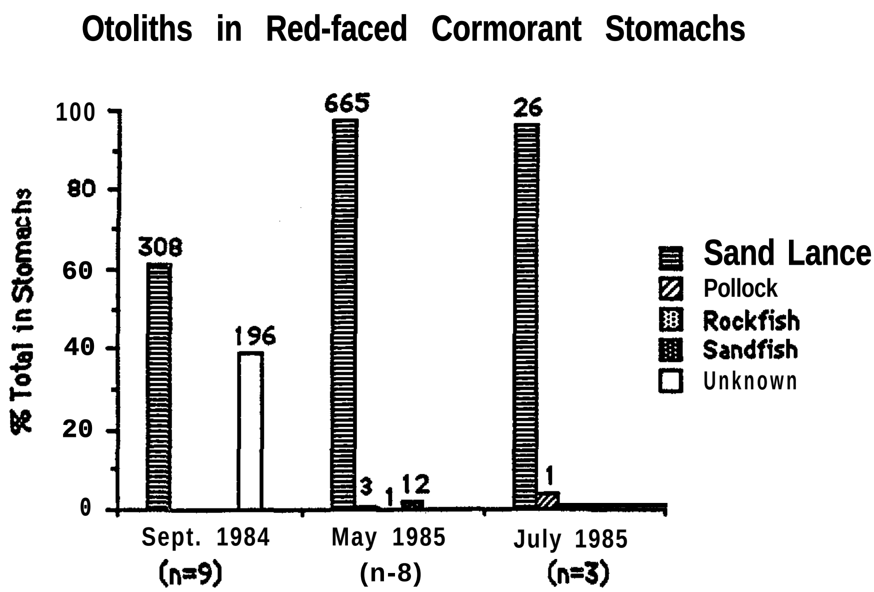


Figure 6.24. Composition of stomach contents of Red-faced Cormorants collected in the North Aleutian Shelf area, Bering Sea, Alaska, May 1984 to July 1985, Alaska.

these periods. The analyses of otoliths found in cormorant stomachs indicated that sand lance were virtually the only species of fish eaten by cormorants during our collection periods (see Fig. 6.25).

Murres, also typically piscivorous, were collected during cruises in May and July (see Tables 6.11 and 6.17). During these two months, the diets of both Common and Thick-billed murres were composed of over 90% fish (Fig. 6.26). Only during the May 1985 cruise did euphausiids form a relatively significant part of the diet of either of the two species of murre (8.8% of wet weight diet of Thick-billed Murre). In all other cruise periods (May 1984 and July 1985), fish comprised *over* 98.7% of the wet weight diet of each species. The analyses of otoliths taken from murre stomachs indicated that sand lance were virtually the only fish eaten by birds collected in waters 50 m deep or shallower (Fig. 6.25). However, one of the more remarkable results of this study was the finding that stomachs of five murres (one Thick-billed and four Common) collected during July 1985 in waters. approximately 70 m deep, had otoliths (a total of 2039) from only walleye pollock. This suggests that the distribution of walleye pollock during the July cruise, and possibly during others, may have beeen restricted to waters beyond the 50-m depth contour. Thus, aside from the small proportion of the May 1985 diet of Thick-billed Murres that consisted of euphausiids (8.8%), sand lance comprised the bulk of the diet of water-golumn-feeding birds in waters shallower than 50 m (see Fig. 6.27). Otoliths from a sample of murres taken at a 70-m station during July 1985 indicates that pollock may be more common in deeper waters offshore from the NAS study area.

Although the July samples of murres from middle-domain waters are small, the fact that they contained pollock is consistent with the findings of others investigating food sources of seabirds in deeper waters of the Bering Sea shelf. Craig (Section 5.0, this report) confirms that pollock are "most abundant in the deeper portions of the NAS study area, paticularly from. about July through September". Apparently after pollock reach sizes of around 35-50 mm, they descend to the bottom-and take up a demersal existence, where they might escape being taken by water-column feeders. Craig found that large pollock were present in the demersal zone of the outer portions of the NAS study area. Schneider and Hunt (1982) found walleye pollock to be the principal fish prey of water-column-



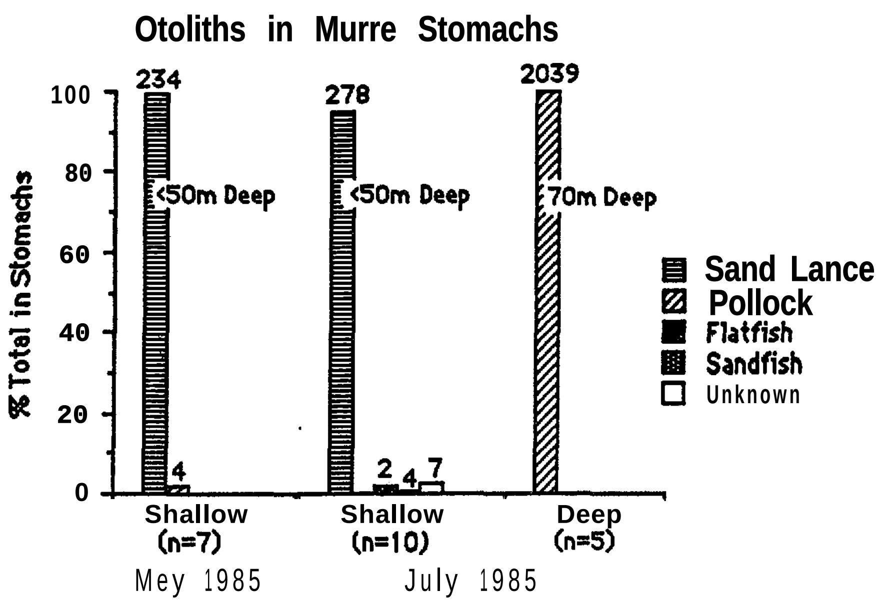
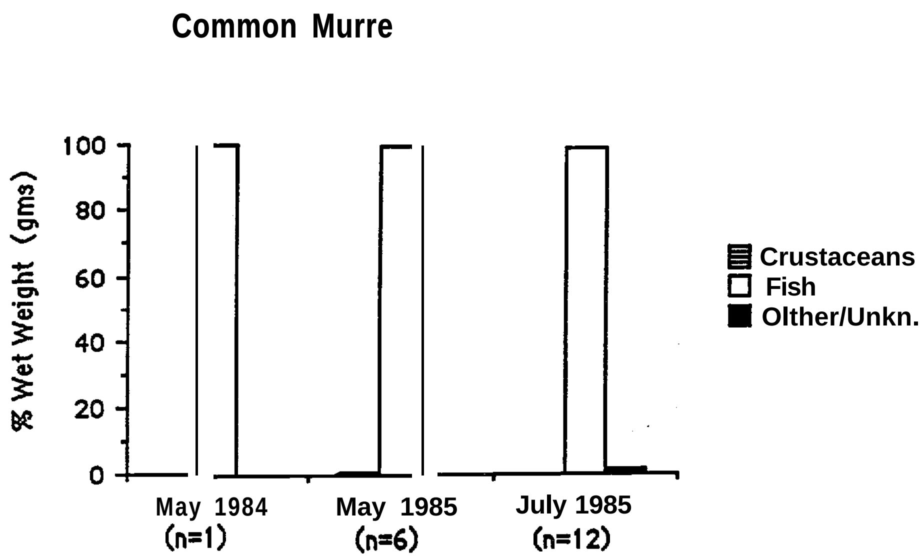


Figure 6.25. **Jdentity of fish otoliths from stomachs of Red-faced Cormorants and murres collected in the. North Aleutian Shelf area, Bering Sea, Alaska, September 1984 to July 1985.**

Table 6.17. Organisms consumed by murres (*Uria* spp.) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska.

	Common Murre						Thick-billed Murre			
	May 1984 (n=1)		May 1985 (n=6)		July 1985 (n=12)		May 1985 (n=8)		July 1985 (n=4)	
	wet wt.		wet wt.		wet wt.		wet wt.		wet wt.	
Major Taxa	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Sand lance	0.0	0.0	79.2	85.6	44.9	31.5	0.0	0.0	0.0	0.0
Other Fish	0.0	0.0	2.2	2.4	0.0	0.0	0.0	0.0	0.0	0.0
Unid. Fish	4.7	100.0	10.5	11.4	95.7	67.2	24.8	91.2	13.1	100.0
All Fish	4.7	100.0	91.9	99.4	140.6	98.7	24.8	91.2	13.1	100.0
Euphausiids	0.0	0.0	0.5	0.5	0.0	0.0	2.4	8.8	tr	tr
Amphipods	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crustaceans	0.0	0.0	0.5	0.5	0.0	0.0	2.4	8.8	0.0	0.0
Other/Unknown*	0.0	0.0	0.1	0.1	2.0	1.3	0.0	0.0	0.0	0.0
Total	4.7	100.0	92.5	100.0	142.6	100.0	27.2	100.0	13.1	100.0

* Sludge, otoliths, nematodes, blood clots, etc.



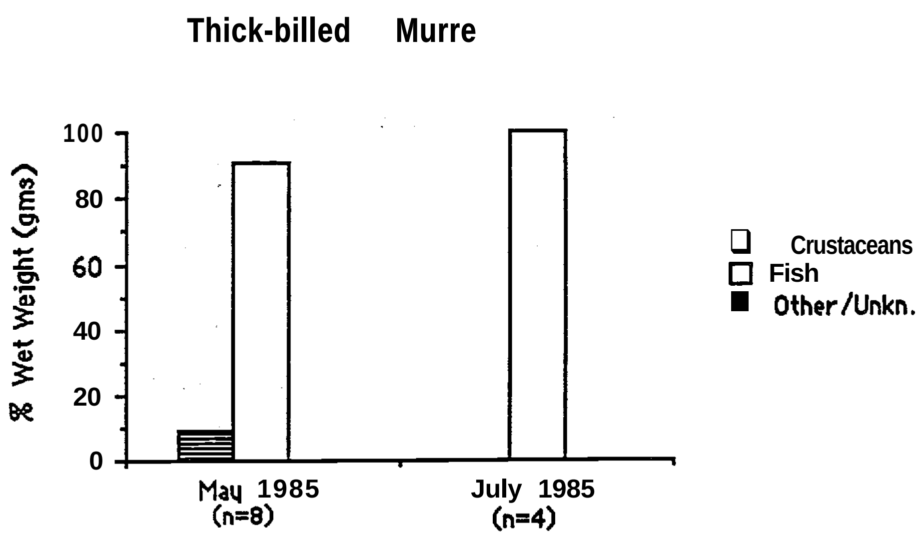
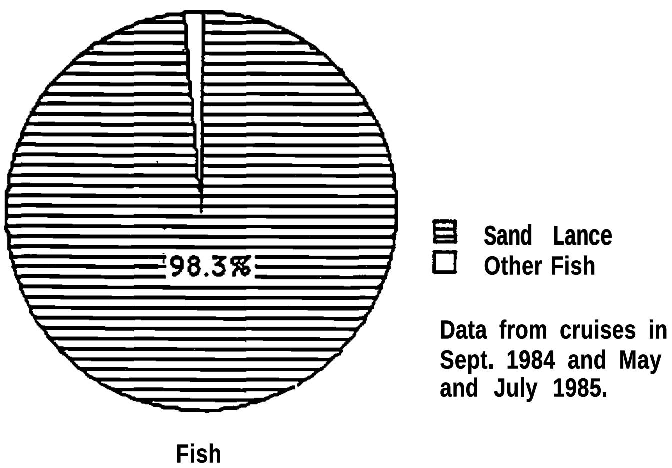


Figure 6 . 26. Composition of stomach contents of murres collected in the North Aleutian Shelf area, Bering Sea, Alaska, May 1984 to July 1985.

Prey of Water **Column Feeding Birds**



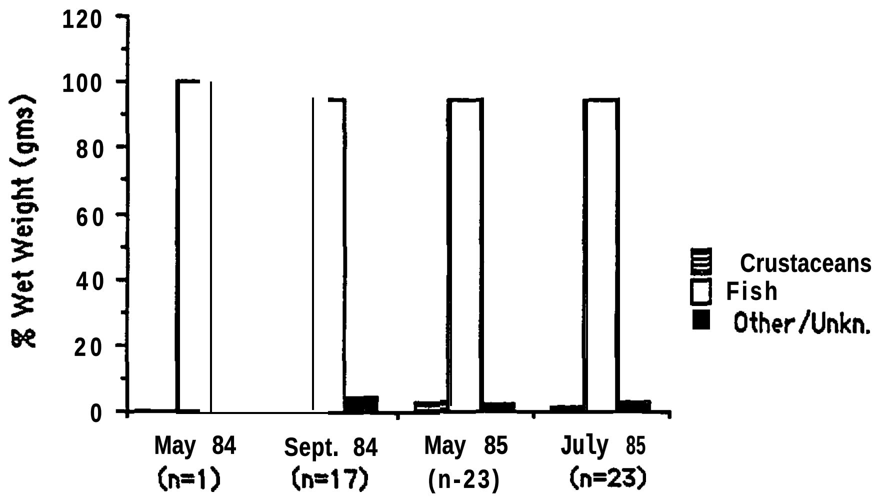


Figure **6.27.** Stomach contents of water column feeding birds (64 individuals of three species)' collected during four cruises over the North Aleutian Shelf, Bering Sea, Alaska, May 1984 to July 1985. (Sample sizes of the three species are 19 Common Murres, 12 Thick-billed Murres, and 33 Red-faced. Cormorants.)

feeding seabirds in deeper waters away from the inner domain. Hunt et al. (1981a) found pollock by far the most important fish in the diet of murres collected near St. George Island, which is very near the deep waters associated with the shelf break community where *many* seabirds (especially kittiwakes) from St. *George* Island feed (see Schneider 1982). Sand lance formed only a *very* minor component of the diets of seabirds studied by Hunt et al. (1981a). In contrast, Bradstreet (1985) found sand lance to form a significant part (23% of the wet weight diets) of foods delivered to Thick-billed Murre chicks *on* St. Paul Island, which is located in the middle domain and is considerably farther from deep, outer domain and continental slope waters, where pollock are more abundant.

Little is known of the distribution and abundance of sand lance in the southeastern Bering Sea or elsewhere in the Pacific Basin. Dick and Warner (1982) give one of the best overall reviews of the life history of this species in the northeastern Pacific area. They described sand lance as abundant but variable in their distribution near the Kodiak Archipelago. Their distribution from May to October in this area was closely associated with warm, relatively shallow waters over substrates of coarse sand and fine gravel, where they bury themselves when inactive. Thus, the distribution and availability of this species in the NAS area, and possibly throughout the southeastern Bering Sea, is probably restricted by water temperature and the distribution of specific bottom substrate types (also see Macy et al. 1978).

6.5.2.3 Bottom-Feeding Birds

Six species of sea ducks comprise our samples of bottom-feeding birds collected during four cruises in the NAS study area. Scoters (White-winged and Black) were collected during cruises in September 1984 and January, May, and July 1985. Bivalve molluscs formed the largest proportion of the wet-weight diet of scoters during all cruises (Table 6.18). Only during September 1984 was the proportion of bivalve molluscs eaten by scoters less than 94% of the total wet-weight diet; crustaceans formed 21.7% of the diet of *scoters* during September 1984 (Fig. 6.28). Sanger and Jones (1984) found that White-winged Scoters feeding in Katchemak Bay, Alaska, during winter 1977/78 were generalists on molluscs.

Table 6.18. Organisms eaten by scoters (*Melanitta nigra* and *Melanitta deglandi*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska, 1984 and 1985

Major Taxa	September 1984 (n=27) wet weight (g)	(%)	January 1985 (n=2) wet weight (g)	(%)	May 1985 (n=5) wet weight (g)	(%)	July 1985 (n=2) wet weight (g)	(%)
Bivalves	61.5	66.6	15.9	91.4	9.8	100 .0	30.2	99.7
Gastropods	5.9	6.4	0.6	3.4	0.0	0.0	0.0	0.0
Molluscs	67.4	73.0	16.5	94.8	9.8	100.0	30.2	99.7
Crustaceans	20.0	21.7	0.1	0.6	0.0	0.0	0.0	0.0
Polychaetes	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Fish (flesh)	4.8	5.2	0.0	0.0	0.0	0.0	0.0	0.0
Other/Unknown*	0.0	0.0	0.8	4.6	0.0	0.0	0.1	0.3
TOTAL	92.3	100.0	17.4	100.0	9.8	100.0	30.3	100.0

* Rocks, sludge, blood clots, etc.

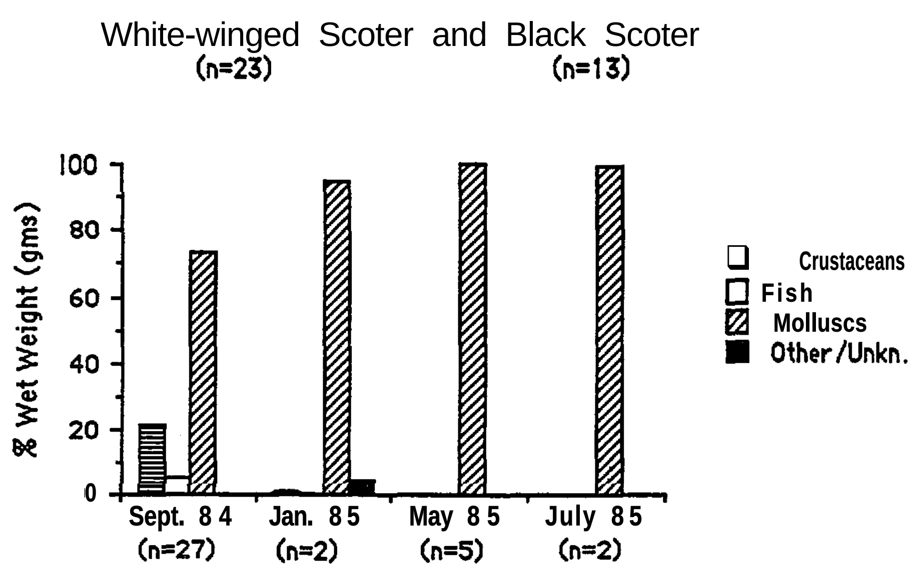


Figure 6.28. Compostion of stomach contents of scoters collected in the North Aleutian Shelf area, Bering Sea, Alaska, September 1984 to July 1985.

Although at least 22 species of molluscs were consumed, the bivalve Protothaca staminea (Pacific littleneck clam) was by far the most important prey consumed. Vermeer and Bourne (1984) also found that molluscs (primarily bivalves) dominated the diets of White-winged, Surf, and Black scoters in British Columbia waters. Large concentrations of scoters occurred at several nearshore locations along the NAS study area, especially during winter. No doubt very large quantities of bivalves are consumed at these locations, which suggests that very large standing stocks occur.

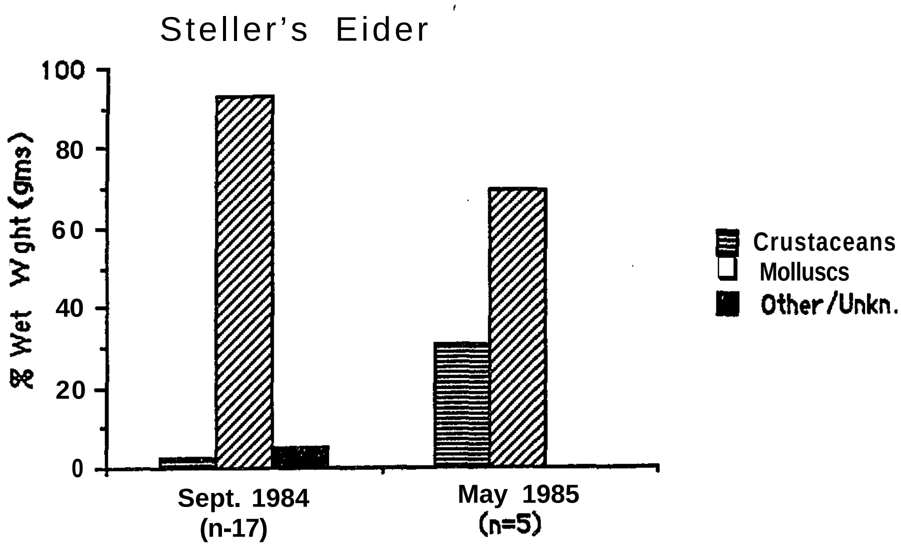
Steller's Eiders were collected during September 1984, when adult females were still in full wing molt, and during May 1985. During both periods bivalve molluscs formedthelargestproportion ofthedietsof this species. In May, however, crustaceans formed a much larger fraction of the total diet (30.3%) than during September (2.4%; see Table 6.19, Fig. 6.29), when most Steller's Eiders preyed heavily on blue mussels Mytilus edulis. In fact, Petersen (1981:261) estimated that during periods of peak abundance (late summer-early fall) at Nelson Lagoon, Stellerls Eiders consumed more than 7.3 metric tons of blue mussels-day-l (119-l 27 g $bird^{-1}$ day^{-1}). Lagoon locations (Nelson Lagoon, Moffet Lagoon, Izembek Lagoon, Bechevin Bay), where large numbers of bottom feeding waterfowl concentrate during fall through spring, are technically outside the main area of interest of this study. However, as mentioned in the discussion above, large concentrations of sea ducks (scoters and eiders) also occur in the shallow nearshore waters outside the lagoons (see also Section 6.1.1 Distribution and Abundance, this chapter), where many of the specimens taken for this study were collected. Information presented by Thomson (Section 4.0, this report) and Cimberg et al. (1984) shows large standing stocks of bivalves at several shallow-water stations along the NAS, especially north of Izembek Lagoon and north of Nelson Lagoon.

King Eiders were collected during cruises in September 1984 and during May and July 1985. The diet of this species Varied considerably among these three cruises (Table 6.20, Fig. 6.29). In September, when most adult females were still in full wing molt, bivalve molluscs dominated the diets of King Eiders (this was the case for Steller's Eiders also); over 99% of the total wet-weight diet during this month was bivalves. In May, molluscs comprised almost 70% of the total diet (42.3%

Table 6.19. Organisms eaten by Steller's Eiders (*Polysticta stelleri*) in near-shore waters of the North Aleutian Shelf, Bering Sea, Alaska.

	September 1984 (n=17)		May 1985 (n=5)	
	Wet Wt.		Wet Wt.	
Major Taxa	(g)	(%)	(g)	(%)
Bivalves	166.0	90.7	32.7	67.4
Gastropods	3.6	2.0	1.1	2.3
Molluscs	169.6	92.7	33.8	69.7
Crustaceans	4.4	2.4	14.7	38.3
Polychaetes	2.8	1.5	0.0	0.0
Vegetation	6.2	3.4	0.0	0.0
Other/Unknown*	0.0	0.0	0.0	0.0
Total	183.0	100.0	48.6	100.0

* Rocks, sludge, cumaceans, nematodes, blood clots, etc.



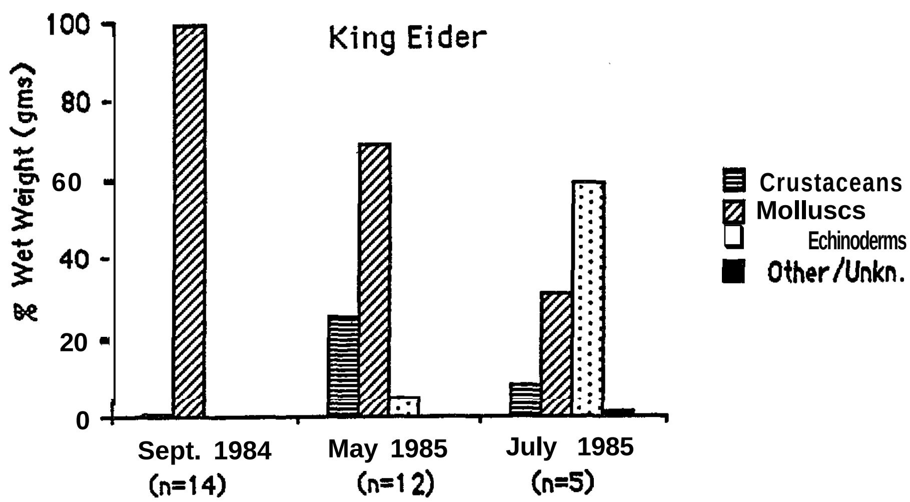


Figure 6.29. Composition of stomach contents of Steller's and King eiders collected in the North Aleutian Shelf area, Bering Sea, Alaska, September 1984 to July 1985.

Table 6.20. Organisms consumed by King Eiders (*Somateria spectabilis*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska.

	Sept. 1984 (n=14)		May 1985 (n=12)		July 1985 (n=5)	
	Wet Wt.		Wet Wt.		Wet Wt.	
Major Taxa	(g)	(%)	(g)	(%)	(g)	(%)
Bivalves	32.5	99.1	47.6	42.3	9.3	14.1
Gastropods	tr*	tr	29.9	26.6	11.2	17.0
Molluscs	32.5	99.1	77.5	68.9	20.5	31.1
Crustaceans	0.2	0.6	28.8	25.5	5.3	8.0
Echinoderm	0.0	0.0	5.9	5.2	39.2	59.4
Polychaetes	tr	tr	0.2	0.2	tr	tr
Fish (flesh)	tr	tr	0.0	0.0	0.0	0.0
Vegetation	0.1	0.3	0.2	0.2	1.0	1.5
Other/Unknown**	0.0	0.0	0.0	0.0	0.0	0.0
Total	32.8	100.0	112.6	100.0	66.0	100.0

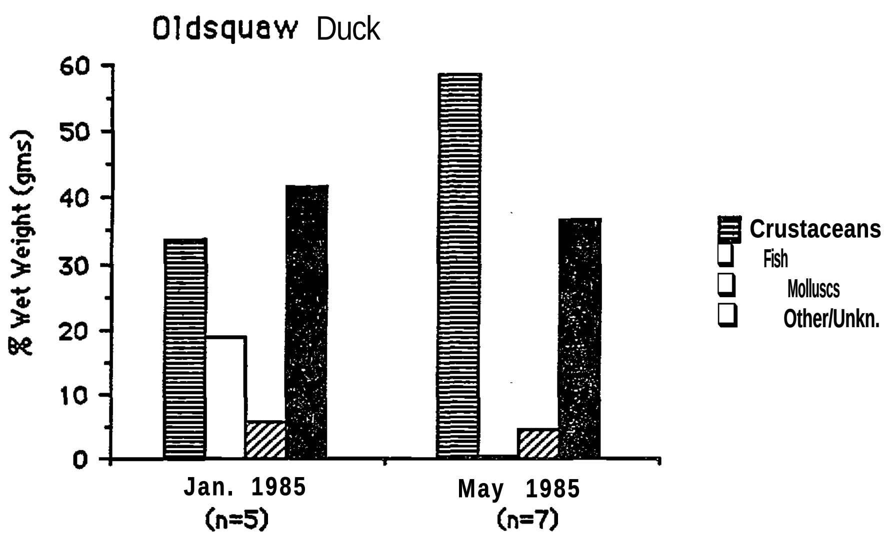
* tr = trace amounts (<0.1%) of organisms.
**Rocks, sludge, cumacaens, nematodes, blood clots, etc.

bivalves, 26.6% **gastropods),** with crustaceans also forming a significant proportion (25.5%) (Fig. 6.29). In July, molluscs comprised only 31.1% of the total King Eider diet; echinoderms represented the largest fraction **(59.4%)**.

Oldsquaws were collected during cruises in January and May 1985. During both of these periods, crustaceans represented the largest fractions of identifiable **taxa** eaten by Oldsquaws (Fig. **6.30);** during January, fish and bivalve molluscs also formed significant fractions of the diet (Table **6,211.** Oldsquaws collected during summer months in shallow coastal lagoons along the Alaskan **Beaufort** Sea coast ate a surprisingly narrow range **of** prey, primarily two species of mysids and one species of amphipod (Johnson **1984).** However, Sanger and Jones **(1984)** found that Oldsquaws collected during winter **1977/78** in Katchemak Bay, Alaska, ate a wide variety of prey; two species of bivalve molluscs **(Stimson's** surf clam **Spisula polynyma** and blue mussel), and surprisingly, sand lance, were the most important prey consumed. Of the few otoliths found in **Oldsquaw** stomachs in this study, most also were from sand lance (see Fig. 6.31).

Harlequin Ducks were collected during cruises in September 1984 and May 1985. During both of these periods, gastropod molluscs comprised over 90% of the identifiable wet weight diet of this species (Table 6.22). The only other identifiable **taxon** found in Harlequin Duck stomachs was **crustacea,** which formed **3.7%** of the diet in May (Fig. **6.30).** No other recent studies have been conducted of the food habits of Harlequin Duck in the southeastern Bering Sea. However, Dzinbal and Jarvis **(1984)** found that Harlequin Ducks in Prince William Sound, Alaska, ate a much wider variety of prey (insects, echinoderms, decapods, eelgrass, many different gastropod molluscs) than we found In our study area.

In summary, the diets of the six dominant species of sea ducks that feed on benthos were composed largely of bivalve molluscs, but amphipod crustaceans and echinoderms also were strongly represented during some periods (Fig. **6.32).** Several species appeared to specialize in preying on specific **taxa, e.g.,** Harlequin Ducks on gastropod molluscs and **scoters** on bivalve molluscs. Other species appeared *to* feed on several different **taxa,** e.g., Oldsquaws on crustaceans, fish and molluscs, and King and **Steller's** eidersonbivalve molluscs during September and molluscs and



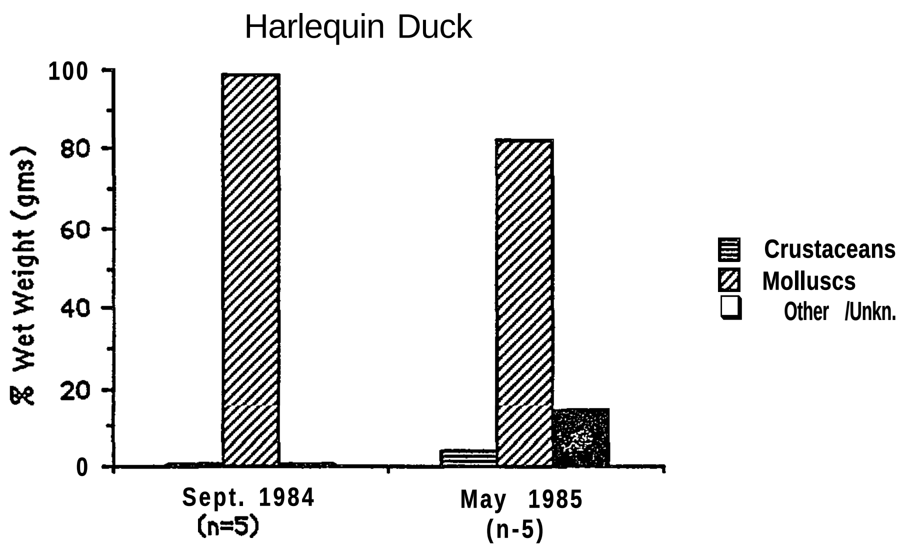


Figure 6.30. Composition of stomach contents of Oldsquaws and Harlequin Ducks collected in the North Aleutian Shelf area, Bering Sea, Alaska, September 1984 to May 1985.

Table 6.21. Organisms eaten by Oldsquaws (*Clangula hyemalis*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska, 1985.

	January 1985 (n=5) wet weight		May 1985 (n=7) wet weight	
	(g)	(%)	(g)	(%)
Bivalves	0.8	5.8	1.0	3.0
Gastropods	0.0	0.0	0.5	1.5
Molluscs	0.8	5.8	1.5	4.5
Crustaceans	4.7	33.8	19.8	58.6
Fish (flesh)	2.6	18.7	0.1	0.3
Unknown/Other*	5.8	41.7	12.4	36.6
TOTAL	13.9	100.0	33.8	100.0

* Rocks, sludge, blood clots, cumaceans, etc.

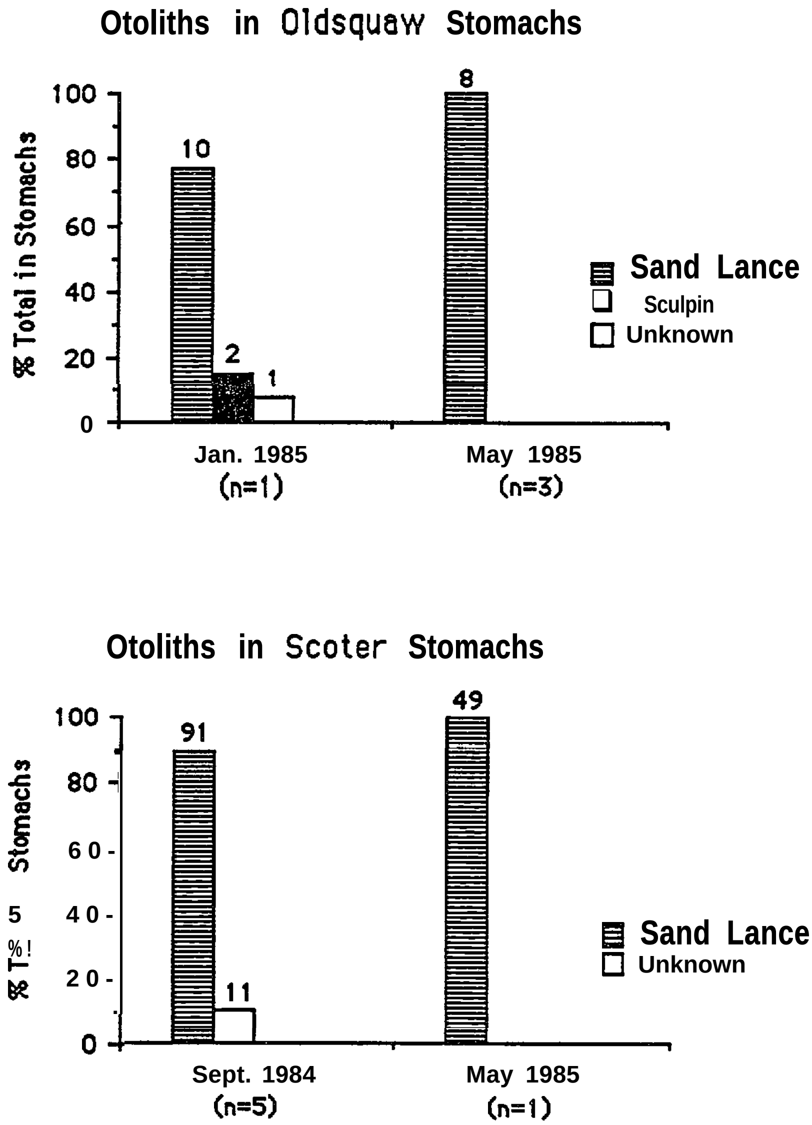


Figure 6.31.. Identity of fish otoliths from stomachs of Oldsquaws and scoters collected in the North Aleutian Shelf area, Bering Sea, Alaska, September 1984 and May 1985.

Table 6.22. Organisms eaten by Harlequin Ducks (*Histrionicus histrionicus*) in nearshore waters of the North Aleutian Shelf, Bering Sea, Alaska, 1984 and 1985.

Major Taxa	September 1984 (n=5) wet weight (g)	(%)	May 1985 (n=5) wet weight (g)	(%)
Gastropods	5.7	98.9	48.9	82.2
Bivalves	tr	tr	tr	tr
Molluscs	5.7	**98.9**	48.9	**82.2**
Crustaceans	tr	0.4	2.2	3.7
Unknown/Other*	tr	0.7	8.4	14.1
TOTAL	5.8	100.0	59.5	100.0

tr = trace amounts (<0.1 g)
* Blood clots, stones, vegetation, feathers, etc.

Prey of Benthic Feeding Birds

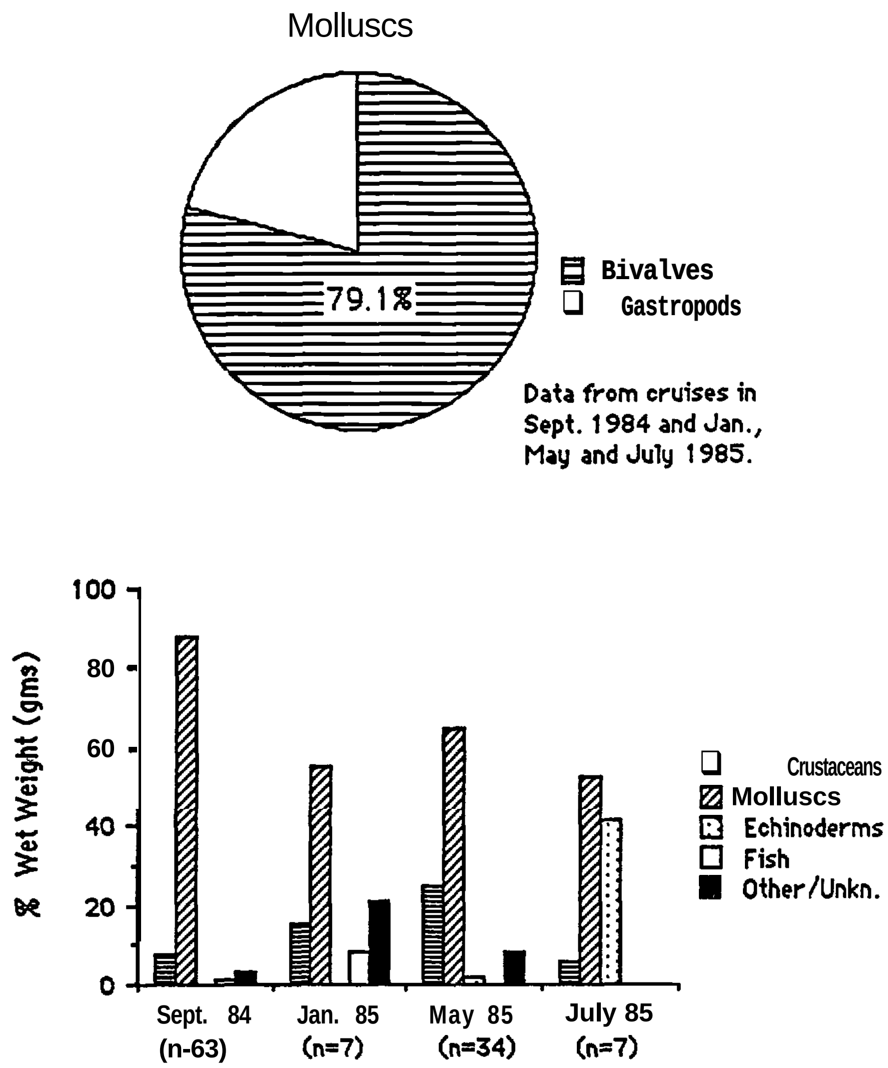


Figure **6.32.** Composition of stomach contents of benthic feeding birds (111 individuals of six species) collected during four cruises over the North Aleutian Shelf, Bering Sea, Alaska, Sept. 1984 to July 1985. (Sample sizes of the six species are: 12 Oldsquaws, 10 Harlequin Ducks, 22 Steller's Eiders, 31 King Eiders, 23 White-winged Scoters, and 13 Black Scoters.)

crustaceans during May and July. As a group, however, the sea ducks comprising the bottom-feeding birds in the NAS study area relied heavily on molluscan prey.

6.6 RECOMMENDED FURTHER RESEARCH

1. Replication of survey effort to assess the yearly (or shorter term) variability of marine bird use of the area. The presentevaluationrelies onpointsurveys (2-3 days) to describe each month.

2. Characterization of areas supporting large concentrations of birds, especially the region north of Unimak Island where major winter aggregations of murres and Crested Auklets have been found.

3. Surveys of the breeding colonies to ascertain the species composition and approximate numbers of attending birds. The seabird colony database reports a great many unidentified murres and cormorants as being present at the NAS colonies.

4. Study effort directed at evaluating the role of oceanographic features, especially the "inner front", in affecting marine bird distribution.

5. Study effort directed at evaluating the role of prey abundance and availability in affecting marine bird distribution.

6. Further studies of seabird trophics in waters offshore from the NAS study area (50-100 m depths), where walleye pollook may replace sand lance as the dominant fish prey of seabirds.

7. More detailed studies of sand lance in the NAS study area, with emphasis on the relationship between bottom substrate type and distribution and abundance of sand lance.

8. Larger collections of most species of sea birds in the NAS study area during the late fall-early spring period (September to April); little seabird trophics information is available for this area during this period.

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D.R. Herter has played a major role in the collection and coding of the aerial survey data and in maintaining our aerial survey equipment for the last minute decisions to take advantage of breaks in the weather. Many pilots from NOAA, ERA, and Seair have taken part in these surveys and we thank them all. We also thank G. LaPiene and M. Meyer of NOAA for managing to arrange for planes at the right times.

The massive job of data entry from both the shipboard and aerial survey programs fell in the hands of Lynn Maritzen and Virginia McCarter who have done a remarkable job in returning clean computer files. Joe C. Truett edited early versions of this report.

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