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SEABIRDS IN THE NORTHERN GULF OF ALASKA AND ADJACENT WATERS, OCTOBER TO MAY

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ABSTRACT: I studied the distribution and abundance of seabirds in the northern Gulf of Alaska and adjacent waters during 16 research cruises from October to May 1997–2001. I recorded 58 species of seabirds on transects, plus one off the transects. The avifauna was dominated numerically by tubenoses (50% of all birds) and alcids (29%), with much smaller numbers of larids (3%), shorebirds (phalaropes; 3%), waterfowl (2%), cormorants (1%), and loons (<1%). Five species each composed $\geq 5\%$, and collectively composed 74%, of the wintering avifauna: the Common Murre (*Uria aalge*; 21%), Northern Fulmar (*Fulmarus glacialis*; 19%), Fork-tailed Storm-Petrel (*Oceanodroma furcata*; 16%), Sooty Shearwater (*Puffinus griseus*; 11%), and Black-legged Kittiwake (*Rissa tridactyla*; 7%). Another nine species collectively composed $\sim 19\%$ of all birds, whereas the other 44 species collectively composed $\sim 7\%$ of all birds. I recorded from 10 to 37 species per cruise; both the number of species and total density of all birds combined decreased from October to March, then increased rapidly in April and (especially) May.

The Gulf of Alaska supports enormous numbers of marine birds, with over 9 million nesting there (Gould et al. 1982, DeGange and Sanger 1986). Up to 40 million feed in the gulf during the summer; in winter, numbers are lower (Gould et al. 1982).

This study investigated some aspects of seabird ecology during a period (nonbreeding) that may affect their populations strongly (Bailey and Davenport 1972, Harrington-Tweit 1979, Blake 1984, Harris 1984, Hope Jones et al. 1984). I studied variation in the abundance of seabirds in the northern Gulf of Alaska from October to May, the nonbreeding period, through four consecutive years (1997–2001). These data on the distribution and abundance of seabirds during this time represent the first step in understanding the ecology of these predators at this high latitude.

Although seabirds have been studied in the Gulf of Alaska for >30 years, few data actually are available for comparison with this study. For example, Gould et al. (1982) presented data by season, but few are available for most months and for particular locations within this region. In addition, one of three multiyear studies of wintering-seabird abundance in this region has

been conducted within protected bays around Kodiak Island since the late 1970s (Forsell and Gould 1981; D. Zwiefelhofer, U.S. Fish and Wildlife Service, pers. comm.). The other two studies comparing year-to-year variation in bird abundance, including winter, were conducted after the *Exxon Valdez* oil spill and were focused on Prince William Sound (e.g., Wiens et al. 1996, Day et al. 1997a, b, Murphy et al. 1997, Lance et al. 1999, Irons et al. 2000). None of these studies, however, addressed the wintering ecology of seabirds in the open northern Gulf of Alaska; furthermore, only one (Day et al. 1997a) examined birds in the gulf itself, and that was only within bays during the summer. Agler et al. (1995) studied birds in the fairly protected lower Cook Inlet in February and March of one winter.

STUDY AREA

My study area encompassed the northern Gulf of Alaska, both neritic and oceanic, and nearby Prince William Sound (Figure 1). It included the 220-km-long Seward Line, a large oceanographic survey line that extends across the continental shelf and slope, and several other oceanographic lines that sampled the shelf and the Alaska Coastal Current in the gulf and within Prince William Sound.

Several structures and water masses characterize the region's physical oceanography. From inshore to offshore, these are the Alaska Coastal Current, the mid-shelf region, the shelf-break front, and the Alaska Current/Alaska Stream (Figure 1). In fall and winter, storms enter the gulf, are blocked by the coastal mountains, and drop precipitation that forms an enormous freshwater "river" (the Alaska Coastal Current) that flows northwest along the coast (Royer 1979, 1982). These storms also generate a cyclonic circulation over the shelf and continental slope, resulting in downwelling most of the time (Reed and Schumacher 1986).

The Alaska Coastal Current is the most prominent feature of ocean circulation over the Gulf of Alaska's continental shelf (Figure 1); it is a fast current of low salinity that typically flows within 35 km of the coast. It varies in width seasonally, being wider in the fall and early winter and narrower in late winter and spring (Royer 1981a, b, Johnson et al. 1988). Part of the Alaska Coastal Current loops through southern Prince William Sound (Niebauer et al. 1994); occasionally, jets of water from the coastal current (indicated by dashed lines in Figure 1) are forced offshore at coastal promontories. In the mid-shelf region, the water moves much more slowly than in both the inshore Alaska Coastal Current and the offshore Alaska Current/Stream, both of which flow strongly to the west (Niebauer et al. 1981, Royer 1981a, Lagerloef 1983). The shelf-break region is an area of complex physics, and the dynamics of the shelf-break front in this region are poorly understood. Hydrographic data collected by the GLOBEC (Global Ocean Ecosystem Dynamics, a joint research project of the National Science Foundation and the National Oceanographic and Atmospheric Administration) study indicate that a front may lie at the bottom, at the surface, at both, at neither, or extend throughout the water column as one large front. Along the continental slope, in the northeastern gulf, flow consists of the broad, diffuse Alaska Current, which becomes transformed into the narrow, rapid Alaska Stream in the northern gulf.

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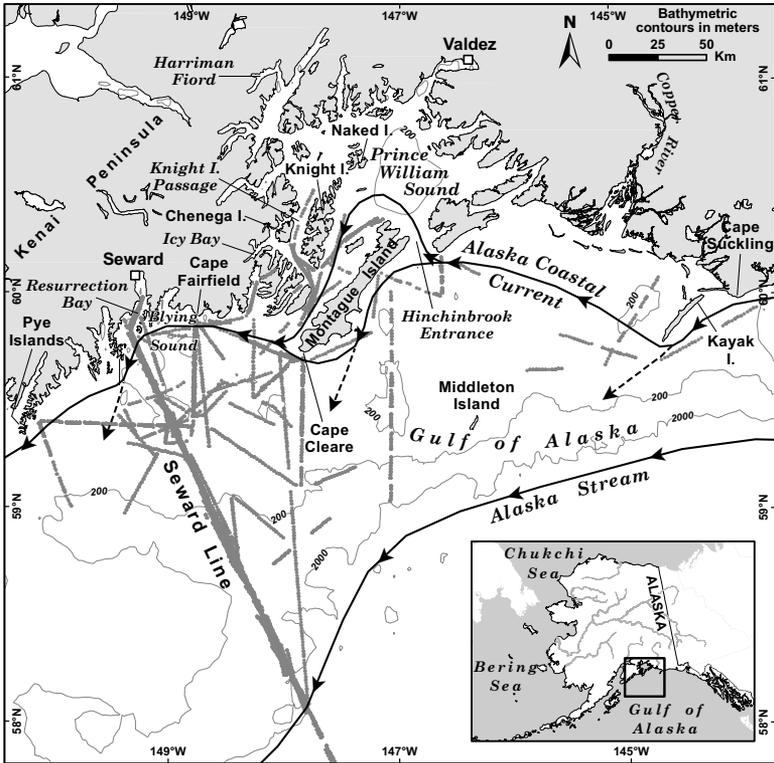


Figure 1. Study area in the northern Gulf of Alaska showing main currents (black lines) and locations sampled during shipboard surveys (gray lines), October–May 1997–2001.

METHODS

Data Collection

I recorded the distribution and abundance of seabirds during 16 oceanographic cruises in the northern Gulf of Alaska and adjacent waters from October 1997 through March 2001. During this period, there was no cruise in December 1997, and I was unable to participate in the October 1998 and 2000 cruises; Randall Mullen replaced me on the latter. Hence this study is based on three October, three December, four March, three April, and three May cruises.

I recorded seabirds on time and space scales similar to those sampled by the Gulf of Alaska GLOBEC Program. The Seward Line, which was sampled on every cruise, extended across the shelf to the Alaska Stream, including Alaska Coastal Current water, mid-shelf water, the shelf break, and oceanic water in the Alaska Stream. The ship's speed averaged ~18.5 km/h. I recorded sea-

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surface temperatures and sea-surface salinities for as many transect samples as possible with an automatic system aboard the ship; however, this system broke down on a few cruises. I rounded temperatures to the nearest 0.1°C and salinities to the nearest 0.1 psu (practical salinity unit).

Following the methods of Tasker et al. (1984) and Gould and Forsell (1989), I recorded my observations as strip transects, in essence, in a zone 300 m off one side of the ship (i.e., from directly forward to 90° starboard) while it moved forward in a straight line at a known and fixed speed. Flying seabirds were recorded according to the "snapshot method" to avoid inflation of density estimates caused by the movement of flying birds through the transect (Tasker et al. 1984, Gould et al. 1989), whereas birds on the water were recorded continuously because they often were difficult to locate with one visual scan and because they were not moving through the transect. Although some authors (e.g., Becker et al. 1997) have argued for the use of line transects in sampling birds at sea, line-transect data are so cumbersome to record in locations with even moderate numbers of birds that the resulting data are of questionable accuracy.

Transects almost always were 5 minutes long, although a few were 4 minutes long if we were stopping at an oceanographic station. Within transects, I recorded data by the minute, allowing calculation of exact location and allowing clumping of data for analyses.

Data Analysis

I pooled all data from the 16 cruises to enumerate the total numbers of each species of seabird seen altogether. For each species and species group, I calculated the percentage of the total number seen. For species richness (Magurran 1988), I counted the number of species seen during each cruise, both for the Seward Line (sampled every cruise) and for all transects on a cruise (the number and location of transects varied somewhat from cruise to cruise, although some areas were sampled on most or all cruises). I then plotted these numbers and interpreted the resulting patterns visually.

I pooled transects into 10-minute intervals when possible because of clumping at different scales (Day and Prichard, unpubl. data). For all cruises combined, the total number of adjusted (5- or 10-minute) transects available for analysis was 2437. For each transect, I divided the total count of birds by the total area sampled to generate a standardized estimate of density (birds/km²). For each species, I calculated mean density \pm 1 standard error (SE) by month and year.

RESULTS

The Environment

Sea-surface temperatures along the Seward Line during my cruises varied seasonally and from year to year. They were highest in October ($10.1 \pm \text{SE} < 0.1^{\circ}\text{C}$), decreased in December ($7.4 \pm < 0.1^{\circ}\text{C}$), were at a minimum in March ($5.5 \pm < 0.1^{\circ}\text{C}$) and April ($5.6 \pm < 0.1^{\circ}\text{C}$), and increased slowly in May ($6.9 \pm < 0.1^{\circ}\text{C}$; Figure 2). The winter of 1997–1998, immediately after the large El Niño of 1997, was the warmest year (mean $7.8 \pm 0.1^{\circ}\text{C}$), followed closely by 1999–2000 and 2000–2001 ($7.6 \pm 0.1^{\circ}\text{C}$ for both); only the winter

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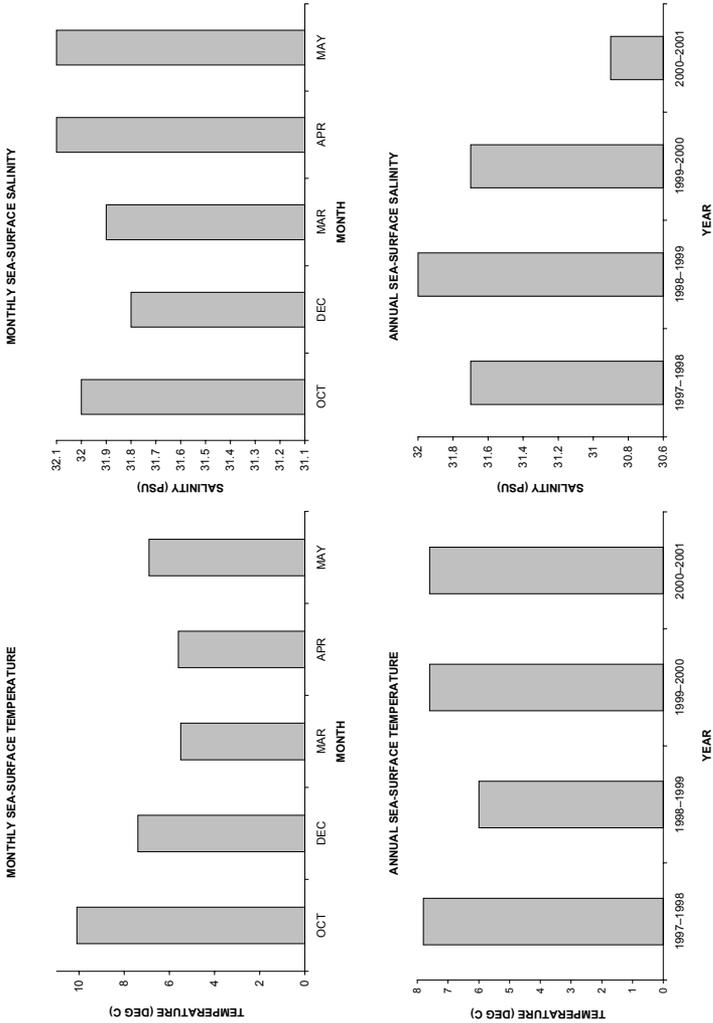


Figure 2. Mean sea-surface temperatures ($^{\circ}$ C) and sea-surface salinities (practical salinity units) recorded during shipboard surveys in the northern Gulf of Alaska, October–May 1997–2001, by month (top row) and year (bottom row). Standard errors are not shown because they all are very small.

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of 1998–1999 was cold ($6.0 \pm <0.1^\circ \text{C}$; Figure 2). I believe, however, that the temperature estimate for 2000–2001 was inflated because I had a large sample from the warm fall (the warmest since El Niño of 1997) but did not sample during the other cold months that winter (April, May). Hence I suspect that the mean temperature for 2000–2001 would have been between those for 1998–1999 and 1997–1998.

Sea-surface salinities along the Seward Line also varied seasonally and from year to year, being lowest in the winter of 2000–2001 (mean 30.9 ± 0.1 psu), intermediate in 1997–1998 and 1999–2000 ($31.7 \pm <0.1$ psu for both), and highest in 1998–1999 ($32.0 \pm <0.1$ psu; Fig. 2). Again, however, my sample for 2000–2001 was incomplete. In general, salinities were lowest in December, after the massive input of precipitation as rain in the fall, and highest in April and May, when most precipitation ended up trapped as snow in the mountains.

Seabirds

During the 16 cruises, I recorded 15,896 seabirds of at least 58 species on transects, plus another species not seen on transects (Tables 1–5). These 58 species represented five orders and nine families: Anseriformes (Anatidae), Gaviiformes (Gaviidae), Procellariiformes (Diomedidae, Procellariidae, and Hydrobatidae), Pelecaniformes (Phalacrocoracidae), and Charadriiformes (Scolopacidae [i.e., phalaropes], Laridae, and Alcidae).

The avifauna was dominated numerically by tubenoses, which collectively represented 50% of all birds (Figure 3); that group was dominated by petrels and shearwaters (31.0% of all birds) and storm-petrels (16.4%), with much smaller numbers of albatrosses (2.9%). Alcids were second in abundance (29%), whereas larids (3%), phalaropes (3%), waterfowl (2%), cormorants (1%), and loons (<1%) occurred in much smaller numbers.

N = 15,896

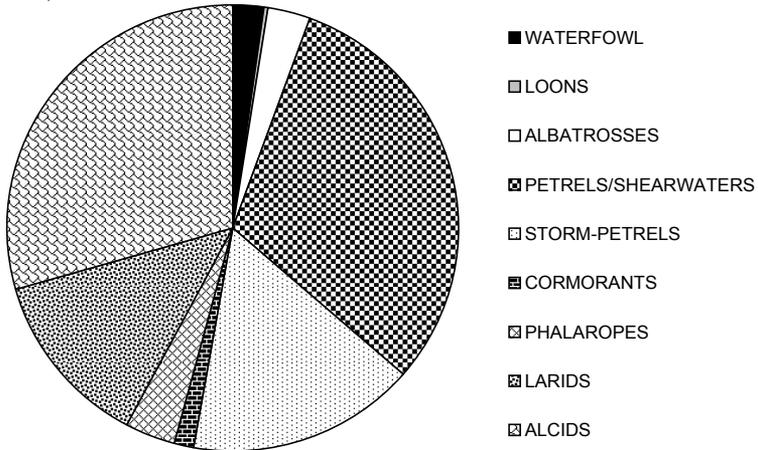


Figure 3. Percent composition of the avifauna of the northern Gulf of Alaska, October–May 1997–2001, by family.

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Table 1 Density of Seabirds in the Northern Gulf of Alaska, October 1997–2000

	Year					
	1997		1999		2000	
	Mean ^a	SE ^b	Mean	SE	Mean	SE
Number of transects	143		147		215	
All species pooled	8.36	1.59	5.37	0.40	5.93	0.97
Mallard	0	0	0	0	0.10	0.10
Northern Shoveler	0	0	0.02	0.02	0	0
Greater Scaup	0.07	0.07	0	0	0	0
Harlequin Duck	0.01	0.01	0	0	0	0
Surf Scoter	0	0	0	0	0.05	0.04
White-winged Scoter	0.19	0.19	0.11	0.11	0.02	0.02
Common Goldeneye	0	0	0	0	0.49	0.41
Pacific Loon	0	0	0.03	0.03	0	0
Common Loon	0	0	0	0	0.01	0.01
Laysan Albatross	0.04	0.02	0.13	0.03	0	0
Black-footed Albatross	0.10	0.03	0.30	0.05	0.26	0.04
Northern Fulmar	1.32	0.14	1.79	0.19	1.08	0.10
Mottled Petrel	0	0	0.10	0.04	0	0
Buller's Shearwater	0.03	0.01	0	0	0	0
Sooty Shearwater	3.07	1.53	1.13	0.29	1.01	0.24
Short-tailed Shearwater	0.01	0.01	0.06	0.02	0.04	0.02
Little Shearwater	0.01	0.01	0	0	0	0
Fork-tailed Storm-Petrel	1.37	0.48	0.71	0.14	0.12	0.03
Double-crested Cormorant	0	0	0	0	0.81	0.80
Red-faced Cormorant	0	0	0	0	<0.01	0.01
Pelagic Cormorant	0.02	0.02	0	0	0.04	0.03
Red Phalarope	0	0	0	0	0.01	0.01
Pomarine Jaeger	0.08	0.03	0.05	0.02	0.05	0.02
Parasitic Jaeger	0.02	0.01	0.01	0.01	0.01	0.01
Bonaparte's Gull	0	0	0	0	0.03	0.01
Mew Gull	0.01	0.01	0.02	0.01	0.06	0.03
Herring Gull	0.04	0.02	0.05	0.02	0.41	0.06
Glaucous-winged Gull	0.25	0.05	0.11	0.03	0.52	0.06
Glaucous Gull	0	0	0	0	<0.01	<0.01
Black-legged Kittiwake	0.51	0.09	0.23	0.05	0.73	0.10
Common Murre	0.86	0.17	0.19	0.07	0.06	0.02
Marbled Murrelet	0	0	0	0	0.01	0.01
Kittlitz's Murrelet	0.02	0.02	0.01	0.01	0	0
Ancient Murrelet	0.02	0.02	0	0	0	0
Cassin's Auklet	0.07	0.04	0.01	0.01	0	0
Parakeet Auklet	0	0	0.10	0.04	0	0
Rhinoceros Auklet	0.02	0.01	0.01	0.01	0	0
Horned Puffin	0.04	0.03	0	0	0	0
Tufted Puffin	0.18	0.05	0.17	0.09	0.01	0.01

^aBirds per square kilometer.^bSE, standard error.

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Table 2 Density of Seabirds in the Northern Gulf of Alaska, December 1998–2000

	Year					
	1998		1999		2000	
	Mean ^a	SE ^b	Mean	SE	Mean	SE
Number of transects	137		133		151	
All species pooled	6.06	0.57	4.46	0.63	4.96	1.19
Harlequin Duck	0	0	0	0	0.01	0.01
White-winged Scoter	0	0	0	0	0.01	0.01
Black Scoter	0	0	0.01	0.01	0	0
Long-tailed Duck	0	0	0	0	0.01	0.01
Common Merganser	0	0	0	0	0.01	0.01
Red-throated Loon	0.01	0.01	0	0	0	0
Common Loon	0	0	0.01	0.01	0	0
Laysan Albatross	0.14	0.04	0.15	0.06	0.04	0.02
Black-footed Albatross	0.14	0.04	0.07	0.03	0.02	0.01
Short-tailed Albatross	0.01	0.01	0	0	0	0
Northern Fulmar	1.78	0.19	1.93	0.53	0.67	0.10
Sooty Shearwater	0.02	0.02	0	0	1.42	1.02
Short-tailed Shearwater	0.24	0.05	0.01	0.01	0.03	0.02
Fork-tailed Storm-Petrel	0.05	0.02	0.02	0.02	0.03	0.02
Pelagic Cormorant	0.01	0.01	0	0	0.02	0.01
Mew Gull	0.01	0.01	0.07	0.03	0.13	0.09
Herring Gull	0.01	0.01	0.03	0.02	0.05	0.02
Thayer's Gull	0	0	0	0	0.01	0.01
Glaucous-winged Gull	0.16	0.03	0.17	0.05	0.19	0.04
Black-legged Kittiwake	0.44	0.07	0.30	0.10	0.44	0.08
Common Murre	2.95	0.54	1.44	0.27	1.76	0.38
Thick-billed Murre	0.01	0.01	0.01	0.01	0	0
Marbled Murrelet	0.01	0.01	0.07	0.04	0.01	0.01
Kittlitz's Murrelet	0.04	0.02	0.15	0.06	0.06	0.04
Cassin's Auklet	0	0	0.02	0.02	0	0
Crested Auklet	0.01	0.01	0.01	0.01	0	0
Horned Puffin	0	0	0	0	0.02	0.01
Tufted Puffin	0.02	0.01	0	0	0	0

^aBirds per square kilometer.^bSE, standard error.

Five species each composed $\geq 5.0\%$ of the total avifauna and collectively composed $\sim 74\%$ of all birds recorded across all cruises: the Common Murre (21.3%), Northern Fulmar (18.5%), Fork-tailed Storm-Petrel (16.3%), Sooty Shearwater (10.7%), and Black-legged Kittiwake (7.0%). Another nine species each composed 1.0–4.9% of the total avifauna and collectively composed $\sim 19\%$ of all birds: the Tufted Puffin (3.9%), Glaucous-winged Gull (3.6%), Red Phalarope (3.1%), Black-footed Albatross (1.9%), Short-tailed Shearwater (1.6%), Kittlitz's Murrelet (1.4%), Marbled Murrelet (1.3%), Double-crested Cormorant (1.1%), and Laysan Albatross (1.0%). Finally, the other 44 of the 58 total species each composed $< 1\%$ and collectively composed $\sim 7\%$ of the total avifauna.

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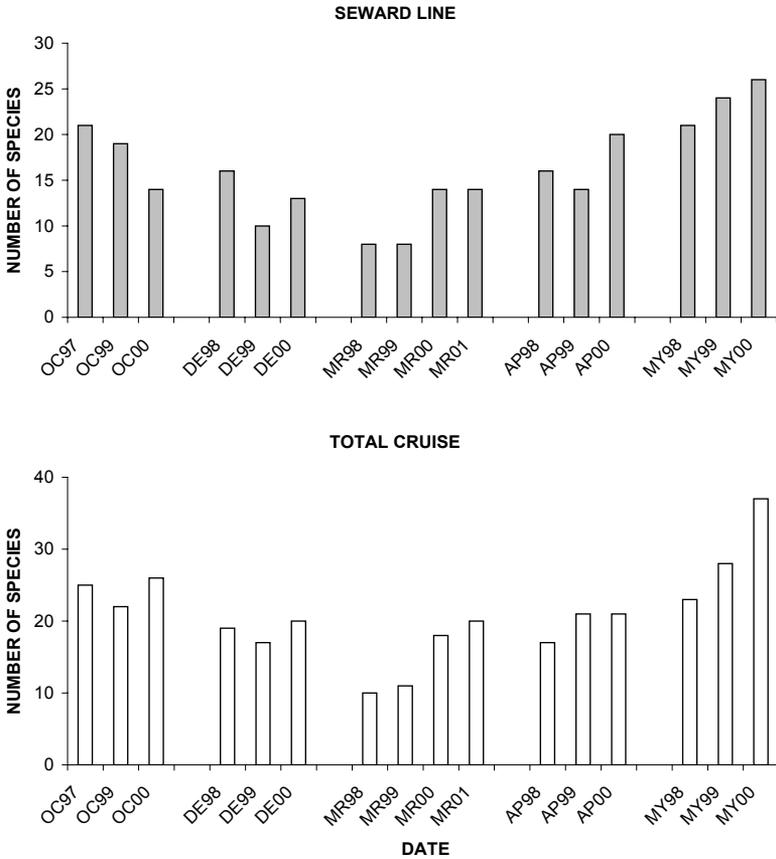


Figure 4. Mean species richness of the wintering avifauna of the northern Gulf of Alaska, October–May 1997–2001, along the Seward Line (top; see location on Figure 1) and across the study area as a whole (bottom).

Species richness and overall densities. Along the Seward Line, I noted between 8 and 26 species per cruise, with an overall mean of 16.1 species (Figure 4). The number decreased seasonally from October (mean 18.0 species per cruise) to December (mean 13.0) and March (mean 11.0), then increased rapidly in April (mean 16.7) and May (mean 23.7), when wintering species are leaving, breeding species are arriving, and migrants are present. Each cruise taken in its entirety, the number varied between 10 and 37 species per cruise, with an overall mean of 20.9 (Figure 4). As seen along the Seward Line, the number for entire cruises decreased seasonally from October (mean 24.3 species per cruise) to December (mean 18.7) and March (mean 14.8), then increased rapidly in April (mean 19.7) and May (mean 29.3).

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Table 3 Density of Seabirds in the Northern Gulf of Alaska, March 1998–2000

	Year							
	1998		1999		2000		2001	
	Mean ^a	SE ^b	Mean	SE	Mean	SE	Mean	SE
Number of transects	128		140		143		148	
All species pooled	4.77	0.51	3.90	0.43	5.98	0.67	6.18	0.95
Harlequin Duck	0	0	0	0	0.03	0.03	0.01	0.01
Surf Scoter	0	0	0	0	0.02	0.02	0	0
White-winged Scoter	0	0	0	0	0	0	0.01	0.01
Pacific Loon	0	0	0	0	0	0	0.01	0.01
Laysan Albatross	0	0	0.02	0.01	0.06	0.02	0.12	0.05
Black-footed Albatross	0.03	0.02	0.03	0.02	0.03	0.02	0.07	0.04
Northern Fulmar	1.40	0.28	1.53	0.25	1.17	0.20	1.22	0.19
Short-tailed Shearwater	0	0	0.01	0.01	0.01	0.01	0	0
Fork-tailed Storm-Petrel	0.15	0.08	0.12	0.04	0.06	0.02	0.09	0.03
Double-crested Cormorant	0	0	0	0	0	0	0.01	0.01
Pelagic Cormorant	0.02	0.02	0.02	0.02	0.03	0.02	0	0
Mew Gull	0	0	0	0	0.03	0.01	0.18	0.11
Herring Gull	0	0	0	0	0.01	0.01	0.01	0.01
Glaucous-winged Gull	0.18	0.04	0.15	0.04	0.16	0.06	0.24	0.05
Black-legged Kittiwake	0.52	0.08	0.37	0.07	0.64	0.10	0.82	0.16
Common Murre	2.13	0.37	1.38	0.31	3.35	0.62	2.65	0.80
Thick-billed Murre	0.05	0.02	0	0	0.01	0.01	0.01	0.01
Unidentified murre	0.01	0.01	0	0	0	0	0	0
Pigeon Guillemot	0.05	0.03	0	0	0	0	0	0
Marbled Murrelet	0	0	0.02	0.02	0.06	0.03	0.33	0.14
Kittlitz's Murrelet	0.24	0.07	0.27	0.12	0.10	0.04	0.22	0.09
Cassin's Auklet	0	0	0	0	0.09	0.06	0.03	0.03
Parakeet Auklet	0	0	0	0	0	0	0.01	0.01
Crested Auklet	0	0	0	0	0	0	0.02	0.02
Tufted Puffin	0	0	0	0	0.14	0.06	0.12	0.06

^aBirds per square kilometer.^bSE, standard error.

Total densities of all species combined followed a seasonal pattern similar to that for species richness, in that overall densities decreased from October (6.4 birds/km²) to December and March (mean 5.2 birds/km² in both months), then increased from March to April (mean 7.6 birds/km²; Figure 5). Total densities peaked in May with a mean of 12.9 birds/km².

Species Accounts

In these accounts, I discuss the abundance of most species in general terms and discuss details of habitat use and seasonal, annual, and/or geographic variation in abundance for the more common species; data on seasonal abundance of all species are presented in Tables 1–5. This difference in detail is necessary because 44 of the 58 species of birds seen on transects were recorded only in small numbers (i.e., each was <1% of the total number

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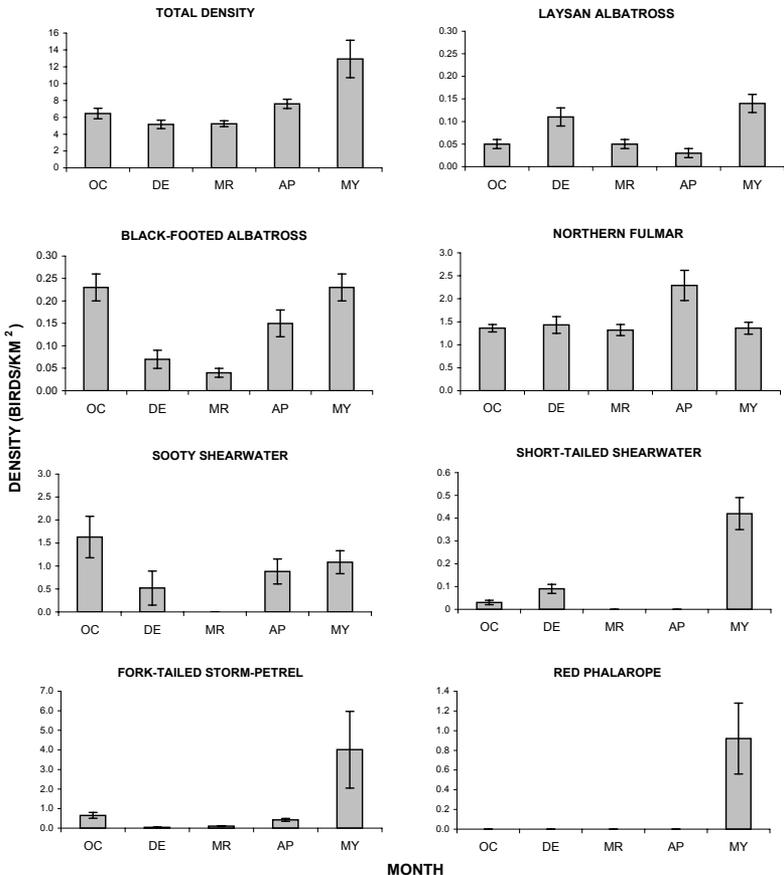


Figure 5. Mean (± 1 standard error) densities (birds/km²) of all birds combined and 7 of the 13 most abundant seabird species in the northern Gulf of Alaska, October–May 1997–2001, by month.

seen). In addition to the 58 species recorded on transects, I saw one species, the Black-headed Gull (*Larus ridibundus*) only off transects. The account specifies the fraction the species constituted of the total count if the fraction is greater than 0.2%; if it is less, this figure is omitted.

I follow Kessel and Gibson (1978) in classifying each species in terms of abundance (abundant, common, fairly common, uncommon, rare, casual, and accidental) during three periods: fall migration (October), winter (December–March, sometimes April), and spring migration (April–May). “Casual” implies not annual, and “accidental” implies that the species is so far from its normal range that further records are unlikely.

Cackling/Canada Goose *Branta hutchinsii/canadensis* (rare fall and spring): On

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Table 4 Density of Seabirds in the Northern Gulf of Alaska, April 1998–2000

	Year					
	1998		1999		2000	
	Mean ^a	SE ^b	Mean	SE	Mean	SE
Number of transects	133		161		104	
All species pooled	10.11	1.04	4.74	0.74	8.79	1.09
Green-winged Teal	0	0	0.09	0.09	0	0
White-winged Scoter	0	0	0.01	0.01	0	0
Black Scoter	0	0	0.01	0.01	0	0
Pacific Loon	0	0	0.02	0.01	0.02	0.02
Yellow-billed Loon	0	0	0.01	0.01	0	0
Laysan Albatross	0.03	0.02	0.02	0.02	0.04	0.02
Black-footed Albatross	0.10	0.04	0.06	0.03	0.35	0.11
Short-tailed Albatross	0	0	0.01	0.01	0	0
Northern Fulmar	4.06	0.91	0.84	0.17	2.28	0.30
Mottled Petrel	0.01	0.01	0	0	0.09	0.04
Sooty Shearwater	0.05	0.04	0.61	0.24	2.35	0.96
Short-tailed Shearwater	0	0	0	0	0.01	0.01
Fork-tailed Storm-Petrel	0.21	0.07	0.21	0.09	1.02	0.18
Red-faced Cormorant	0.09	0.06	0	0	0.01	0.01
Pelagic Cormorant	0.14	0.09	0.05	0.04	0	0
Pomarine Jaeger	0	0	0	0	0.01	0.01
Mew Gull	0.03	0.03	0.02	0.01	0	0
Herring Gull	0.02	0.01	0	0	0.04	0.03
Glaucous-winged Gull	0.49	0.10	0.48	0.14	0.07	0.03
Glaucous Gull	0	0	0	0	0.01	0.01
Black-legged Kittiwake	0.59	0.10	0.82	0.33	0.56	0.11
Common Murre	3.92	0.51	1.28	0.19	1.45	0.30
Thick-billed Murre	0.02	0.01	0	0	0.02	0.02
Marbled Murrelet	0	0	0.02	0.02	0.11	0.07
Kittlitz's Murrelet	0.31	0.08	0.08	0.04	0.18	0.08
Cassin's Auklet	0.01	0.01	0.01	0.01	0.01	0.01
Rhinoceros Auklet	0.02	0.02	0.07	0.04	0.04	0.03
Tufted Puffin	0	0	0.01	0.01	0.09	0.04

^aBirds per square kilometer.^bSE, standard error.

transects, a flock of four flying north in the mid-shelf area, ~35 km offshore, on 6 May 1999. Off transects, a flock of 40 sitting on the ocean ~9 km south of Cape Fairfield on 10 October 1999, three flying off outer Montague Island on 17 April 1999, and a flock of 18 flying in the mid-shelf area, ~35 km offshore, on 7 May 1998. Both species cross the Gulf of Alaska during migration, and I noted some of these as "small geese," suggesting that they were Cackling Geese.

Brant *Branta bernicla* (rare–uncommon spring): On transects, a flock of four flying north (presumably coming in from the deep North Pacific) near the shelf break on 6 May 1999 and four flying east (not west) off the mouth of Resurrection Bay on 17 May 2000. Off transects, a flock of six sitting on the ocean, one bird flying northwest, and ~20 flying west–northwest, all over the outer part of the mid-shelf on 8 May

Table 5 Density of Seabirds in the Northern Gulf of Alaska, May 1998–2000

	Year					
	1998		1999		2000	
	Mean ^a	SE ^b	Mean	SE	Mean	SE
Number of transects	128		173		253	
All species pooled	11.17	0.89	6.38	0.53	18.28	4.81
Cackling/Canada Goose	0	0	0.06	0.06	0	0
Brant	0	0	0.02	0.02	0.03	0.03
Northern Shoveler	0	0	0	0	0.02	0.02
Green-winged Teal	0	0	0.01	0.01	0	0
Greater Scaup	0	0	0.11	0.11	0	0
Common Eider	0.22	0.22	0	0	0	0
Long-tailed Duck	0	0	0.04	0.04	0.24	0.18
Red-throated Loon	0	0	0.04	0.02	0	0
Pacific Loon	0.14	0.12	0.10	0.03	0.01	0.01
Yellow-billed Loon	0.01	0.01	0	0	0.01	0.01
Laysan Albatross	0.25	0.05	0.06	0.02	0.14	0.03
Black-footed Albatross	0.18	0.06	0.30	0.07	0.20	0.04
Northern Fulmar	2.40	0.35	0.93	0.11	1.12	0.21
Sooty Shearwater	0.34	0.08	0.77	0.35	1.66	0.49
Short-tailed Shearwater	0.62	0.12	0.28	0.10	0.41	0.11
Fork-tailed Storm-Petrel	1.38	0.26	0.65	0.15	7.64	4.28
Leach's Storm-Petrel	0	0	0	0	0.09	0.04
Double-crested Cormorant	0	0	0	0	<0.01	<0.01
Red-faced Cormorant	0	0	0	0	0.01	0.01
Pelagic Cormorant	0.02	0.01	0	0	0.02	0.02
Red-necked Phalarope	0	0	0	0	0.31	0.11
Red Phalarope	0.04	0.04	0	0	2.00	0.79
Pomarine Jaeger	0	0	0.05	0.02	0.10	0.03
Parasitic Jaeger	0	0	0	0	<0.01	<0.01
Long-tailed Jaeger	0	0	0.01	0.01	0.04	0.02
Bonaparte's Gull	0	0	0	0	0.02	0.01
Mew Gull	0	0	0.01	0.01	<0.01	<0.01
Herring Gull	0.02	0.02	0.04	0.02	0.04	0.01
Glaucous-winged Gull	0.27	0.07	0.38	0.08	0.35	0.08
Glaucous Gull	0	0	0.02	0.01	0	0
Sabine's Gull	0	0	0	0	0.05	0.02
Black-legged Kittiwake	0.25	0.06	0.40	0.11	0.64	0.12
Arctic Tern	<0.01	0.02	0.24	0.08	0.17	0.10
Common Murre	2.76	0.69	0.64	0.15	0.93	0.32
Thick-billed Murre	0	0	0	0	0.01	0.01
Pigeon Guillemot	0.02	0.01	0	0	0	0
Marbled Murrelet	0.17	0.07	0.11	0.04	0.43	0.08
Kittlitz's Murrelet	0.19	0.07	0.02	0.01	0.07	0.02
Ancient Murrelet	0.16	0.16	0.04	0.02	0.16	0.05
Cassin's Auklet	0.01	0.01	0.04	0.02	0.04	0.02
Parakeet Auklet	0	0	0	0	0.02	0.01
Rhinoceros Auklet	0.03	0.02	0.01	0.01	<0.01	<0.01
Horned Puffin	0	0	0	0	0.28	0.08
Tufted Puffin	1.67	0.30	0.99	0.12	1.00	0.12

^aBirds per square kilometer.^bSE, standard error.

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1999. Thus, in spring, the species appears to migrate through the region primarily far offshore (see also Gabrielson and Lincoln 1959).

Mallard *Anas platyrhynchos* (rare fall): On transects, a flock of 21 flying southeast over the mid-shelf on 4 October 2000. The lack of other records probably reflects the species' primary wintering habitat in protected waters and on shorelines (Forsell and Gould 1981, Day et al. 1997b).

Northern Shoveler *Anas clypeata* (rare–uncommon fall and spring): On transects, a flock of three flying east ~20 km offshore on 7 October 1999 and a flock of four flying west ~110 km offshore on 17 May 2000. Off transects, three flying east ~150 km offshore on 7 October 1999, two flying northwest ~260 km offshore and clearly migrating over the deep North Pacific on 7 May 1999, and a flock of 17 sitting on the ocean ~165 km offshore on 8 May 1999.

Green-winged Teal *Anas crecca* (rare spring): On transects, a flock of seven sitting on the ocean 5–10 km south of Montague Island on 17 April 1999 and one flying north (presumably coming inshore from the deep North Pacific) over the mid-shelf on 12 May 1999.

Greater Scaup *Aythya marila* (rare fall, uncommon spring): On transects, a flock of nine flying east on 13 October 1997 and a flock of 17 sitting on the ocean on 8 May 1999, both ~160 km offshore near the shelf break. Off transects, 20 birds ~37 km offshore and 5 birds ~160 km offshore, near the shelf break, both on 6 May 1999, and 1 pair flying inshore (north) from the deep North Pacific ~200 km offshore on 18 May 2000.

Common Eider *Somateria mollissima* (rare spring): On transects, a flock of 26 flying southwest over the mid-shelf on 7 May 1998. The Common Eider is a rare visitor to the region, being more common in winter and primarily along the open coast (Isleib and Kessel 1973).

Harlequin Duck *Histrionicus histrionicus* (rare fall–spring): Total six during transects, scattered between October and March. All except two were in the Alaska Coastal Current; the two exceptions were in inner part of the mid-shelf.

Surf Scoter *Melanitta perspicillata* (rare fall–spring): On transects, a pair in western Prince William Sound on 5 October 2000, five just south of Cape Fairfield on 10 October 2000, and a pair in southern Prince William Sound on 11 March 2000. Off transects, scattered birds were in Prince William Sound March–May.

White-winged Scoter *Melanitta fusca* (uncommon fall, rare winter and spring): Total of 52 in 7 groups during transects, representing 0.3% of all birds seen on transects. Most common in October, when recorded every year, but occurred sparingly December–April. Occurred widely from Prince William Sound to ~185 km offshore, with latter group (15 birds) seen migrating over the deep North Pacific on 6 October 1999. Off transects, scattered birds in Prince William Sound October–April of most years and seven flying northwest ~45 km offshore on 20 May 2000.

Black Scoter *Melanitta nigra* (rare winter and spring): Single birds flying west of Kayak Island on 5 December 1999 and ~55 km offshore, in the mid-shelf, on 16 April 1999.

Long-tailed Duck *Clangula hyemalis* (rare winter, uncommon spring): On transects, total 70 birds, two in December and the rest in May; represented 0.4% of all birds. Single birds in Blyng Sound on 3 and 6 December 2000; flocks of six and two flying west ~18 and ~37 km south of Cape Fairfield on 11 May 1999 and 20 May 2000, respectively; and flocks of 45 and 15 flying east (not west) ~45 km offshore, over the mid-shelf, on 19 May 2000. Off transects, one bird ~150 km offshore, over the shelf break, on 2 December 1999; 25–30 in Icy Bay (Prince William Sound) on 18 April 1999; flock of 16 flying west over the mid-shelf on 8 May 1998; and ~200 birds in 5 groups flying northeast or east (not west) over the mid-shelf on 19 May 2000.

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Common Goldeneye *Bucephala clangula* (uncommon fall): Not seen on open water. Flocks of 79 and 17 in Bainbridge Passage (Prince William Sound) on 6 October 2000 represented 0.6% of all birds.

Common Merganser *Mergus merganser* (rare winter): One in Blying Sound on 3 December 2000.

Red-throated Loon *Gavia stellata* (rare winter and spring): Total eight during transects: single bird in lower Resurrection Bay on 1 December 1998 and seven scattered others, mostly migrating west over the inner and mid-shelf, 6–11 May 1999.

Pacific Loon *Gavia pacifica* (uncommon fall–spring): Total 45 during transects, representing 0.3% of all birds: flock of four migrating west ~14 km south of Cape Fairfield on 10 October 1999; two single birds in southern Prince William Sound on 12 March 2001; five single birds migrating west in Blying Sound in April 1999 and 2000; and 34 birds, mostly migrating west, spread across the shelf in May of every year. Off transects, six birds flying west in southern Prince William Sound on 12 March 2001 and two in the western part of the sound on 10 May 1999.

Common Loon *Gavia immer* (rare fall and winter): Single birds ~18 km south of Cape Fairfield on 6 October 2000 and east of Kayak Island on 5 December 1999.

Yellow-billed Loon *Gavia adamsii* (rare winter and spring): On transects, four single birds: one in western Prince William Sound on 17 April 1999, one south of Montague Island on 13 May 1998, and two south of the Copper River mouth on 23 May 2000. Off transects, one in central Prince William Sound on 5 December 1998.

Laysan Albatross *Phoebastria immutabilis* (uncommon–fairly common fall–spring): Seen on 14 of 16 cruises and in every month; most common in December and May and least common in March and April (Figure 5). Represented 1.0% of all birds and constituted up to 3.4% of all birds on some cruises. Occurred primarily at the shelf break and in the oceanic water of the Alaska Stream but regular inshore as far as the outer part of the mid-shelf; one even was seen in the Alaska Coastal Current. Although Gould et al. (1982) suggested that the species occurs only from March to November, these data indicate that the species occurs year round.

Black-footed Albatross *Phoebastria nigripes* (common fall and spring, uncommon winter): Seen on every cruise, although least common in December and March (Figure 5); represented 1.9% of all birds (ninth most abundant species), constituting up to 5.7% of all birds on some cruises. Although most occurred at the shelf break and in the Alaska Stream, some ranged regularly as far inshore as the outer part of the mid-shelf (especially during warmer months), and several were seen inshore in the Alaska Coastal Current. Although Isleib and Kessel (1973) and Gould et al. (1982) suggested that the species was irregular from October to May, these data indicate that the species occurs year round.

Short-tailed Albatross *Phoebastria albatrus* (rare winter and spring): Two juveniles during transects, one at 58° 46' N, 148° 27' W on 2 December 1998 and one at 58° 35' N, 148° 14' W on 13 April 1999 (both near the shelf break). Off transects, one adult while the ship was on station at 58° 06' N, 147° 48' W (in the Alaska Stream) on 18 May 2000.

Northern Fulmar *Fulmarus glacialis* (common fall and winter, common–abundant spring): Seen during every cruise, representing 18.5% of all birds seen during transects (second most abundant species) and up to 43.7% of all birds on some cruises. Most abundant in April (Figure 5), suggesting migration through area. Most abundant at the shelf break, least common in the Alaska Coastal Current, and absent from Prince William Sound.

Mottled Petrel *Pterodroma inexpectata* (rare–uncommon fall and spring): Total

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of 20 birds on 3 of 16 cruises: 12 at the shelf break and in oceanic water (150–200 km offshore) on 6 and 7 October 1999, one at the shelf break (~150 km offshore) on 4 April 1998, and seven from the mid-shelf to the Alaska Stream (70–200 km offshore) on 18 and 19 April 2000. On the last dates, single birds at 58° 11' N, 148° 47' W and 58° 11' N, 148° 48' W were the farthest inshore I have seen this oceanic species, which concentrates over the deep waters of the Alaska Gyre (Day 1992). The species was previously recorded as late as October but not as early as April (Gould et al 1982).

Buller's Shearwater *Puffinus bulleri* (casual, possibly rare, fall): Four on transects and two off transects, all over the mid-shelf, in October 1997. On 13 October 1997 (during large El Niño that year), single birds were at 58° 47' N, 148° 30' W, 58° 36' N, 148° 16' W, and 58° 35' N, 148° 15' W. On 15 October, one was at 59° 35' N, 148° 53' W, and single birds were off transects at 58° 43' N, 148° 25' W and 59° 27' N, 148° 52' W. The species is a rare summer visitor to oceanic waters of the Gulf of Alaska from April to October (Kessel and Gibson 1978, Gould et al 1982, Isleib and Kessel 1989).

Sooty Shearwater *Puffinus griseus* (common fall and spring, rare winter): Regular in October, April, and May, rarer in December, and never seen in March (Figure 5). Represented 10.7% of all birds (fourth most abundant species) and constituted up to 36.2% of all birds on some cruises. Essentially occurred only in the Gulf of Alaska, with only one seen in Prince William Sound (3 December 2000). Moved onto the shelf and into the Alaska Coastal Current during the warmer months of October and May but occurred farther offshore in April, suggesting inshore–offshore seasonal movement.

Short-tailed Shearwater *Puffinus tenuirostris* (rare fall, rare–uncommon winter, common spring): Seen during 12 of 16 cruises and in all months, although common only during May (Figure 5). Represented 1.6% of all birds (tenth most abundant species) and constituted as much as 6.0% of all birds on some cruises. Occurred only in the Gulf of Alaska, usually in small groups associated with or near Sooty Shearwaters, and ranged from the Alaska Coastal Current to the Alaska Stream, being most abundant at the shelf break and in the Alaska Stream.

Little Shearwater *Puffinus assimilis* (accidental visitor): One bird at 59° 24' N, 149° 03' W on 12 October 1997, over the mid-shelf, during El Niño of 1997. This very small shearwater was seen closely: underwing nearly completely white, with narrow black border on forward edge of wing and white extending over most of undersides of primaries; axillaries and undertail-coverts also white; unfortunately, I did not notice whether dark cap extended above or below eye (nominate *assimilis* from the southwestern Pacific has white on face to above the eye, whereas *elegans* from near New Zealand has a dark cap extending below eye; Harrison 1985). These characters separate the Little from Audubon's Shearwater, which is slightly larger, has more black on the underwing, and has black in the axillaries. Complete details are on file at the University of Alaska Museum (UAM). The only other records of this species for western North America are a sighting by Jeff B. Allen of one near Kodiak Island, Alaska, on 26 August 1996 (drawing and details at UAM) and of one photographed in Monterey County, California, on 29 October 2003 (San Miguel and McGrath 2005). The only other records for the North Pacific come from Midway in the Leeward Hawaiian Islands, where the species is accidental (AOU 1998); Reginald E. David (in litt.) pulled a calling bird from a burrow there in December 1991.

Fork-tailed Storm-Petrel *Oceanodroma furcata* (uncommon fall, rare winter, abundant spring): Seen on all cruises and in all months, although least abundant from December to April (Figure 5). Represented 16.3% of all birds (third most abundant species) and constituted up to 43.9% of all birds on some cruises. Occurred in both the Gulf of Alaska and Prince William Sound but abandoned nearshore waters nearly

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completely in December and March, suggesting inshore–offshore seasonal movement. Densities highest over the mid-shelf and at shelf-break front. Although the species supposedly does not occur inshore until May (Isleib and Kessel 1973, Forsell and Gould 1981, Gould et al. 1982), these data suggest that inshore movement takes place earlier than that.

An enormous feeding flock of Fork-tailed Storm-Petrels was along the mid-shelf part of the Seward Line on 19 and 20 May 2000, concentrated in an area ~18 km north–south and ≥ 9 km east–west, for a minimal area of ~162 km²; I suspected that the flock was even larger than this. Associated with this flock were Red and Red-necked phalaropes, the only Leach's Storm-Petrels recorded during surveys, and Humpback Whales (*Megaptera novaeangliae*). At a mean density of ~146 birds/km², this flock probably contained >25,000 Fork-tailed Storm-Petrels, plus large numbers of Red Phalaropes and small numbers of Leach's Storm-Petrels and Red-necked Phalaropes.

Leach's Storm-Petrel *Oceanodroma leucorhoa* (casual, probably annual, in spring): Total of 17, all in May 2000: one ~65 km offshore on 19 May 2000 and 16 over the mid-shelf with Fork-tailed Storm-Petrels and phalaropes on 18 May 2000 (see above).

Double-crested Cormorant *Phalacrocorax auritus* (rare–fairly common fall, rare winter and spring): Total 169 birds, although four of five records were of single birds. Represented 1.1% of all birds and constituted up to 15.9% of all birds on some cruises. Single birds were in Blying Sound on 6 October 2000, at the mouth of Resurrection Bay on 8 October 2000, and in western Prince William Sound on 5 March 2001 and 25 May 2000. Largest group was a flock of 165 migrating east at 58° 50' N 148° 32' W (~120 km offshore, just inshore of the shelf break) on 8 October 2000. In contrast to these data, Gould et al. (1982) suggested that this species migrates coastally in the Gulf of Alaska.

Red-faced Cormorant *Phalacrocorax urile* (rare fall and spring): On transects, total of 14 over 4 cruises during the warmer months: one in fall (lower Resurrection Bay, 10 October 2000), the rest in April or May. Off transects, two in Bainbridge Passage (Prince William Sound) on 18 April 1999 and one ~9 km offshore on 9 May 1999. All birds except one in mid-shelf water were in the Alaska Coastal Current. The population appeared to have expanded dramatically in 1960s (Isleib and Kessel 1973); first recorded in the region in 1959, the Red-faced was the most common breeding cormorant in Gulf of Alaska by 1976 (Kessel and Gibson 1978), but in recent years has been greatly outnumbered by the Pelagic (unpubl. data), suggesting a major decline.

Pelagic Cormorant *Phalacrocorax pelagicus* (rare fall and winter, uncommon spring): On transects, total of 51 during 11 cruises and in all months, representing 0.3% of all birds. Noted off transects in both the Gulf of Alaska and Prince William Sound. Least common in December and most common in April and in the gulf. Most frequent in the Alaska Coastal Current, but a few strayed into inner part of the mid-shelf; one bird was ~160 km offshore, at the shelf break, on 2 December 1998.

Red-necked Phalarope *Phalaropus lobatus* (rare spring): Total of 60 in May 2000, representing 0.4% of all birds. Occurred in the Alaska Coastal Current and occasionally mid-shelf water, in the Gulf of Alaska only. Many were seen feeding in surface "slicks" or wrack lines indicating surface convergences and divergences.

Red Phalarope *Phalaropus fulicarius* (rare fall, common spring): Seen only during migration, with one in October and many in May, although not annually (Figure 5). Represented 3.1% of all birds (eighth most abundant species), even though it occurred essentially during May only, and constituted up to 11.4% of all birds seen on some cruises. Occurred from the Alaska Coastal Current to the Alaska Stream but most common over the mid-shelf.

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Pomarine Jaeger *Stercorarius pomarinus* (rare fall and spring): On transects, total of 52, representing 0.3% of all birds. Noted every October, once in April, and on two of three May cruises. Equally common in October and May. An early migrant was at 58° 17' N, 147° 58' W, over the Alaska Stream, on 19 April 2000; otherwise, all birds occurred over the mid-shelf and, less commonly, the Alaska Coastal Current. Off transects, one near Cape Fairfield on 11 May 1999.

Parasitic Jaeger *Stercorarius parasiticus* (rare fall and spring): On transects, total six birds. Seen every fall but only twice in spring (one ~35 km south of Cape Fairfield on 20 May 2000; one off transects south of Montague Island on 17 April 1999). Occurred only in the Gulf of Alaska and in mid-shelf water.

Long-tailed Jaeger *Stercorarius longicaudus* (rare spring): Total 12 birds, all during May (1 in 1999 and 11 in 2000). Most were migrating west over the Gulf of Alaska. Four were over the Alaska Coastal Current, and eight were over mid-shelf water up to ~55 km offshore.

Black-headed Gull *Larus ridibundus* (casual winter): One off transects, a basic-plumaged bird visiting the ship while it was on station at 59° 25' N, 149° 04' W on 3 March 2001. Observed closely, it was substantially larger than a Bonaparte's Gull and its primaries had a dark underside. The only other record for the Gulf of Alaska is of one bird in late summer–fall 1977 (Isleib and Kessel 1989). This is the only winter record of the Black-headed Gull in Alaska.

Bonaparte's Gull *Larus philadelphia* (rare fall and spring): Total ten birds, five each in October 2000 and May 2000. Occurred in both Prince William Sound and the Gulf of Alaska, primarily in the Alaska Coastal Current, with a few seen over mid-shelf water up to ~45 km offshore. In the Gulf of Alaska, the species is a coastal migrant, rarely seen offshore (Gould et al. 1982).

Mew Gull *Larus canus* (rare–uncommon winter fall–spring): Total 79 birds, representing 0.5% of all birds. Occurred every month but considerably more common October–March, becoming much rarer in April and May, when moving to coastal and inland sites to breed. All records except three were for the Alaska Coastal Current; the exceptions were two individuals over the mid-shelf and one ~150 km offshore, at the shelf break.

Herring Gull *Larus argentatus* (rare–uncommon fall and winter, rare spring): On transects, total of 114 on 13 of 16 cruises, representing 0.7% of all birds. Although seen every month, most common in October and December and least common in March and April, increasing in abundance again in May. Decreased in abundance from the Alaska Coastal Current to oceanic waters (to ~220 km offshore). Off transects, birds seen from October to May and in both the Gulf of Alaska and Prince William Sound.

Thayer's Gull *Larus thayeri* (casual winter): On transects, two single birds in western Prince William Sound on 4 December 2000; off transects, four in Harriman Fjord (Prince William Sound) on 5 December 2000. Much rarer than Isleib and Kessel (1973) suggested, perhaps because the species is rare offshore.

Glaucous-winged Gull *Larus glaucescens* (common fall and spring, uncommon winter): Seen during every cruise, although most common in October, April, and May (Figure 6). Represented 3.6% of all birds (seventh most abundant species), constituting as much as 10.2% of all birds on some cruises. Occurred widely from the Alaska Coastal Current (most common) to the Alaska Stream; in the Gulf of Alaska, the Glaucous-winged Gull is primarily a neritic species.

Glaucous Gull *Larus hyperboreus* (rare fall–spring): On transects, total of six: one in October, one in April, and four in May, all in 2000 and over the Alaska Coastal Current or mid-shelf. Off transects, one in Prince William Sound on 5 March 2001,

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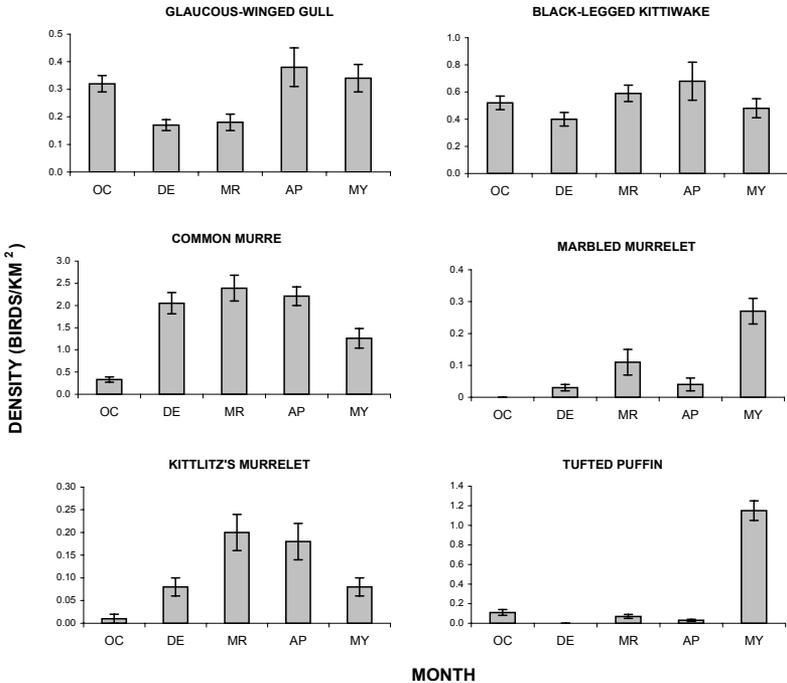


Figure 6. Mean (± 1 standard error) densities (birds/km²) of 6 of the 13 most abundant seabird species in the northern Gulf of Alaska, October–May 1997–2001, by month.

several there on 10 May 1999, single birds over the mid-shelf and at the shelf break on 8 May 1999, and three ~35 km south of Cape Fairfield on 11 May 1999.

Sabine’s Gull *Xema sabini* (rare spring; survey timing possibly incorrect for determining true abundance): On transects, total of 12, all from 22 to 25 May 2000. I suspect that other May cruises were too early for arrival of these migrants, although the species simply may be rare in this area at all times. Seen south of Montague Island, south of Hinchinbrook Entrance, and west of Kayak Island, over both the Alaska Coastal Current and mid-shelf water. All were in alternate plumage. Also suggesting late migration through region, D. D. Gibson (UAM, unpubl. data) recorded one in spring at Giacomini Seamount (56° 07' N, 147° 09' W), in the oceanic Gulf of Alaska, on 14 May 1986.

Black-legged Kittiwake *Rissa tridactyla* (uncommon–common fall–spring): Seen during every cruise, being most common in March and April, when it returned prior to breeding (Figure 6). Represented 7.0% of all birds (fifth most abundant species) and constituted up to 18.5% of all birds on some cruises. Primarily neritic, although less common inshore in December and March, suggesting inshore–offshore seasonal movement.

Arctic Tern *Sterna paradisaea* (rare spring): Total of 81, all spring migrants in May,

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representing 0.5% of all birds. All but one were in the Gulf of Alaska. Many were migrating west, although some were headed east or northeast. Occurred primarily over mid-shelf water, occasionally in the Alaska Coastal Current; three were over deep water up to ~220 km offshore, on 7 May 1999.

Common Murre *Uria aalge* (uncommon fall, abundant winter and spring): Seen during every cruise, although most abundant in March and April (Figure 6). Represented 21.3% of all birds (most abundant species), constituting as much as 45.4% of all birds on some cruises. Occurred in both the Gulf of Alaska and Prince William Sound but rare in the sound in October and December, suggesting inshore-offshore seasonal movement. Also occurred primarily over the shelf, especially the mid-shelf, being rare at the shelf-break or in the Alaska Stream. Many were flying inshore as early as March, and seasonal movement inshore continued to May, prior to breeding. In October, most appeared to be unwilling or unable to fly, suggesting flightlessness at that time because of synchronous molt of flight feathers.

Thick-billed Murre *Uria lomvia* (rare winter and spring): Total 15 birds, occurring sporadically among the abundant Common Murres. Records ranged from December to May, with most in March and April. The Thick-billed occurred only in the Gulf of Alaska, where it ranged widely from the Alaska Coastal Current to the shelf break (one) and deep water ~165 km offshore (three); however, it was most frequent over the mid-shelf. Although Gould et al. (1982) suggested that Thick-billed Murres wintering in the gulf prefer waters deeper than does the Common Murre, my data do not support this claim.

Pigeon Guillemot *Cephus columba* (rare winter and spring): On transects, total of six, all in March and May 1998. Occurred in both the Gulf of Alaska and Prince William Sound, all in the Alaska Coastal Current.

Marbled Murrelet *Brachyramphus marmoratus* (rare fall and winter, rare-common spring): Seen during 12 of 16 cruises and in all months, most commonly in spring (Figure 6). Represented 1.3% of all birds, constituting as much as 6.1% of all birds on some cruises. Occurred in both Prince William Sound and the Gulf of Alaska, where it occurred primarily in the Alaska Coastal Current and over the mid-shelf. Off transects, one was in central Prince William Sound on 5 December 1998 and 15–20 were in Harriman Fjord (an arm of the sound) on 5 December 2000.

Kittlitz's Murrelet *Brachyramphus brevirostris* (rare-uncommon fall-spring): Seen during 15 of 16 cruises and in all months, being most numerous in March and April (Figure 6), presumably as birds move inshore to bays prior to breeding. Represented 1.4% of all birds, constituting as much as 7.0% of all birds on some cruises. Occurred in both Prince William Sound and the Gulf of Alaska, being more common in the gulf, primarily in the Alaska Coastal Current and over the mid-shelf. One bird was ~180 km offshore at the shelf-break front on 9 March 1998, but I saw none in the Alaska Stream. Off transects, three basic-plumaged birds (presumably just molted) were flying east south of Montague Island on 16 October 1997, 12–15 were in central Prince William Sound on 5 December 1998, two were off the dock at Seward on 2 March 2001, one was south of Montague Island on 14 March 1998, and four (two obvious pairs) were in Icy Bay (an arm of the sound) on 18 April 1999. None, however, were in Harriman Fjord on 5 December 2000. Interestingly, the mean sea-surface temperature where I recorded this species during nonbreeding period (6.2° C overall) is essentially identical to mean temperature in which species occurs in Prince William Sound in summer (6.1° C overall; Day et al. 1999, 2003). Overall densities suggest that the northern Gulf of Alaska shelf is an important wintering area for this rare species (see Day et al. 1999), supporting perhaps several thousand.

Ancient Murrelet *Synthliboramphus antiquus* (rare fall, rare-uncommon spring):

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On transects, total 52, with 3 in October 1997, the remainder spread across three May cruises; represented 0.3% of all birds. All records were from the Gulf of Alaska, primarily in mid-shelf water, secondarily in the Alaska Coastal Current. One was seen ~140 km offshore, just inshore of the shelf break.

Cassin's Auklet *Ptychoramphus aleuticus* (rare fall–spring): On transects, total 42, representing 0.3% of all birds. Noted on 11 of 16 cruises and in all months, being least numerous in December and March and most numerous in May. Occurred only in the Gulf of Alaska, from the Alaska Coastal Current to the Alaska Stream, most frequently from the outer part of the mid-shelf to oceanic water (up to ~220 km offshore). Appears to shift seasonally, moving off the shelf in fall (although the one December record was inshore) and back onto the shelf in spring.

Parakeet Auklet *Aethia psittacula* (rare fall–spring): On transects, total 17, in October, March, and May. Occurred only in the Gulf of Alaska, from the Alaska Coastal Current to the Alaska Stream; least frequent in the coastal current and equally frequent from the mid-shelf to the Alaska Stream, ranging up to ~185 km offshore. Appears to move seasonally, being farther offshore in October, absent in December, and back inshore in spring.

Crested Auklet *Aethia cristatella* (rare winter): On transects, total six: single birds at 58° 54' N, 148° 03' W and 58° 56' N, 148° 07' W on 3 December 1998 (both near the shelf break), one at 59° 24' N, 149° 05' W (over the mid-shelf) on 5 December 1999, one at 58° 55' N, 148° 35' W (near the shelf break) on 7 March 2001, and two at 58° 52' N, 148° 30' W (near the shelf break) on 9 March 2001. Off transects, one at 59° 51' N, 149° 28' W (~15 km offshore) on 30 November 1999 and one off the dock at Seward on 30 November 1998. These data suggest that the species is annual in the northern gulf, although previously it has been considered casual in winter (Isleib and Kessel 1973, Gould et al. 1982).

Rhinoceros Auklet *Cerorhinca monocerata* (rare fall and spring): On transects, total 22: rare in October, absent in December and March, and slightly more frequent in April and May. Most frequent over the mid-shelf and less so in the Alaska Coastal Current and Alaska Stream; seen up to ~200 km offshore.

Horned Puffin *Fratercula corniculata* (rare fall and spring, casual winter; spring survey schedule probably incorrect for determining true abundance): On transects, total 59, representing 0.4% of all birds: four in October 1997, three in December 2000, and the rest in May 2000. Occurred only in the Gulf of Alaska, where it ranged from the Alaska Coastal Current to the Alaska Stream; seen up to ~210 km offshore. It also appeared to move seasonally, leaving the shelf in winter. Noticeable inshore movement in May 2000 (the latest May cruise), with birds seen copulating on the water.

Tufted Puffin *Fratercula cirrhata* (rare fall and winter visitor, rare–abundant spring): Seen during 11 of 16 cruises and in all months, but abundant only in May (Figure 6). Even though it was not present all winter, it represented 3.9% of all birds seen during transects (sixth most abundant species) and constituted up to 15.3% of all birds on a cruise. Except for a single individual in Prince William Sound, all Tufted Puffins were in the Gulf of Alaska. The species moved seasonally, into the deep North Pacific to winter and back onto the shelf in spring.

DISCUSSION

The avifauna was dominated numerically by tubenoses, which collectively represented 50% of all marine-oriented birds seen. Alcids and larids brought

the total percent to 92% overall. Thus only two orders, the Procellariiformes and Charadriiformes, dominate this fauna. Five species each composed $\geq 5\%$ of the total avifauna (Common Murre, Northern Fulmar, Fork-tailed Storm-Petrel, Sooty Shearwater, and Black-legged Kittiwake) and collectively composed nearly 74% of all birds seen on all cruises. Another nine species each composed 1.0–4.9% and collectively represented 19% of the total avifauna. The remaining 44 species could be considered trace elements and collectively represented 7% of the wintering avifauna. Hence, the nonbreeding seabird community of the northern Gulf of Alaska is simple and characterized by just a few species, most of which are tubenoses.

Species Richness

For all transects combined, species richness varied between 10 and 37 species per cruise, with an overall mean of 20.9 species per cruise. Richness varied strongly by season, decreasing from October to March, then increasing rapidly again to May, when wintering species are still present, breeding species are arriving, and migrant species are crossing the region. December and March, which have the lowest number of species, are dominated numerically by just a few species, indicating that only a few are able to thrive at this high a latitude during the coldest and darkest months of the year. Presumably much of the stress is caused by food limitation, but cold temperatures and short days that limit the time available for foraging also must be of some importance. The avifauna during both months is dominated numerically by the Northern Fulmar, Black-legged Kittiwake, and Common Murre, with the Laysan and Black-footed albatrosses, Glaucous-winged Gull, and Kittlitz's Murrelet forming a small but regular part of the avifauna.

Regular Species

Fourteen species constitute the core of the wintering avifauna, forming 93% of all wintering birds. Most occur all winter, although some (e.g., Sooty Shearwater, Red Phalarope, Tufted and Horned puffins) are absent during one or more of the months. Several other species were present all winter but clearly were more abundant during some seasons (usually October, April, and/or May). For example, some species, such as the Tufted Puffin, move off the shelf to winter in the deep North Pacific, returning to the shelf again only in April and May. Most Black-legged Kittiwakes also leave the northern gulf to winter farther out at sea and down the western coast of North America, although they return in numbers in March, earlier than the puffins; consequently, they were detected continuously during these surveys and were present in low numbers all winter. Only a few species were present in substantial numbers during most or all of the winter: the Common Murre, Northern Fulmar, and Glaucous-winged Gull.

My work suggests that the shelf of the northern Gulf of Alaska is an important wintering area for Kittlitz's Murrelet, as suspected previously (Day et al. 1999). This species clearly wintered in numbers over the open shelf of the gulf and secondarily in Prince William Sound. Given the substantial area of continental shelf in the study area and the mean densities recorded in this study, it is probable that several thousand winter here.

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Rare Species

These 44 species fell into several categories. Some winter in the Gulf of Alaska, sometimes in numbers, but only within protected bays or in coastal waters; the seaducks and cormorants are prominent members of this group. Some winter elsewhere and pass through the northern gulf only in fall and/or spring. Numerous species, such as the Red-necked Phalarope and Sabine's Gull, fall into this category. Some species winter in the gulf but are generally rare everywhere; the Yellow-billed Loon falls into this group. Finally, a few species are accidental to casual, with few or no further records predicted; the Buller's and Little shearwaters and Black-headed Gull constituted this group. My observation of the Little Shearwater constitutes the second sight record of that species for Alaska. Both shearwaters' occurring during the strong El Niño of 1997 suggests a northward movement with the unusually warm water found in the Gulf of Alaska that fall. In addition, a leatherback sea turtle (*Dermochelys coriacea*) was recorded at Montague Island around the same time (article in Cordova newspaper that fall), suggesting that seabirds were not the only organisms moving north with El Niño.

Some species were surprisingly rare or absent. For example, I did not record the Aleutian Tern (*Sterna aleutica*), which does not migrate along the coast but instead comes inshore from the deep ocean (D. D. Gibson, UAM, pers. comm.). In contrast, the absence of grebes suggests that they migrate so coastally that they were not detected in this study. I also saw surprisingly few migrating Arctic Terns. As indicated above, the dearth of Sabine's Gulls possibly resulted from timing of the sampling rather than from low numbers migrating through the area.

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