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Seabirds of the Chukotka Peninsula, Russia

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ABSTRACT. We conducted seabird surveys along the entire coast of the Chukotka Peninsula (northwestern Siberia, Russia) from 1983 to 1991. We present the first comprehensive descriptions of the distribution and size of Chukotkan seabird colonies. Thirteen species of seabirds were recorded breeding on the peninsula, with an additional 13 migrant or vagrant species. Our estimate that at least 3 300 000 seabirds breed on the Chukotka Peninsula demonstrates the importance of this region to arctic seabird populations. Colony size and species composition may be determined by availability of adequate breeding sites, access to foraging areas, and variable ice conditions.

Key words: Chukotka, Russia, seabirds, marine birds, colony, census, population status

РЕФЕРАТ. Исследования, связанные с изучением распределения и видового состава колоний морских птиц, проводились на побережье Чукотского полуострова в 1983-91 гг. В 1985 г был обследован участок побережья от мыса Сердце-Камень на севере до мыса Беринга - на юге, в 1987 г. - от пос. Сиреники до о. Ратманова. Практически все работы выполнялись с воды, что позволило достаточно полно провести учеты птиц на птичьих базарах. Исследования показали, что на побережье полуострова гнездится тринадцать видов морских птиц и еще тринадцать видов отмечены как мигрирующие или залетные. Общая численность морских птиц, гнездящихся в колониях, оценивается, как минимум, в 3,3 млн. особей, однако она явно занижена из-за трудностей учета скрытогнездящихся видов чистиковых (тупиков, конюг, чистиков и пр.). Численность, видовой состав и распределение колоний морских птиц по побережью полуострова зависит от ряда причин: ледовой обстановки, наличия и структуры береговых обрывов, характера течений, определяющих доступность кормов и расстояния от мест гнездования до мест кормежки. Немаловажную роль в формировании авифауны южного побережья играет Сиреникovская стационарная береговая полынья, поддерживающая самую северную в Пацифике популяцию глупыша и являющаяся местом зимовки ряда видов морских птиц.

Ключевые слова: Чукотка, Россия, морские птицы, колонии, учеты, статус популяций.

RÉSUMÉ. De 1983 à 1991, on a effectué des relevés d'oiseaux marins tout le long du rivage de la péninsule de Tchoukotka (nord-ouest de la Sibérie, en Russie). On présente les premières descriptions exhaustives de la distribution et de la taille des colonies d'oiseaux marins de la Tchoukotka. On a relevé 13 espèces d'oiseaux marins nichant sur la péninsule, et, en plus, 13 espèces d'oiseaux en migration ou errants. Notre estimation d'une population nicheuse d'au moins 3 300 000 oiseaux marins dans la péninsule de Tchoukotka illustre l'importance de la région pour les populations d'oiseaux marins de l'Arctique. La taille des colonies et la composition des espèces pourraient être déterminées par la disponibilité de sites adéquats pour les nids, l'accès à des zones d'alimentation, et la variabilité des conditions de la glace.

Mots clés: Tchoukotka, Russie, oiseaux de mer, oiseaux marins, colonie, recensement, statut de la population

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INTRODUCTION

The coastlines bordering the Bering Sea support globally significant breeding populations of seabirds (Sowls et al., 1978; Belopol'skii and Shuntov, 1980; Kondratyev, 1991). The eastern populations, in northwestern North America, have been well studied: most seabird colonies have been censused at least once in modern times (Sowls et al., 1978; Vermeer et al., 1993). However, the western coastline of the Bering Sea has been relatively poorly studied (Litvinenko, 1986, 1987).

The Chukotka Peninsula, the easternmost point of Asia, is no exception, as evidenced by the paucity of data available on Chukotkan seabird colonies. Portenko's studies (1972, 1973) in the 1930s were the first major contribution to our knowledge of the avifauna of the Chukotka Peninsula, but seabirds were only a small part of Portenko's work, and surveys along the coastline were limited.

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Similarly, other investigators (Golovkin and Flint, 1975; Tomkovich and Sorokin, 1983; Bogoslovskaya et al., 1988) examined seabird colonies only on small sections of the Chukotka Peninsula coast. Velizhanin (1978) compiled data from existing sources, but added no new information. Seabird colonies described by Kondratyev (1986) and Korovin (1987) were located northwest of the Chukotka Peninsula.

In this paper, we describe for the first time the distribution and size of seabird colonies along the entire Chukotka Peninsula coast, from Cape Serdtse-Kamen in the north to Cape Bering in the south. We also report the presence of seabird species that may not breed on the peninsula, but do use its coastline as a migratory route. Included are new data on poorly documented and globally or regionally rare species. Finally, we identify three factors that may be the principal determinants of the distribution and species composition of Chukotkan seabird colonies. These data should be useful in assessing regional ecological changes as well as the impact of future development, as the Chukotka Peninsula and its surrounding seas may become targeted for increased activity by resource extraction industries.

STUDY AREA AND METHODS

The Chukotka Peninsula is generally mountainous, particularly in the south. The climate of coastal areas is moderated by surrounding seas. In summer, the mean air temperature near the southern coast is between 4˚and 13˚C, and winter temperatures rarely fall below -15˚C. Inland parts of the peninsula experience temperature extremes about 10˚C higher in summer and 10˚C lower in winter than the coast. Snowmelt and river breakup on the southern coast occur in mid-May. Maritime tundra becomes free of snow during the first half of June.

The Bering Sea is shallow in its northern half, less than 50 m deep within 10–15 km of shore. This shallow area provides extensive foraging habitat for seabirds. The main current flows from the Pacific to the Arctic Ocean. Along the southern coast of the peninsula, the Anadyr current runs from west to east (Coachman et al., 1975). Besides this major current, there are opposite nearshore currents, irregular in time and space, along the southern coast and along the northern and eastern parts of the coast at least from Cape Serdtse-Kamen to Lavrentiya Bay (Fig. 1).

The predominant winter winds are northerly and serve to drive ice floes out to sea, preventing the formation of landfast ice. These winds, in combination with the southern current, create a recurring shore polynya near Sireniki village (hereafter called Sireniki polynya), which extends along the coast from ca. Cape Bering to the mouth of Provideniya Bay. This polynya greatly influences the seabird fauna of the southern coastal area.

Colonies and seabirds at sea were censused by Konyukhov, Bogoslovskaya, and Zvonov in 1985 from 2 August to 3 September, and in 1987 from 6 to 17 August. All observations were made within 20 km of the peninsula

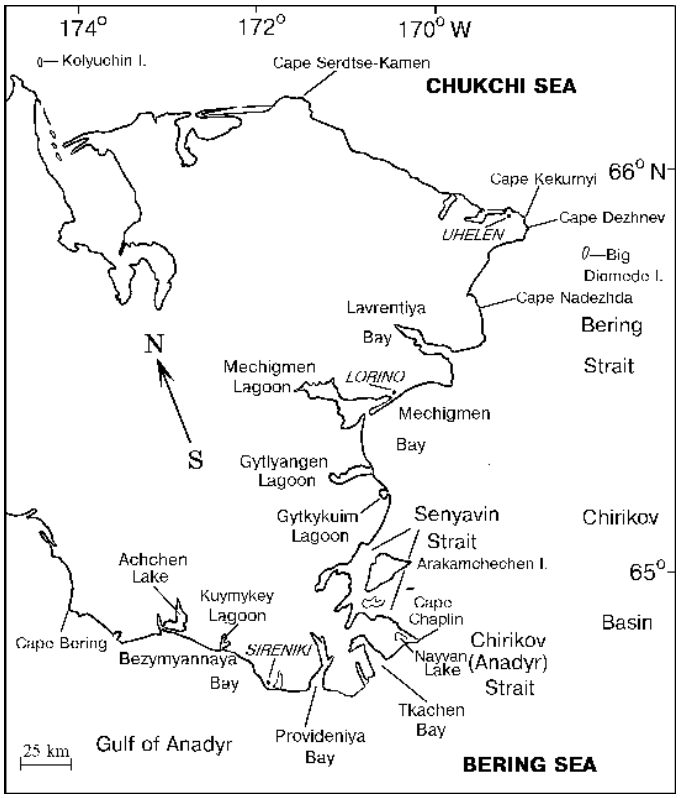

FIG. 1. Map of the Chukotka Peninsula with locations of sites mentioned in the text.

coastline, which allowed us to observe both colonies and seabirds at sea. Occasional observations were made from the motor vessels *Zvyozdnyi*, *Vega*, and *Inzhener Kazandzhi*. However, the majority of our at-sea surveys were conducted using *anyapiks*, traditional Yupik skin-covered boats. In 1985, we sailed by *anyapik* along the coast from Cape Bering to Cape Serdtse-Kamen and back, and in 1987 we sailed from Sireniki village north through Puutyn Bay to Big Diomede Island and back to Sireniki. In addition, Konyukhov made supplemental surveys of seabirds irregularly from 1983 to 1991, both at sea and at selected colonies along the southern coast. These surveys took place between late March and mid-October while Konyukhov worked with walrus hunters from Sireniki village. Much preliminary information on seabird distribution, abundance, and phenology obtained from the Native people of that village helped us to plan later surveys. Because we spent the most time working along the southern coast of the peninsula, the majority of the information presented on arrival and migration of Chukotkan seabirds relates to that area.

In late winter 1988–89, Konyukhov studied seabirds wintering in the Sireniki polynya, an important site for wintering seabirds, and conducted seabird surveys from Cape Yagnochymlo to Cape Lysaya Golova.

Bird counts were carried out according to methods used previously in similar investigations (Belopol'skii, 1952; Bédard, 1969a; Nettleship, 1976; Birkhead and Nettleship, 1980; Byrd et al., 1983; Kondratyev et al., 1992; Zubakin

et al., 1992; Zubakin and Zubakina, 1992). Surface nesters (murres, gulls, etc.) were counted directly. Crevice-nesting species (puffins, guillemots, auklets) were more difficult to count. In locations where high concentrations of pigeon guillemots and puffins were found, they were counted directly during morning surveys, when birds were present at colonies. If a surveyed cliff face was sporadically populated by crevice-nesting species, we concluded that they were breeding at that location, but we present no estimation of population size (marked as "+" in Table 1). If we observed birds of a crevice-nesting species in the water near a colony (especially during the second half of the day, when most birds depart their colonies), we decided they were possible breeders at a colony (marked as "?" in Table 1). Crested and least auklets were counted during their morning or evening activity periods at colonies. We counted birds both on the colony surface and flying over the colony.

Since seabird presence at colonies depends on species-specific rhythms, weather conditions, and other factors (Nettleship, 1976; Birkhead and Nettleship, 1980; Kondratyev et al., 1992), counts carried out only once or twice always underestimate real population size. Therefore, in Table 1 we present only maximum population counts. However, seabirds at colonies from Cape Yakun to Cape Lesovskiy were censused several times in different years, so the population size estimates presented for that region are relatively accurate.

Population sizes for crevice-nesting species tend to be especially underestimated. By comparing boat survey colony counts to later, repeated counts made at the colony, we determined that population sizes of parakeet auklets and pigeon guillemots based on single counts were underestimated by a factor of ca. three, and those of horned and tufted puffins by ca. four. We used these extrapolations in the population size estimates presented in our results.

For ease of discussion, we divided the surveyed coastline of the Chukotka Peninsula into three sections: the south coast, from Cape Bering to Cape Chaplin; the east coast, from Cape Chaplin to Cape Dezhnev; and the north coast, from Cape Dezhnev to Cape Serdtse-Kamen. Major geographical features and locations of seabird colonies mentioned in the text are shown in Figures 1 and 2, respectively. In figures and tables, we used the following abbreviations of common names for bird species: NOFU (northern fulmar); PECO (pelagic cormorant); GLGU (glaucous gull); HERG (herring gull); BLKI (black-legged kittiwake); TBMU (thick-billed murre); COMU (common murre); PIGU (pigeon guillemot); KIMU (Kittlitz's murrelet); CRAU (crested auklet); LEAU (least auklet); PAAU (parakeet auklet); HOPU (horned puffin); and TUPU (tufted puffin).

RESULTS

A total of 26 seabird species were recorded on the Chukotka Peninsula, comprising 13 breeding species and 13 migrant or vagrant species. Detailed accounts for each species follow. Unless otherwise specified, population sizes given here include both breeding and nonbreeding birds. See Table 1 for breeding population estimates.

Annotated List of Birds

Northern Fulmar *Fulmarus glacialis*: This species breeds only on the south coast of the peninsula (Fig. 3; Bogoslovskaya and Konyukhov, 1986; Konyukhov, 1986; Bogoslovskaya and Konyukhov, 1988). The fulmar is the first seabird to return to colonies in the spring. Actual time of arrival varies from year to year depending on local ice conditions, but most fulmars usually appear during the first half of April. In 1989, they were present on 31 March. Immediately after arrival, fulmars are inconsistent in their colony attendance and will commonly leave the colony if ice forms or weather conditions deteriorate (Hatch, 1989).

Fulmars nested both on cliff-face ledges and on nearly flat tops of *kekurs* (isolated sea stacks), as well as on intermediate slopes. The width of ledges used for breeding sites appeared to influence nesting distribution, whereas the degree of grass cover seemed unimportant. Fulmars were observed breeding on cliffs anywhere from a few metres above sea level to the tops of high cliffs (200–300 m).

Egg laying normally began in early June, and chick fledging occurred between late September and early October. Fulmar chicks depart the colony by tumbling off the nest site and fluttering onto the sea below, a behaviour similar to that of murre (*Uria* sp.) fledglings. We observed some fulmar fledglings swimming in a southerly direction, but we do not know whether that behaviour is part of a general pattern.

Short-tailed Shearwater *Puffinus tenuirostris*: This species has been observed annually on the nearshore waters of the southern and eastern parts of the coast (Bogoslovskaya and Konyukhov, 1988). Birds were usually at least 1 km offshore, moving in narrow (100–200 m) flocks during migration. Flocks were sometimes so large that their numbers were difficult to estimate: one aggregation of short-tailed shearwaters near the Chukotka Peninsula measured 74 × 30 km (Bogoslovskaya and Konyukhov, 1988), and other flocks were longer than 100 km. We observed unbroken flocks of birds flying past for several days at a time, from dawn until dusk. Occasionally, two such flocks flew parallel to each other. We cannot say whether shearwaters migrated at night or not.

Shearwater migration at sea off the Chukotka Peninsula normally began in late July and continued until early September. All of the birds observed flew eastward along the south coast and northward along the east coast (i.e., from the Bering Sea to the Chukchi Sea). We observed no birds flying in the opposite direction.

Pelagic Cormorant *Phalacrocorax pelagicus*: Breeding pelagic cormorants are more or less evenly distributed along the Chukotka coastline (Fig. 4), but comprise only 0.57% of the total number of seabirds. Chukotkan pelagic

TABLE 1. Species and numbers of seabirds at colonies on the coast of the Chukotka Peninsula, Russia (in thousands of individuals). Numbers preceding colony names refer to Figure 2. Refer to text for the key to species abbreviations.

Colony name and location	NOFU	PECO	GLGU	HERG	BLKI	TBMU & COMU	PIGU	CRAU & LEAU	PAAU	HOPU	TUPU	Total
1 C. Bering (65°00′N 175°54′W)[1]	-	0.15	0.1	-	0.5	1.0	0.3	-	+	+	+	2.05
2 C. Enmelen (64°57′N 175°48′W)[1]	6.0	0.05	0.1	+	0.25	2.5	0.1	-	+	+	+	9.0
3 C. Matchan (64°55′N 175°39′W)[1]	-	-	-	-	0.1	-	+	-	+	0.1	0.1	0.3
4 C. Ukilyun (64°52′N 175°32′W)[1]	-	0.2	+	+	0.5	0.2	0.2	-	+	0.5	3.5	5.1
5 C. Kekilin (64°50′N 175°29′W)[1]	0.8	1.5	+	+	8.0	12.0	0.1	50.0	+	3.0	8.0	83.4
6 C. Chypatyn (64°48′N 175°28′W)[2]	1.4	0.04	+	+	0.15	0.45	0.07	-	+	0.8	1.2	4.11
7 C. Achchen (64°47′N 175°26′W) [2]	1.0	0.1	+	+	0.11	-	0.11	-	+	0.15	0.6	2.07
8 C. Tkeyutun (64°47′N 175°20′W)[2]	0.2	0.003	0.011	?	0.02	-	+	-	+	0.01	0.04	0.284
9 C. Chenlin (64°46′N 175°12′W)[2]	1.4	0.05	0.017	-	0.05	0.05	0.07	-	0.3	0.03	0.02	1.987
10 C. Skalistyi (64°46′N 175°03′W)[2]	0.3	0.01	+	-	1.5	3.7	+	-	+	+	+	5.51
11 C. Galgan (64°46′N 174°59′W)[2]	2.0	0.02	0.007	-	0.35	0.125	+	-	+	+	+	2.502
12 C. Shpanberg (64°42′N 174°39′W)[2]	-	0.05	0.02	-	-	-	0.06	-	?	0.02	0.01	0.16
13 C. Galgangay (64°38′N 174°22′W)[2]	-	0.2	0.08	-	-	-	0.2	-	+	0.3	0.25	1.03
14 C. Zelyonyi (64°35′N 174°14′W)[2]	-	0.036	0.016	-	-	-	0.02	-	+	0.02	0.025	0.117
15 C. Yagnochymlo (64°28′N 174°03′W)[2]	12.0	0.1	+	+	2.0	4.5	1.2	600.0	0.5	0.6	2.5	623.4
16 C. Yakun (64°25′N 174°00′W)[2]	8.0	-	+	+	0.02	-	0.5	-	1.0	2.0	1.0	12.52
17 C. Ulyakhpen (64°23′N 173°54′W)[4, a]	13.0	0.1	0.3	?	1.0	0.8	2.7	120.0	1.0	2.0	1.0	141.9
18 C. Imtook (64°22′N 17°47′W)[4, a]	3.0	0.15	+	+	0.3	0.3	3.5	30.0	0.3	1.0	2.0	40.55
19 C. Agykhlik (64°21′N 173°42′W)[4, a]	0.4	0.1	+	+	0.25	-	+	-	+	0.01	0.1	0.86
20 C. Stoletiya (64°20′N 173°39′W)[4, a]	30.0	3.0	+	+	4.0	50.0	+	-	+	2.0	2.0	91.0
21 C. Lesovskiy (64°20′N 173°32′W) [a]	2.0	0.05	+	?	0.4	0.3	+	-	+	+	+	2.75
22 C. Lysaya Golova (64°17′N 173°22′W) [a]	-	0.05	-	-	-	-	+	100.0	+	+	+	100.05
23 C. Chukotskiy (64°05′N 173°07′W) [12, a]	-	0.5	0.005	-	0.08	-	+	-	0.1	+	+	0.685
24 C. Skobelev (64°24′N 173°44′W)[5]	-	0.13	0.01	-	0.4	-	+	-	?	+	+	0.54
25 C. Sivolkut (64°23′N 172°36′W) [5, a]	-	0.01	+	-	0.1	-	+	-	?	-	-	0.11
26 C. Mertens (64°33′N 172°25′W) [5, a]	-	0.7	0.05	0.02	0.1	0.3	0.15	-	-	0.02	0.01	1.35
27 Nuneangan I. (64°37′N 172°21′W)[2]	-	2.8	0.2	0.1	4.5	27.0	0.2	-	-	0.05	0.1	34.95
(28–32 on Yttygran I.)												
28 C. Amago-Melgot (64°37′N 172°27′W)[5]	-	0.1	+	+	0.2	2.5	+	-	-	+	-	2.8
29 C. Skalistyi (64°39′N 172°41′W)[6]	-	0.03	0.015	0.02	0.1	0.5	0.025	-	-	0.01	-	0.7
30 C. Sygrak (64°39′N 172°38′W)[6]	-	0.03	0.02	0.025	-	-	0.1	-	-	0.1	0.02	0.295
31 C. Konovak (64°39′N 172°31′W)[5]	-	0.15	0.01	0.02	0.1	2.0	0.06	-	-	0.77	0.05	3.16
32 C. Navak (64°39′N 172°29′W)[5]	-	0.012	-	-	-	0.1	+	-	-	0.006	0.01	0.128
33 Kynkay I. (64°41′N 172°44′W)[6, a]	-	-	+	+	-	-	0.3	-	-	1.0	0.3	1.6
(34–35 on Arakamchechen I.)												
34 C. Kuguvan (64°50′N 172°23′W)[7]	-	0.036	0.03	0.07	0.32	-	0.01	-	-	0.05	0.01	0.526
35 C. Makoguvan (64°49′N 172°18′W)[7]	-	1.2	0.18	0.09	0.4	6.5	0.1	-	-	0.1	0.1	8.67
36 Achinkinkan I. (64°49′N 172°46′W)[6]	-	0.15	0.028	0.015	0.35	-	0.1	-	-	0.35	0.2	1.193
37 Merkinkan I. (64°50′N 172°49′W)[6]	-	-	0.015	0.015	-	-	0.05	-	-	0.7	0.3	1.08
38 C. Iranki (64°47′N 172°45′W)[6]	-	0.1	0.015	-	0.15	-	+	-	-	+	+	0.265
39 C. Ngeegchen (64°55′N 172.°25′W)[8, b]	-	0.02	0.002	0.025	0.25	0.4	0.04	-	-	?	+	0.737
40 C. Khalyustkin (65°16′N 172°11′W)[9, b]	-	1.5	0.02	0.015	3.0	26.0	0.15	-	-	0.05	0.014	30.749
41 C. Kriguygun (65°28′N 171°03′W)[10, 11, c]	-	0.71	?	?	0.15	-	0.02	-	-	0.02	-	0.9
42 C. Verkhovskiy (65°38′N 171°07′W)[A]	-	0.35	-	-	0.15	-	+	-	-	?	?	0.5
43 Bennett I. (65°45′N 171°18′W)[A]	-	0.05	0.06	0.01	0.05	-	0.002	-	-	0.02	0.006	0.198
44 Balka I. (65°46′N 171°22′W)[A]	-	-	-	-	-	-	0.02	-	-	0.3	0.004	0.324
45 C. Nunyamo (65°36′N 170°36′W)[10, c]	-	0.4	0.002	0.002	-	-	0.01	-	-	+	-	0.414
46 Puutyn Bay (65°52′N 170°30′W)[12]	-	0.07	0.1	0.01	1.2	0.7	0.3	-	-	0.2	0.05	2.63
47 C. Leymin (65°57′N 170°14′W)[12]	-	0.02	0.12	0.015	1.2	7.7	0.6	-	-	0.35	0.15	10.155
48 C. Verblyuzhyi (66°01′N 170°05′W)[12]	-	-	0.05	-	-	-	0.1	-	-	0.05	0.002	0.202
49 Naukan village (Cape Peek) (66°01′N 169°40′W)[11,12]	-	0.15	+	+	2.1	4.5	+	-	-	+	+	6.75
50 Big Diomede I. (65°45′N 169°05′W)[d]	-	0.1	0.1	-	20.0	12.0	3.0	2000.0	10.0	15.0	1.5	2061.7
51 C. Kekurnyi (66°08′N 169°40′W)[12]	-	0.3	0.06	0.012	0.07	0.02	0.07	-	-	0.03	0.005	0.567
52 C. Inchoun (66°18′N 170°20′W)[13]	-	0.05	0.06	0.012	0.1	0.15	0.07	-	-	0.02	0.01	0.472
53 C. Volnistyi (66°25′N 170°50′W)[13]	-	0.07	0.2	0.007	0.25	0.45	0.05	-	-	0.45	0.15	1.627
54 Chegetun River mouth (66°35′N 171°10′W)[14]	-	0.01	0.03	-	-	6.5	+	-	-	+	+	6.54
55 C. Iikugur (66°45′N 171°20′W)[14]	-	0.4	0.05	0.01	1.2	6.0	0.07	-	-	0.07	0.05	7.85
56 C. Serdtse-Kamen (66°55′N 171°40′W)[14]	-	0.02	0.03	-	-	-	?	-	-	0.1	?	0.15
Total	81.5	16.127	2.113	0.493	56.02	179.245	14.727	2900.0	13.2	32.356	25.386	3321.167

" + " = individuals present at the colony, but numbers unknown; " ? " = species probably present at the colony; " - " = species not found at the colony.

Date of counts: (in July 1983) [A]30–31; (in August 1985) [1]31, [2]13, [3]02, [4]12, [5]03, [6]04, [7]05, [8]11, [9]08, [10]09, [11]19, [12]12, [13]13, [14]14; (in August 1987) [a]06, [b]07, [c]10, [d]11–16.

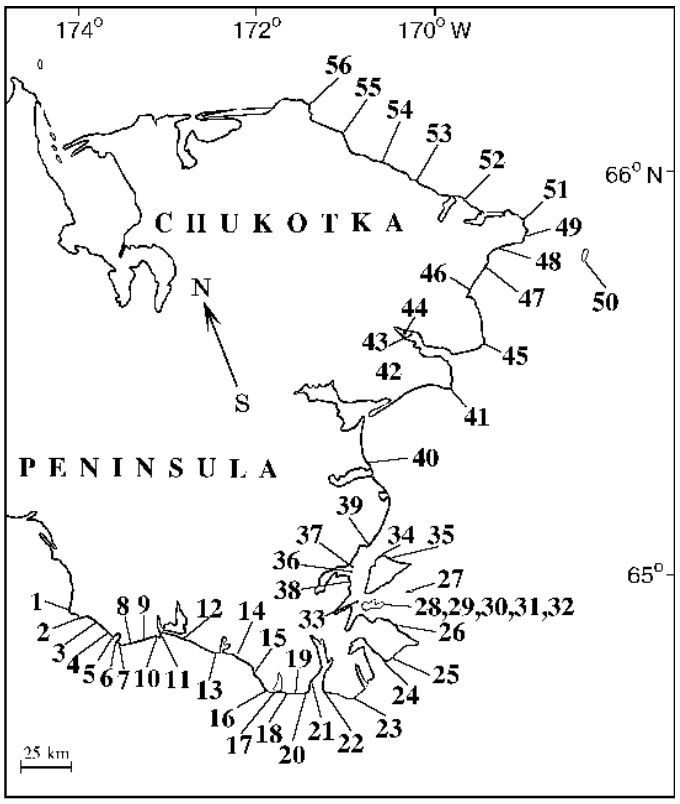

FIG. 2. Location of seabird colonies on the Chukotka Peninsula (see Table 1 for species abundance): 1. Bering, 2. Enmelen, 3. Matchan, 4. Ukilyun, 5. Kekilin, 6. Chypatyn, 7. Achchen, 8. Tkeyutun, 9. Chenlin, 10. Skalistyi, 11. Galgan, 12. Shpanberg, 13. Galgangay, 14. Zelyonyi, 15. Yagnochymlo, 16. Yakun, 17. Ulyakhpen, 18. Imtook, 19. Agykhlik, 20. Stoletiya, 21. Lesovskiy, 22. Lysaya Golova, 23. Chukotskiy, 24. Skobelev, 25. Sivolkut, 26. Mertens, 27. Nuneangan I., 28-32 Yttygran I. (Amago-Melgot, Skalistyi, Sygrak, Konovak, Navak), 33. Kynkai I., 34. Kuguvan, 35. Makoguvan, 36. Achinkinkan I., 37. Merkinkan I., 38. Iranki, 39. Ngeegchen, 40. Khalyustkin, 41. Kriguygun, 42. Verkhovskiy, 43. Bennett I., 44. Balka I., 45. Nunyamo, 46. Puutyn Bay, 47. Leymin, 48. Verblyuzhyi, 49. Naukan village (Cape Peek), 50. Big Diomede I., 51. Kekurnyi, 52. Inchoun, 53. Volnistyi, 54. the Chegetun River mouth, 55. Iikugur, 56. Serdtse-Kamen.

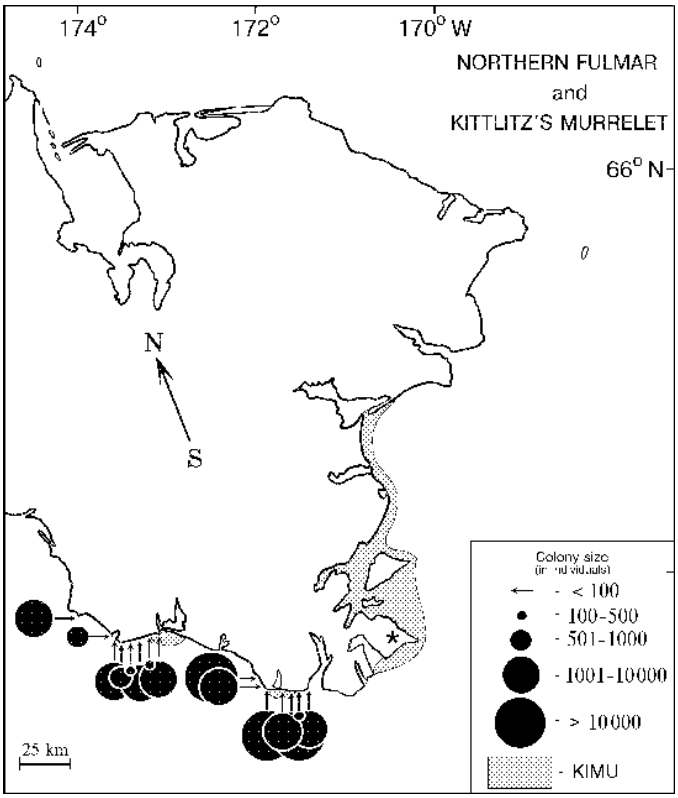

FIG. 3. Distribution and size of Chukotkan northern fulmar colonies, and at-sea distribution (shaded area) of Kittlitz's murrelets (see Table 2; asterisk shows approximate location of the Kittlitz's murrelet nest mentioned in the text).

cormorants are always found in multispecies colonies, usually as a small fraction of the total number of breeding birds in a given colony (Table 1). They are the dominant species only at the Cape Mertens and Cape Kriguygun colonies, as 51.85% and 78.89% of the total, respectively.

Cormorants began to occupy nest sites on cliffs during the second half of April. They need wide cliff ledges to support their relatively large nests, which occur singly and in small groups. In addition to their nesting colonies, pelagic cormorants occupy persistent roosting sites, both on coastal boulders and on snow-covered shorelines, where a few to several dozen individuals may gather. We estimate that about 20 000 individual pelagic cormorants (both breeding and nonbreeding) roost in persistent sites on the Chukotka Peninsula.

This species winters in the Sireniki polynya, where individual birds were consistently observed in nearshore waters.

Pomarine Jaeger *Stercorarius pomarinus*: This jaeger migrates along the Chukotka Peninsula. From mid-May through early June, flocks of up to 44 birds flew eastward along the south coast; dark-phase individuals were common. Totals of 120–150 birds were recorded annually. In late July through August, individual birds were observed flying eastward along the north coast. It is possible that those movements were the beginning of their fall migration.

Parasitic Jaeger *Stercorarius parasiticus*: This species is rare but breeds sporadically in the coastal area of the Chukotka Peninsula. Two adults were observed feeding a chick near Lorino village on 6 August 1983. Birds attacking human observers were recorded on 6 July 1987 at the Kurupkan River delta, Kuymykey Lagoon, but no nest was found.

Long-tailed Jaeger *Stercorarius longicaudus*: Long-tailed jaegers migrate along the peninsula, and vagrants occur occasionally. A weak migration from east to west occurred from late May through early July along the south coast. Vagrant pairs were observed near Cape Khalyustkin, Cape Kriguygun, and on the southern shore of Mechigmen Lagoon in 1984.

The number of migrating jaegers was certainly underestimated. All three species migrated very close to the shore and consequently would have been rarely seen, since we generally worked farther out to sea.

Slaty-backed Gull *Larus schistisagus* and **Glaucous-winged Gull** *Larus glaucescens*: These gull species are both common summer vagrants; small numbers were observed annually in different parts of the peninsula beginning in late June (Tomkovich and Sorokin, 1983; Konyukhov, unpubl. data). Eighty-nine percent (n = 19) of

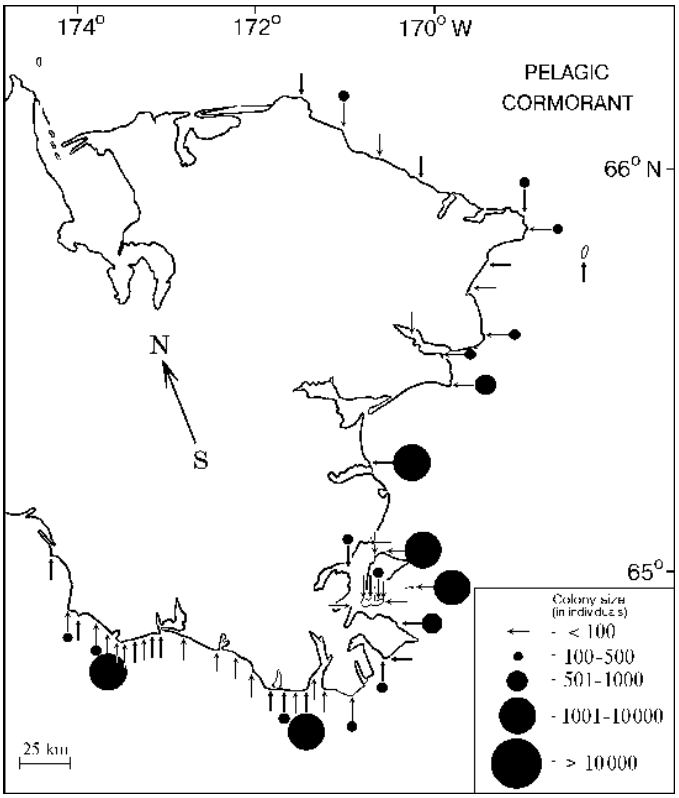

FIG. 4. Distribution and size of colonies of pelagic cormorants on the Chukotka Peninsula.

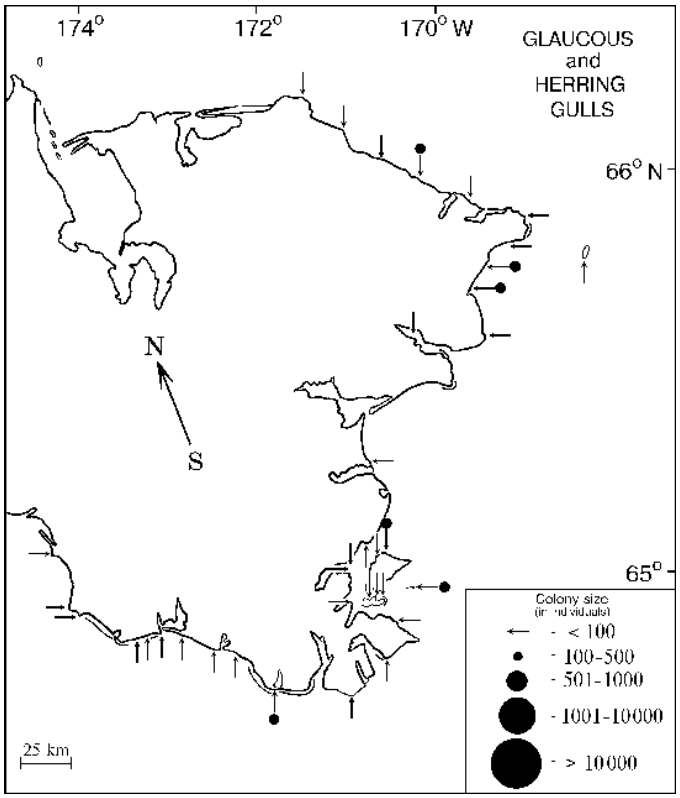

FIG. 5. Distribution and size of colonies of glaucous and herring gulls on the Chukotka Peninsula. (Sparsely populated cliffs are shown by the lines parallel to the coastline.)

the slaty-backed gulls and 84% (n = 51) of the glaucous-winged gulls observed were subadults.

Glaucous Gull *Larus hyperboreus* and **Herring Gull** *Larus argentatus*: The first migrating glaucous gulls arrived in the Sireniki village area in early April and occupied their nest sites soon afterwards. Herring gulls arrived later, usually in mid-April, with a peak around mid-May. Both species usually formed small breeding groups (Fig. 5). Colonies are typically found both on grassy cliff-edge slopes and on the flat tops of *kekurs*. Some pairs nested on wide ledges on shoreline cliff faces.

Glaucous gulls were evenly distributed along the entire Chukotkan coast. Herring gulls were also found on the north and east coasts, but were virtually absent from the south coast (Table 1). On the east coast, herring gulls comprised 30.8% of the total number of nesting *Larus* gulls. This proportion declined to about 8.7% on the north coast. At Big Diomede Island, herring gulls did not breed at all.

Both glaucous and herring gulls tend to congregate in large, mixed flocks near villages. Groups of up to 450 gulls have been observed near Sireniki and Lorino. The species composition depends on the roosting habitat. Near Sireniki, for example, the ratio of herring to glaucous gulls in mixed flocks was 12:1 at a fur farm, whereas it varied between 1:19 and 1:50 at a nearby river delta.

Glaucous gulls winter in the Sireniki polynya. While they are rarely found at sea, winter congregations may occur near villages.

Sabine's Gull *Xema sabini*: This species is very rare during the summer months. Sabine's gulls are believed to winter in the Gulf of Anadyr near the southern peninsula coast (Trukhin and Kosygin, 1987). We observed Sabine's gulls on only two occasions: a single bird near Uhelen village on 26 June 1983, and a second near Cape Chaplin on 22 August 1985.

Black-legged Kittiwake *Rissa tridactyla*: Individual birds began to arrive in the vicinity of colonies on the south coast in late April. Beginning in early May, the bulk of the peninsula's kittiwake population arrived and began to move northward along the east coast. Flock size was normally 20–30 birds, but ranged up to 150 birds. Nests were found all along the surveyed coastline (Fig. 6). Kittiwakes build their nests on tiny projections and narrow ledges on cliff faces. They sometimes compete with thick-billed murres for nest sites. We estimate the total Chukotkan population of black-legged kittiwakes to be about 60 000 individuals.

Ivory Gull *Pagophila eburnea*: This species has only been observed during spring migration along the south coast of the Chukotka Peninsula. Aerial observations have shown that ivory gulls winter in the pack ice of the Gulf of Anadyr and adjacent waters (Trukhin and Kosygin, 1987). Ivory gulls usually first appeared in nearshore waters in early May, although in 1989 the first birds arrived in early April. Intensive spring movements were detected from late May through early June. Only adults were observed during early migration, but by late May both subadults and

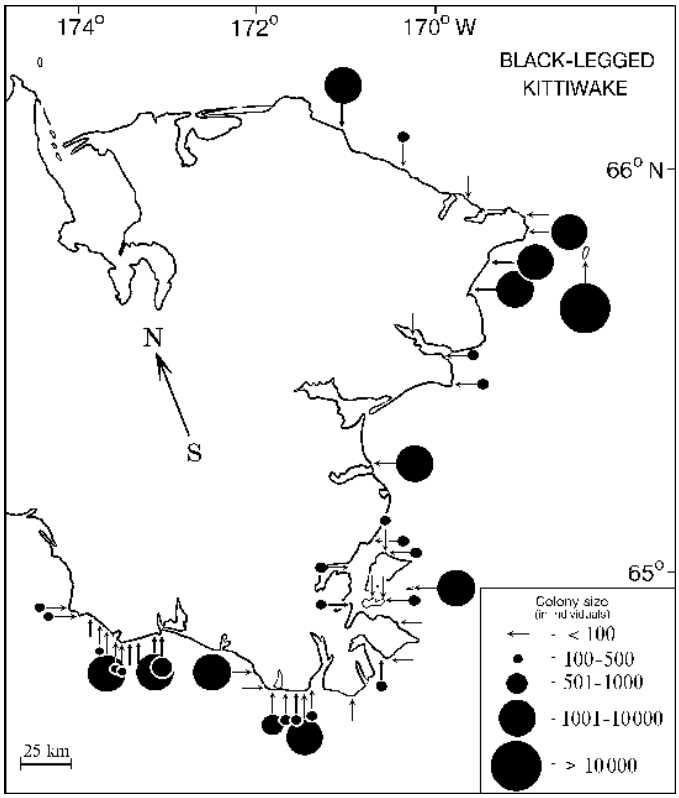

FIG. 6. Distribution and size of colonies of black-legged kittiwakes on the Chukotka Peninsula.

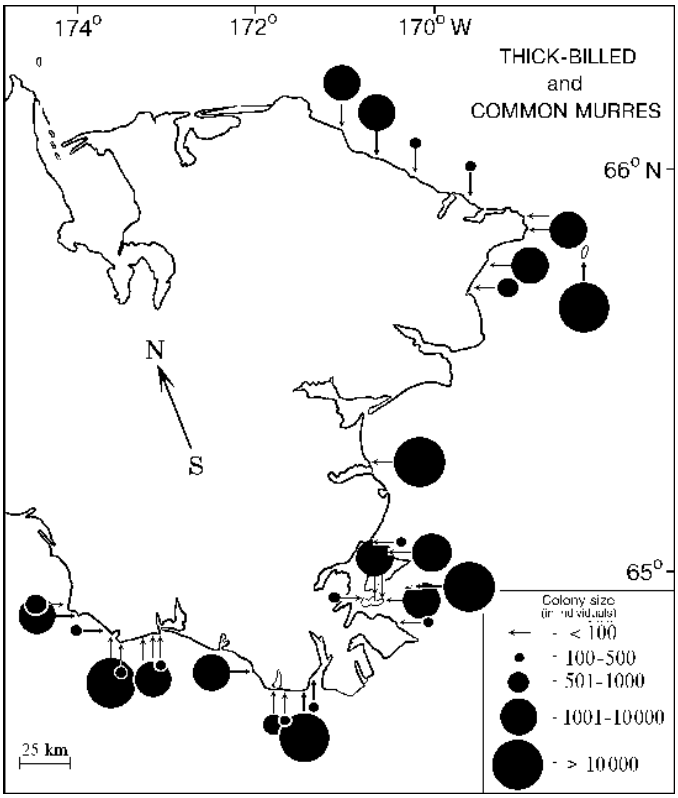

FIG. 7. Distribution and size of colonies of thick-billed and common murres on the Chukotka Peninsula.

adults were present. Individuals and small flocks of 2–4 birds were also observed at sea flying eastward. During migration, gulls formed flocks of up to 53 individuals, which fed near villages on the remains of marine mammals killed by Yupik hunters. An individual subadult was seen near the town of Anadyr on 15 July 1987, suggesting that a small number of individuals may summer in the Gulf of Anadyr.

Arctic Tern ***Sterna paradisaea***: This species breeds sporadically on the peninsula. All birds observed were in the vicinity of freshwater or brackish lakes and lagoons. At least 11 pairs of arctic terns on eggs and/or chicks were recorded in Kuymykey Lagoon between 5 and 11 July 1987. The presence of aggressive adults and suitable nesting habitat indicates that they may also breed near Achchen and Nayvan lakes; near Gytlyangen, Gytkykuim, and Mechigmen lagoons; and at Cape Ngeegchen.

Dovekie *Alle alle*: Dovekies have been observed at several different auklet colonies in the northern Bering Sea (Day et al., 1988). On the Chukotka Peninsula, dovekies were observed at sea near Cape Yagnochymlo on 31 July 1987 and at auklet colonies on Big Diomede Island in July 1985. Small numbers of solitary dovekies were recorded annually (1987–90) at the auklet colony on Cape Ulyakhpen.

Thick-billed Murre *Uria lomvia* and **Common Murre** *Uria aalge*: Breeding murres were recorded all along the coastline surveyed (Fig. 7). We estimate that a total of 200000 to 220000 murres of both species currently populate the Chukotka Peninsula. In mixed colonies, the ratio of common to thick-billed murres depends mainly on the morphology of the cliff face, and it may differ between areas in a single colony or between disjunct colonies. Common murres tend to breed on wide ledges, whereas thick-billed murres use narrower ledges (Birkhead and Nettleship, 1987). At Kolyuchin Island, where murre ecology was studied independent of our surveys, common murres comprised 2–70% of total murres in different parts of the colony, averaging 16.2% over the colony as a whole (Korovin, 1987).

Thick-billed murres winter in the Sireniki polynya and were the only seabird species feeding in the polynya far from shore. Only a few individual thick-billed murres were observed at sea during late winter surveys in 1989, but according to Yupik hunters, murres sometimes move in large flocks and congregate in the nearshore area of the polynya in winter. Common murres arrived at sea near colonies on the south coast in late April. The bulk of the spring migration of both murre species occurs between late April and mid-May. Birds were seen in small flocks (up to 20 individuals) flying eastwards along the coastline.

Black Guillemot *Cepphus grylle*: This species winters and possibly breeds on the Bering Sea coast of the Chukotka Peninsula. Small numbers (1–2 birds per day) were detected in the Sireniki polynya in April and May (Konyukhov, 1990a). Spring migration to nearshore waters occurs in May and early June.

Some black guillemots remained in Chukotkan waters over the entire summer. Individuals were observed at sea near Cape Nadezhda and Cape Nunyamo in August 1987, at Little Diomede Island in early July 1991, and at Cape

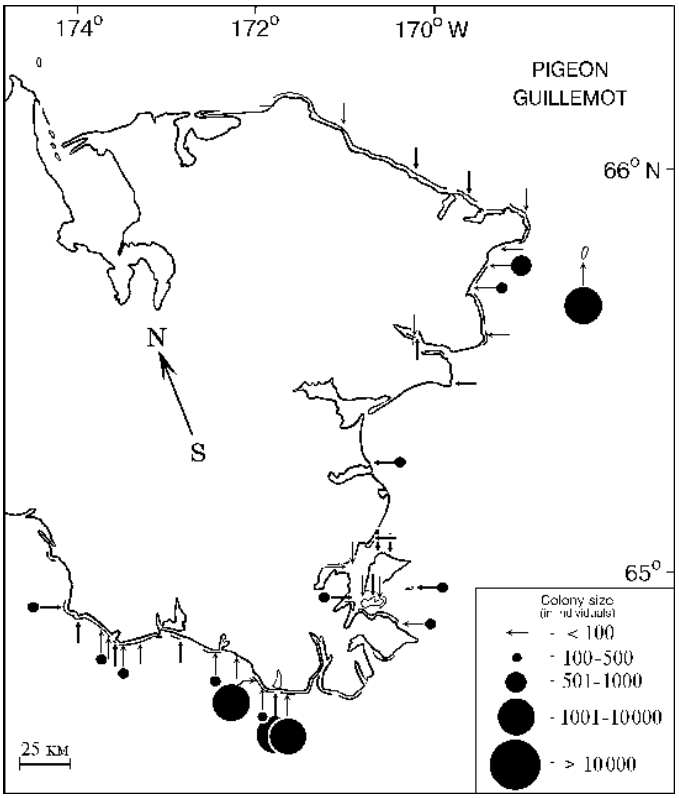

FIG. 8. Distribution and size of colonies of pigeon guillemots on the Chukotka Peninsula. (Sparsely populated cliffs are shown by the lines parallel to the coastline.)

Ulyakhpen each summer between 1988 and 1991. At Cape Ulyakhpen, three black guillemots (including two males) were observed in a pigeon guillemot colony. In each of the four years, one black guillemot male attempted to pair with a pigeon guillemot female (Konyukhov and Ewins, 1992), but all attempts failed, owing to differences in courtship behavior.

Pigeon Guillemot *Cepphus columba*: Pigeon guillemots began to arrive in the vicinity of their colonies near Sireniki village in early April, with most birds arriving in late April. Initially, they congregated at sea near their colonies, usually early in the morning. First landing at the colonies occurred by the second half of May. Following chick fledging (usually in early September), pigeon guillemots departed their colonies and the coastal region (Konyukhov, 1993).

Pigeon guillemots nested all around the peninsula (Fig. 8), using crevices in cliff faces and in talus slopes, from sea level up to heights of 150 m. They reached their highest breeding density in areas of large talus. It is possible that the largest colonies within the species' Asian breeding range occur on the south coast of the Chukotka Peninsula: Capes Yagnochymlo, Ulyakhpen, and Imtook support breeding populations of 1200, 2700–2900, and 3500 birds, respectively. We estimate that a total of 25 000 pigeon guillemots breed on the Chukotka Peninsula.

Kittlitz's Murrelet *Brachyramphus brevirostris*: The non-colonial Kittlitz's murrelet breeds solitarily on inland

TABLE 2. Number of Kittlitz's murrelets recorded on boat surveys off the Chukotka Peninsula in three different years (See Figs. 1 and 2 for corresponding areas).

Location	1985	1987	1991	TOTAL
Mechigmen Bay	2	3	4	9
Khalyustkin Cape -Aracamchechen I.	20	9	64	93
Aracamchechen I.- Cape Chaplin	21	4	7	32
Cape Chaplin -Tkachen Bay mouth	66	11	32	109
TOTAL	109	27	107	243

alpine habitat (Kistchinsky, 1968; Day et al., 1983). Its breeding range in Chukotka is poorly known, but is believed to be concentrated on the southeastern tip of the peninsula, from the mouth of Mechigmen Lagoon south to the mouth of Tkachen Bay (Fig. 1). The highest Kittlitz's murrelet densities were in the easternmost part of the south coast (Table 2, Fig. 3), which is where the only Chukotkan nest of this species has been found (Tomkovich and Sorokin, 1983). One pair and two single birds were seen at sea near Sireniki village on 8 April, 10 May, and 15 May in 1989, respectively (Konyukhov, 1992), and a single bird was also seen in Bezymyannaya Bay on 26 August 1985.

Ancient Murrelet *Synthliboramphus antiquus*: This species is a rare but regular visitor in the northern Bering Sea. A single pair was recorded at sea near Cape Chukotskiy on 2 August 1985. Walrus hunters have observed this species in Senyavin Strait (N. Galgaugye, pers. comm. 1985) and one bird was taken in Provideniya Bay on 31 August 1950 (specimen No. R-79152, Zoological Museum, Moscow University). In addition, ancient murrelets have been seen on the Pribilof Islands (Gabrielson and Lincoln, 1959), St. Lawrence Island (Gabrielson and Lincoln, 1959; Bédard, 1966), the Bering Strait area (Kessel, 1989), and in the central region of the Gulf of Anadyr (Ogi et al., 1985).

Crested Auklet *Aethia cristatella* and **Least Auklet** *Aethia pusilla*: These planktivorous species were first observed at sea beginning around the second half of May. Least auklets usually appeared several days after crested auklets. Both species began to visit their colonies around 24–28 May. Least auklets departed their breeding grounds in late August, although they were observed in Provideniya Bay in early October. Crested auklets remained until mid-September (Konyukhov, 1993).

Both auklet species breed along the south coast of Chukotka and on Big Diomede Island (Fig. 9). The suggestion that *Aethia* auklets breed along the northern coastline of the Chukotka Peninsula (Golovkin and Flint, 1975) was not supported by our survey results: no signs of any auklets were found along the north coast west of Cape Volnistyi. Crested auklets were more numerous at colonies on the mainland, whereas least auklets predominated at Big

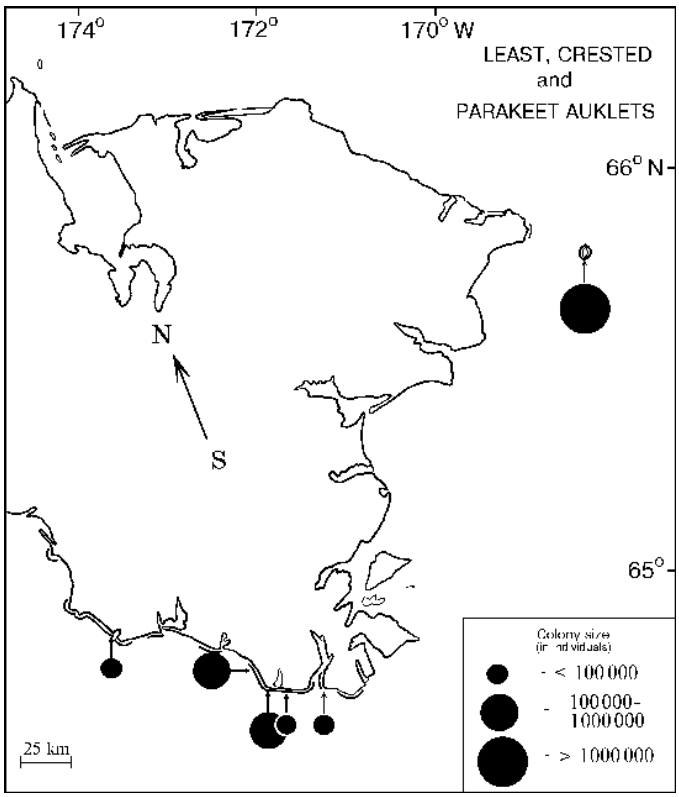

FIG. 9. Distribution and size of colonies of crested and least auklets on the Chukotka Peninsula. Parakeet auklet distribution is shown by the lines parallel to the coastline.

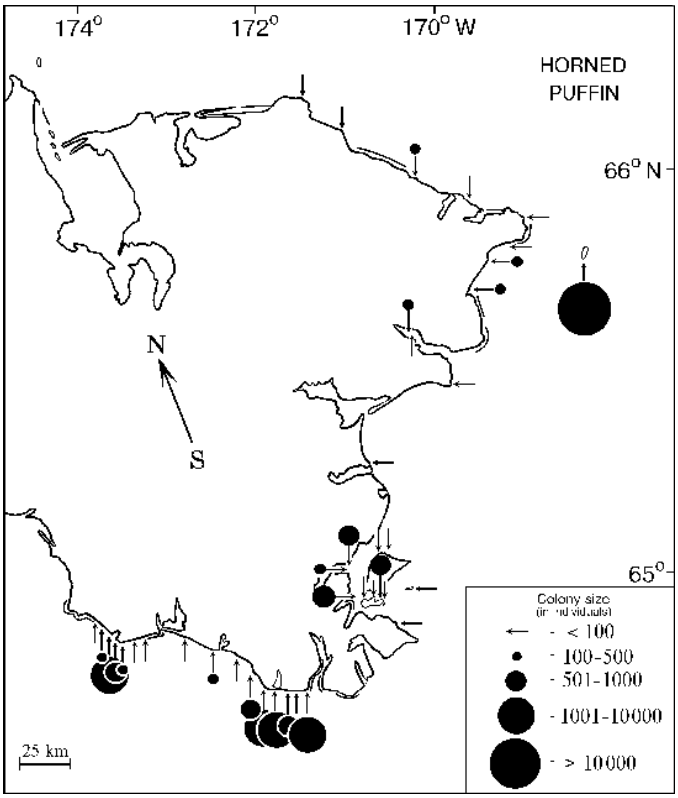

FIG. 10. Distribution and size of colonies of horned puffins on the Chukotka Peninsula. (Sparsely populated cliffs are shown by the lines parallel to the coastline.)

Diomede Island. We estimate the total number of *Aethia* auklets in the study area to be ca. 3.5 million birds.

Parakeet Auklet *Cyclorrhynchus psittacula*: This is the first of the planktivorous auklet species to arrive at its nesting area on the south coast in spring. Parakeet auklets were first detected at sea on 5 May 1989, via their distinctive vocalizations; the majority arrived soon after mid-May. They departed their colonies in late August.

Breeding parakeet auklets were found along the entire southern part of the Chukotka Peninsula, from Cape Bering to Cape Chukotskiy. Along the east coast, they were found only near Cape Dezhnev and at Big Diomede Island (Fig. 9). Parakeet auklets nest in talus hollows and in cliff-face crevices, from just above sea level up to heights of 200 m. Our results indicate that at least 35 000 parakeet auklets breed on the Chukotka Peninsula, of which only about 4000 birds nest in compact aggregations (Table 1).

Rhinoceros Auklet *Cerorhinca monocerata*: Only one adult rhinoceros auklet was identified during our surveys, at the Cape Ulyakhpen pigeon guillemot colony on 11 July 1988. This constitutes the northernmost record for the species (Gabrielson and Lincoln, 1959; Murie, 1959; Sowls et al., 1978; Kessel, 1989; Shibaev, 1990).

Horned Puffin *Fratercula corniculata*: This species was the last of the family Alcidae to arrive at its nesting sites on the south coast. Horned puffins were first observed near the end of May. They nest in cracks and hollows in cliff faces, a habitat type that is more or less evenly distributed along the coast, as shown by the distribution of colonies (Fig. 10). They were also recorded breeding in hollows under boulders at Kynkai, Merkinkan, and Achinkinkan Islands in Senyavin Strait, and Balka Island in Lavrentiya Bay. We estimate the total population of horned puffins breeding on the Chukotka Peninsula to be ca. 45 000 individuals (Table 1).

Tufted Puffins *Fratercula cirrhata*: Tufted puffins began to arrive at their colonies during the second half of May, about one week earlier than horned puffins. The distribution and number of tufted puffins along the coast depends mainly on habitat availability (Fig. 11). Throughout their breeding range, they dig burrows where sufficient soil exists. On the south coast, most birds nested predominantly in burrows, with some in cliff-face crevices and hollows. At the northern limit of their breeding range, they nested mostly in cliff-face crevices, competing with horned puffins for suitable nest sites. Tufted puffins were also found breeding in hollows of large boulder talus at Cape Imtook, and on Kynkai, Merkinkan, and Achinkinkan Islands. We estimate that the total Chukotkan population of tufted puffins is 30 000–35 000 individuals.

DISCUSSION

The total population of seabirds in surveyed colonies was at least 3 300 000 individuals (Table 1). We

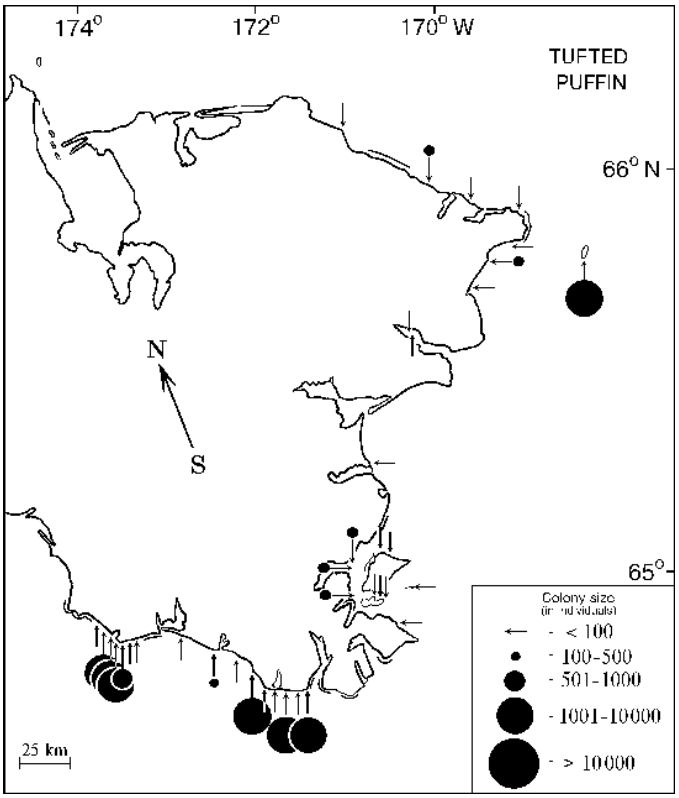

FIG. 11. Distribution and size of colonies of tufted puffins on the Chukotka Peninsula. (Sparsely populated cliffs are shown by the lines parallel to the coastline.)

found the species composition of seabirds breeding on the Chukotka Peninsula to be quite similar to that of the nearby Seward Peninsula, Alaska. Alcids are most numerous on both peninsulas, comprising 90.4% and 97.8% of all seabirds, respectively (Table 1; Sowls et al., 1978). Among the alcids, crested and least auklets are the most abundant. The main difference in marine avifaunas between the two peninsulas is the distribution of northern fulmars, which are absent from the Seward Peninsula, but breed on the south coast of the Chukotka Peninsula, apparently because of its polynya. Northern fulmar colonies have been shown to rely on such polynyas in other regions of the Arctic, e.g., in Franz Josef Land and in northern Greenland (Uspenski, 1972; Falk and Moller, 1997).

Three primary factors likely influence the distribution and species composition of seabird colonies along the coast of the Chukotka Peninsula: available breeding habitat, accessible foraging areas, and ice conditions. Foremost among these is the availability of suitable nest sites. Although the Chukotka Peninsula is generally mountainous, coastal cliffs are concentrated on the south coast. The east coast is mostly flat, and the few coastal cliffs suitable for nesting are all occupied by seabirds. Much of the north coast consists of cliffs, but their overall structure and physical characteristics do not provide the habitats necessary for breeding seabirds.

At all scales, structural habitat characteristics (cliff ledge width, slope, soil accumulation, talus boulder size, etc.) appear to be important determinants of colony species composition. The numerous broad ledges typical at Cape Mertens and Cape Kriguygun probably account for their relatively high pelagic cormorant abundance. Ledge size also appears to influence the small-scale differential distribution of murres on cliff faces; common murres prefer broad ledges or flat island plateaus (Tuck, 1961; Kharitonov, 1980; Birkhead and Nettleship, 1987; Trukhin and Kuzin, 1996). We did not distinguish between the two murre species during counts, but our observations at sea indicated that thick-billed murres were more abundant at Chukotkan colonies, as we would have predicted from the narrow-ledged cliff-face structure characteristic of Chukotkan coasts.

We found that the abundance of tufted puffins on cliffs depended on the amount of soil accumulation. The ratio of tufted to horned puffins sharply decreased from 2.5:1 on the south coast to 0.3:1 on the north coast (Fig. 12), in correspondence with a general northerly decrease in soil accumulation. Absolute numbers of both tufted and horned puffins also tended to decrease with increasing latitude.

The absence of auklets on the east coast may also relate to a lack of suitable breeding areas. Islands in Chirikov Basin and Bering Strait, where such breeding areas (large, grass-free talus slopes) do exist, support huge auklet colonies (Sowls et al., 1978). Kittlitz's murrelet is another species whose distribution may relate to availability of breeding sites. This species is known to breed on vegetation-free alpine talus slopes (Kistchinsky, 1968; Day et al., 1983). On the Chukotka Peninsula, Kittlitz's murrelets were most numerous in waters around the southeastern tip (Table 2), which is also the portion of coast closest to appropriate alpine nesting habitat.

The second major factor influencing Chukotkan seabird colony distribution and composition is the distance between foraging and breeding areas. Each species has a maximum distance beyond which it cannot forage and still breed successfully. The number of least auklets at colonies on the south coast is a case in point. In contrast to the parakeet auklet, least and crested auklets are obligatorily colonial species (Zubakin, 1985). They need large areas of grass-free talus for nesting and require specific oceanographic conditions for effective feeding (Hunt et al., 1993). Owing to these constraints, *Aethia* auklet colonies are unevenly scattered throughout their breeding range. In the northern Bering Sea, suitable conditions for auklet feeding exist along the border between the Anadyr and Bering Shelf water masses in the Chirikov Basin and Bering Strait areas (Piatt and Springer, 1992). These feeding grounds are used by auklets from St. Lawrence, King, and the Diomede Islands (Bédard, 1969b; Hunt and Harrison, 1990; Piatt et al., 1992). Auklets from Chukotkan colonies, except Cape Kekilin birds, also fed in Chirikov (Anadyr) Strait. The relative number of least to crested auklets in Chukotkan auklet colonies decreases as distance increases to foraging areas in Chirikov Strait, from 70% (Cape Lysaya Golova) to 25% (Cape Ulyakhpen) to zero

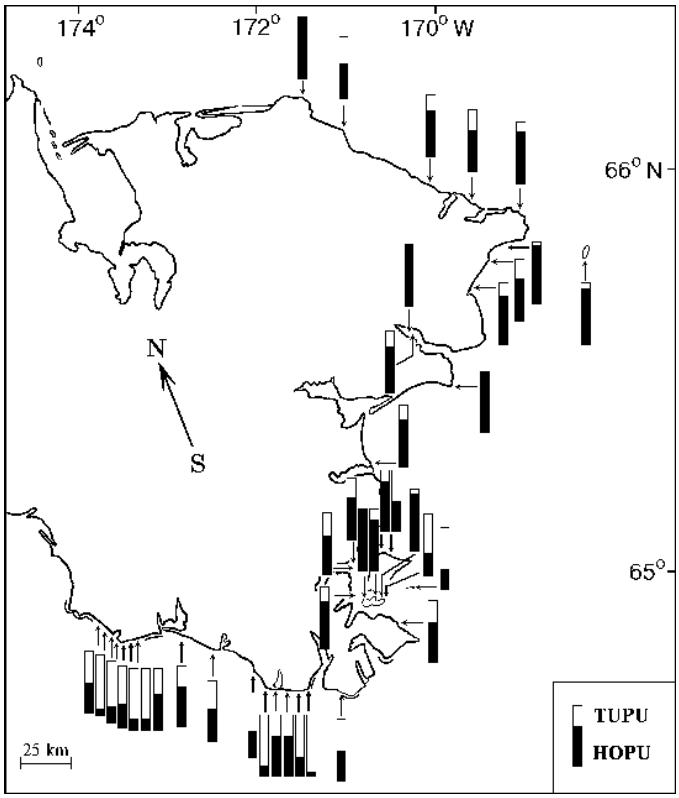

FIG. 12. Relative numbers of horned and tufted puffins in Chukotkan colonies.

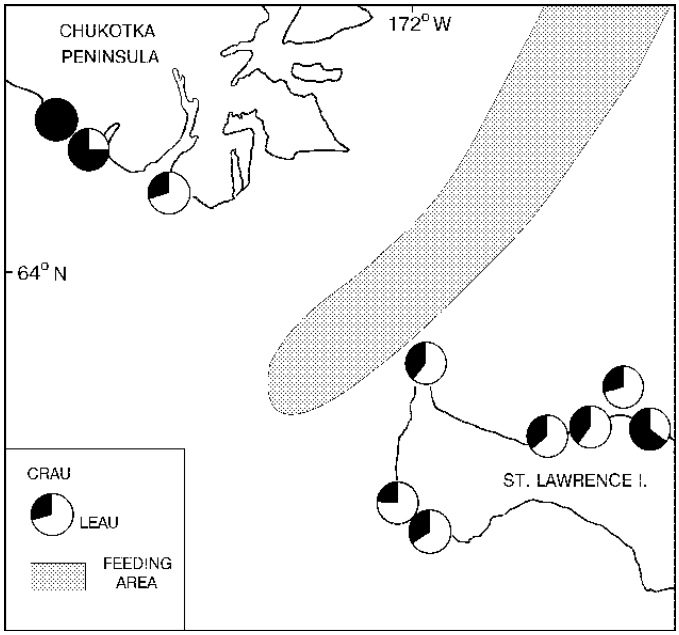

FIG. 13. Relative numbers of least and crested auklets in Chukotkan and St. Lawrence Island colonies. Shaded area represents the approximate range of auklet feeding areas.

(Cape Yagnochymlo; Fig. 13). We observed a similar pattern along the north coast of St. Lawrence Island, where the relative number of least auklets decreased from 60.7% in the west (Sevuokuk Mountain) to 35.1% in the east (Cape Singikpo; Sowls et al., 1978; Fig. 13). We hypothesize that least auklets, because of their smaller size, cannot fly as far as crested auklets to foraging areas. Further studies in the Chirikov Strait area are necessary to test this hypothesis.

Foraging limitations may also explain the marked absence of planktivorous alcids along the Chukchi Sea coastline of the Chukotka Peninsula. The Chukotkan coastline bordering the Chukchi Sea tends sharply northwest, while the plankton-bearing water mass travels due north beyond the Bering Strait. The farther northwest along the coast, the greater the distance between this water mass and possible coastal breeding sites. In addition to plankton abundance, auklet distribution is also controlled by water column stratification. Auklet feeding is facilitated by a highly stratified water column that concentrates their plankton prey. Such structured water is present in the Chirikov and Bering Straits, but disappears downstream (Piatt and Springer, 1992). Nonbreeding birds that have no connection to land may follow this plankton-bearing non-stratified water mass, with a very small number eventually reaching Wrangel Island in the Chukchi Sea and the western Beaufort Sea (Stishov et al., 1985; Johnson and Herter, 1989).

The third major factor is ice conditions, which further affect colony distribution and composition along Chukotkan coasts by constraining seabird foraging. The south coast is unique because of the Sireniki polynya, a consistent oceanographic feature that strongly influences both resident and migrating birds. Like other Arctic polynyas (Brown and Nettleship, 1981; Prach et al., 1981; Falk et al., 1997), it serves as a wintering area for seabirds and marine mammals. Ten species of seabird were found there in winter 1989 (Konyukhov, 1990b). The species composition of wintering birds in the Sireniki and Canadian Arctic polynyas appears to be quite similar, with oldsquaw (*Clangula hyemalis*), common eider (*Somateria mollissima*), king eider (*S. spectabilis*), glaucous gull, black guillemot, and thick-billed murre commonly found in both regions. Unique to the Sireniki polynya were pelagic cormorants, spectacled eiders (*S. fischeri*), and Kittlitz's murrelets. We suspect that ivory gulls also overwinter in the Sireniki polynya. The Sireniki polynya supports the northernmost fulmar colonies in the Pacific Ocean, allowing them to begin their breeding season at the same time as fulmars from lower-latitude colonies (Sudilovskaya, 1951; Fisher, 1952; Shuntov, 1982). In spring, the south coast area is very important for migrating sea ducks and alcids. The relatively high species diversity found in the Sireniki polynya is probably due to its relatively southern latitude.

The north coast becomes ice-free later in the spring than the south coast and, unlike the south coast, it can be closed in summertime by ice floes and patch-ice carried by the coastal current from the East Siberian Sea (Coachman et al., 1975; Andrew and Haney, 1992). Unusually heavy patch-ice during summer can also make unavailable the feeding areas used by seabirds from colonies in the Bering Strait, especially in Lavrentiya Bay, but such ice

conditions are less frequent and more ephemeral than on the north coast.

The presence of auklet colonies on the south coast of the peninsula confirms the importance of the availability of both food and breeding sites in the distribution of these species. Chukotkan auklet colonies are unique because of their mainland position. Three of them—at capes Yagnochymlo, Ulyakhpen, and Lysaya Golova—are easily accessible to terrestrial predators (brown bear *Ursus arctos*, arctic fox *Alopex lagopus*, and red fox *Vulpes vulpes*). In spite of their apparent vulnerability to predation, auklets have historically bred at those colonies, and their contemporary populations are stable or continue to increase at roughly the same rate as the auklet populations on predator-free St. Lawrence Island (Piatt et al., 1990; Konyukhov, 1993).

Among piscivorous seabirds breeding on the Chukotka Peninsula, murres were the most numerous (Fig. 14). Since murres and black-legged kittiwakes, unlike planktivores, do not exhibit water mass preference in Chirikov Basin (Elphick and Hunt, 1993), we think that their populations are most strongly regulated by the availability of breeding sites. Farther north where suitable cliffs are present (e.g., at Capes Thompson and Lisburne in Alaska or on Wrangel and Herald Islands in the Chukchi Sea), they form large colonies (Sowls et al., 1978; Stishov et al., 1991).

Chukotkan pigeon guillemots were extraordinarily numerous (especially on the south coast) relative to other areas in their North Pacific breeding range. Their abundance is probably due to high breeding habitat availability and possibly to abundant food sources that could support such a large population of this nearshore-feeding species.

Because of some unknown combination of external and intrinsic factors, three of the seabird species documented in our surveys appear to be expanding their breeding range. Despite the absence of dovekie breeding records in the northern Bering Sea (Day et al., 1988), we suspect that a small population of Pacific dovekies has formed, with its wintering area somewhere near the Kuril Islands. Such a scenario could explain the occurrence of dovekies at Talan Island, in the Sea of Okhotsk, during the summers of 1987–88 (Kharitonov, 1990). Auklets from North Pacific colonies may have carried dovekies along to their wintering area around the Kuril Islands, where they may have joined auklets from the Sea of Okhotsk, to later accompany them back to Talan Island.

The common murre is currently expanding its breeding range northwest along the Chukotkan coast (Tomkovich and Sorokin, 1983; Kondratyev et al., 1987; Korovin, 1987), but the factors driving this expansion are unclear.

On the basis of their winter presence in North Pacific polynyas, we conclude that black guillemots are attempting to breed in the Pacific. Because of differences in courtship behaviour, mixed pairs of male black and female pigeon guillemots are impossible (Konyukhov, 1993), but hybridization between female black and male pigeon guillemots may occur. It seems possible that black guillemots breed elsewhere in the northern Bering Sea, since they have been observed on St. Lawrence Island (Bédard, 1966) and at King Island and Little Diomede Island (Sowls et al., 1978).

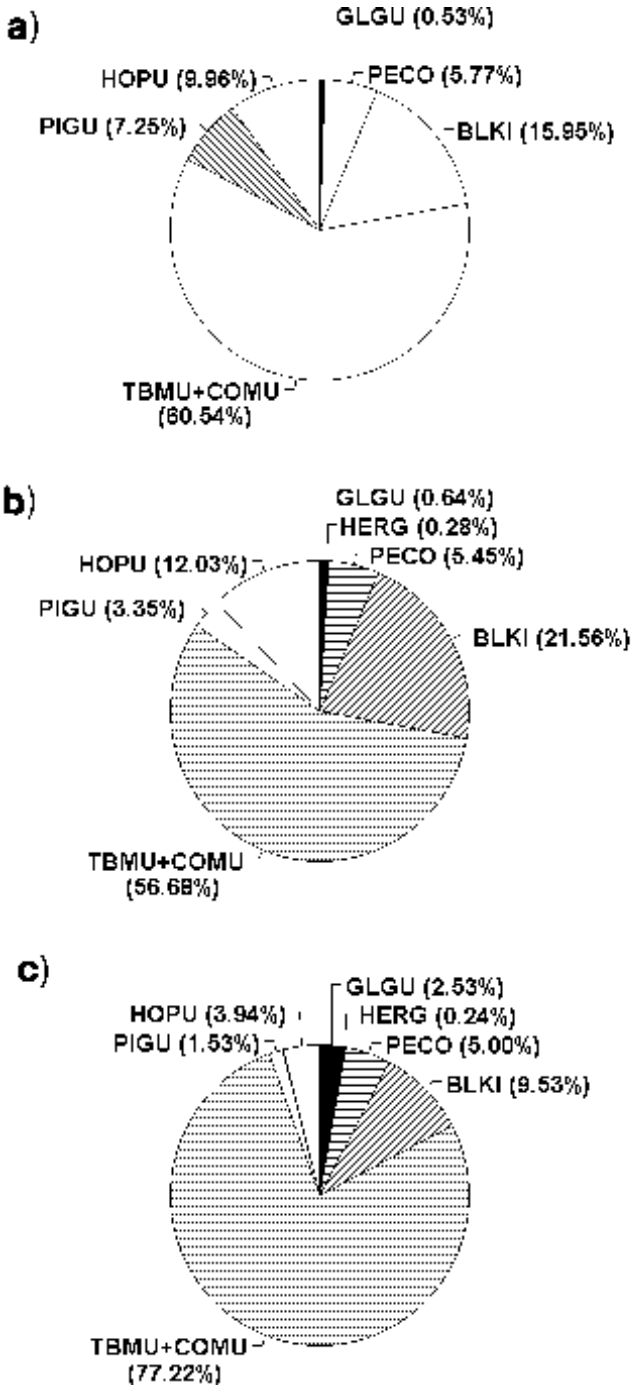

FIG. 14. Relative numbers of piscivorous seabirds breeding at colonies on the south (a), east (b), and north (c) coasts of the Chukotka Peninsula.

CONCLUSION

These data outline our knowledge about the distribution and biology of Chukotkan seabirds. The region's global importance to seabird populations cannot be disputed. To more closely resolve our population estimates, and to assess our hypotheses on the factors limiting population abundance and distribution, more extensive studies of Chukotkan seabird biology and the marine ecology of adjacent waters are necessary. We hope that such studies can be undertaken prior to or in coordination with the eventual regional expansion of oil and gas extraction, mining, commercial fishing, and other resource industries.

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REFERENCES

ANDREW, J.M., and HANEY, J.C. 1992. Water masses and seabird distributions in the southern Chukchi Sea. In: Nagel, P.A., ed. Results of the Third Joint US-USSR Bering & Chukchi Seas Expedition (BERPAC), summer 1988. Washington, D.C.: U.S. Fish and Wildlife Service. 381–388.

BÉDARD, J. 1966. New records of alcids from St. Lawrence Island, Alaska. Condor 68:503–506.

———. 1969a. The nesting of the crested, least and parakeet auklets on St. Lawrence Island, Alaska. Condor 71:386–398.

———. 1969b. Feeding of the least, crested, and parakeet auklets around St. Lawrence Island, Alaska. Canadian Journal of Zoology 47:1025–1050.

BELOPOL'SKII, L.O. 1952. Uchety severnykh morskikh kolonialnykh ptits [Counts of northern colonial seabirds]. In: Metody ucheta chislennosti i geograficheskogo rasprostraneniya pozvonochnykh zhivotnykh. Moscow: Nauka. 304–315.

BELOPOL'SKII, L.O., and SHUNTOV, V.P. 1980. Ptitsy morey i okeanov [Birds of seas and oceans]. Moscow: Nauka. 186 p.

BIRKHEAD, T.R., and NETTLESHIP, D.N. 1980. Census methods for murres, *Uria* species: A unified approach. Canadian Wildlife Service Occasional Paper No. 43. 25 p.

———. 1987. Ecological relationships between common murres, *Uria aalge*, and thick-billed murres, *Uria lomvia*, at the Gannet Islands, Labrador. II. Breeding success and site characteristics. Canadian Journal Zoology 65:1630–1637.

BOGOSLOVSKAYA, L.S., and KONYUKHOV, N.B. 1986. Breeding colonies of fulmar of Anadyr Gulf. 19th Congressus Internationalis Ornithologicus. Ottawa, Ontario: Abstract 633.

———. 1988. Trubkonosye Vostochniy Chukotki [Tubinares of Eastern Chukotka]. Ornitologiya 23:194–197.

BOGOSLOVSKAYA, L.S., ZVONOV, B.M., and KONYUKHOV, N.B. 1988. Kolonii morskikh ptits na vostochnom poberezhye Chukotskogo poluostrova [Seabird colonies of the eastern coast of the Chukotka Peninsula]. In: Izuchenie i okhrana ptits vekosistemakh Severa. Vladivostok: Far East Science Center, Academy of Sciences of the USSR. 24–27.

BROWN, R.G.B., and NETTLESHIP, D.N. 1981. The biological significance of polynyas to arctic colonial seabirds. In: Stirling, I., and Cleator, H., eds. Polynyas in the Canadian Arctic. Canadian Wildlife Service Occasional Paper No. 45. 59–65.

BYRD, G.V., DAY, R.H., and KNUDSON, E.P. 1983. Patterns of colony attendance and censusing of auklets at Buldir Island, Alaska. Condor 85:274–280.

COACHMAN, L.K., AAGAARD, K., and TRIPP, R.B. 1975. Bering Strait: The regional physical oceanography. Seattle: University of Washington Press.

DAY, R.H., OAKLEY, K.L., and BARNARD, D.R. 1983. Nest sites and eggs of Kittlitz's and marbled murrelets. Condor 85:265–274.

DAY, R.H., DEGANGE, A.R., DIVOKY, G.J., and TROY, D.M. 1988. Distribution and subspecies of the dovekie in Alaska. Condor 90:712–714.

ELPHICK, C.S., and HUNT, G.L., Jr. 1993. Variations in the distributions of marine birds with water mass in the northern Bering Sea. Condor 95:33–44.

FALK, K., and MOLLER, S. 1997. Breeding ecology of the fulmar *Fulmarus glacialis* and the kittiwake *Rissa tridactyla* in high-arctic Northeastern Greenland, 1993. Ibis 139: 270–281.

FALK, K., HJORT, C., ANDREASEN, C., CHRISTENSEN, K.D., ELANDER, M., ERICSON, M., KAMPP, K., KRISTENSEN, R.M., MOBJERG, N., MOLLER, S., and WESLAWSKI, J.M. 1997. Seabirds utilizing the Northeast Water polynya. Journal of Marine Systems 10:47–65.

FISHER, J. 1952. The fulmar. London: N.M.N. Collins. 496 p.

GABRIELSON, I.N., and LINCOLN, F.C. 1959. The birds of Alaska. Harrisburg, Pennsylvania: The Stackpole Company. 922 p.

GOLOVKIN, A.N., and FLINT, V.E. 1975. Kolonialnye gnezdovya morskikh ptits v rayone mysa Serdtse-Kamen (Chukotka) [Seabird colonies in the vicinity of Cape Serdtze-Kamen (Chukotka Peninsula)]. In: Kolonialnye gnezdobya okolovodnykh ptits I ikh okhrana. Moscow: Nauka. 171–173.

HATCH, S.A. 1989. Diurnal and seasonal patterns of colony attendance in the northern fulmar, *Fulmarus glacialis*, in Alaska. Canadian Field-Naturalist 103:248–260.

HUNT, G.L., Jr., and HARRISON, N.M. 1990. Foraging habitat and prey taken by least auklets at King Island, Alaska. Marine Ecology Progress Series 65:141–150.

HUNT, G.L., Jr., HARRISON, N.M., and PIATT, J.F. 1993. Foraging ecology as related to the distribution of planktivorous auklets in the Bering Sea. In: Vermeer, K., Broggs, K.T., Morgan, K.H., and Siegel-Causey, D., eds. The status, ecology, and conservation of marine birds of the North Pacific. Special Publication. Ottawa, Ontario: Canadian Wildlife Service. 18–26.

JOHNSON, S.R., and HERTER, D.A. 1989. The birds of the Beaufort Sea. Anchorage, Alaska: BP Exploration (Alaska) Inc. 272 p.

KESSEL, B. 1989. Birds of the Seward Peninsula, Alaska. Fairbanks, Alaska: University of Alaska Press. 330 p.

KHARITONOV, S.P. 1980. Materialy po ptitsam octrova Ajony [Materials on birds of Aion Island]. Ornitologiya 15:10–15.

———. 1990. Lyurik v Okhotskom more [Dovekie (*Alle alle*) in the Sea of Okhotsk] In: Kondratyev, A.Y., ed. Izuchenie morskikh kolonialnykh ptits v SSSR. Magadan: Institute of Biological Problems of the North. 46.

KISTCHINSKY, A.A. 1968. K biologii dlinnoklyuvogo i korotkoklyuvogo pyzhykov [On the biology of the marbled murrelet (*Brachyramphus marmoratus*) and Kittlitz's murrelet (*B. brevirostris*)]. Ornitologiya 9:208–213.

KONDRATYEV, A.Y. 1986. Kolonii morskikh ptits na arkticheskom poberezhe kraynego Severo-Vostoka SSSR [Colonies of seabirds on the Arctic coast of the extreme northeast USSR]. In: Litvinenko, N.M., ed. Morskie ptitsy Dalnego Vostoka. Vladivostok: Far East Science Center, Academy of Sciences of the USSR. 37–47.

———. 1991. Status of the seabirds nesting in northeast USSR. In: Croxall, J.P., ed. Seabird status and conservation: A supplement. Cambridge: International Council for Bird Preservation Technical Publication No. 11. 165–173.

KONDRATYEV, A.Y., KOROVIN, M.M., and BODYAK, N.D. 1987. Chislennost i struktura koloniy morskikh ptits na octrove Kolyuchin (Chukotskoe more) [The number and structure of seabird colonies on Kolyuchin Island (Chukchi Sea)]. In: Litvinenko, N.M., ed. Rasprostranenie i biologiya morskikh ptits Dalnego Vostoka. Vladivostok: Far East Science Center, Academy of Sciences of the USSR. 22–35.

KONDRATYEV, A.Y., ZUBAKIN, V.A., and KHARITONOV, S.P. 1992. Metody otsenki chislennosti massovykh vidov morskikh ptits (*Aethia cristatella*, *A. pusilla*) [Methods for population number estimation of seabird species (*Aethia cristatella*, *A. pusilla*)]. In: Tschernyavsky, F.B., and Kondratyev, A.Y., eds. Pribrezhnye ekosistemy severnogo Okhotomorya. Ostrov Talan. Magadan: Institute of Biological Problems of the North. 137–152.

KONYUKHOV, N.B. 1986. K biologii glupysha v Severnoy Patsyfike [On the biology of the fulmar in northern Pacific]. In: Izuchenie ptits v SSSR, ikh okhrana i ratsyonalnoe ispolzovanie. Leningrad: Nauka. 313–314.

———. 1990a. Chistik (*Cepphus grylle*) na Chukotskom poluostrove [The black guillemot on the Chukotka Peninsula]. In: Kondratyev, A.Y., ed. Izuchenie morskikh kolonialnykh ptits v SSSR. Magadan: Institute of Biological Problems of the North. 25–27.

———. 1990b. Zimovka morskikh ptits na Sirenikovskoy polynye [Wintering seabirds in the Sireniki polynya]. In: Kondratyev, A.Y., ed. Izuchenie morskikh kolonialnykh ptits v SSSR. Magadan: Institute of Biological Problems of the North. 36–39.

———. 1992. Vstrechi korotkoklyuvogo pyzhika v vodakh Vostochnoy Chukotki [Occurrence of the Kittlitz's murrelet in waters of the eastern Chukotka Peninsula]. In: Kondratyev, A.Y., ed. Izuchenie morskikh kolonialnykh ptits v SSSR. Magadan: Institute of Biological Problems of the North. 31–33.

———. 1993. Sravnitelnaya biologiya nekotorykh bidov zakrytognezdyashchikhsya bidov chistikovykh [Comparative biology of some species of crevice-nesting alcids]. Unpubl. Ph.D. thesis, Institute of Evolution, Morphology, and Animal Ecology, Moscow.

KONYUKHOV, N.B., and EWINS, P.J. 1992. Behavior and occurrence of black guillemots *Cepphus grylle* in a colony of pigeon guillemots *C. columba* on the Chukotka Peninsula, USSR. Seabirds 14:27–32.

KOROVIN, M.M. 1987. Sravnitelnaya ekologiya tolstoklyuvoy i tonkoklyuvoy kair na ostrove Kolyuchin [Comparative ecology of thick-billed and common murres at Kolyuchin Island]. Unpubl. M.S. thesis, Moscow University, Moscow.

LITVINENKO, N.M., ed. 1986. Morskie ptitsy Dalnego Vostoka [Seabirds of the Far East]. Vladivostok: Far East Science Center, Academy of Sciences of the USSR. 164 p.

———, ed. 1987. Rasproctranenie i biologiya morskikh ptits Dalnego Vostoka [Distribution and biology of seabirds of the Far East]. Vladivostok: Far East Science Center, Academy of Sciences of the USSR. 96 p.

MURIE, O.J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. North American Fauna. Washington, D.C.: U.S. Fish and Wildlife Service. No. 61.

NETTLESHIP, D.N. 1976. Census techniques for seabirds of arctic and eastern Canada. Canadian Wildlife Service Occasional Paper No. 25. 33 p.

OGI, H., TANAKA, H., and TSUITA, T. 1985. The distribution and feeding ecology of murres in the northwestern Bering Sea. J. Yamashina Institute for Ornithology 17:44–56.

PIATT, J.F., and SPRINGER, A.M. 1992. Physical and biological structure of seabird food webs on the northern Bering and Chukchi Sea shelf. In: Piatt, J.F., Pinchuk, A., Kitaiskiy, A.S., Springer, A.M., and Hatch, S.A. Foraging distribution and feeding ecology of seabirds at the Diomede Islands, Bering Strait. Final Report for Minerals Management Service (OCS Study MMS 92-0041). Anchorage, Alaska: U.S. Fish and Wildlife Service. 77–117.

PIATT, J.F., ROBERTS, B.D., and HATCH, S.A. 1990. Colony attendance and population monitoring of least and crested auklets on St. Lawrence Island, Alaska. Condor 92:97-106.

PIATT, J.F., PINCHUK, A., KITAISKIY, A.M., SPRINGER, A.M., and HATCH, S.A. 1992. Foraging distribution and feeding ecology of seabirds at the Diomede Islands, Bering Strait. Final Report for Minerals Management Service (OCS Study MMS 92-0041). Anchorage, Alaska: U.S. Fish and Wildlife Service. 133 p.

PORTENKO, L.A. 1972. Ptitsy Chukotskogo poluostrova i ostrova Wrangelya [Birds of Chukotka Peninsula and Wrangel Island]. Leningrad: Nauka. 424 p.

———. 1973. Ptitsy Chukotskogo poluostrova i ostrova Wrangelya [Birds of the Chukotka Peninsula and Wrangel Island]. Leningrad: Nauka. 324 p.

PRACH, R.W., BOYD H., and COOCH, F.G. 1981. Polynyas and seaducks. In: Stirling, I., and Cleator, H., eds. Polynyas in the Canadian Arctic. Canadian Wildlife Service Occasional Paper No. 45. 67–69.

SHIBAEV, Y.V. 1990. Tupik-nosorog [rhinoceros auklet]. In: Flint, V.E., and Golovkin, A.N., eds. Ptitsy SSSR. Chistikovye. Moscow: Nauka. 139–148.

SHUNTOV, V.P. 1982. Otryad Trubkonosye [Order Procellariiformes]. In: Ilichev, V.D., and Flint, V.E., eds. Ptitsy SSSR. Istoriya izucheniya. Gagary. Poganki. Trubkonosye. Moscow: Nauka. 357–427.

SOWLS, A.L., HATCH, S.A., and LENSINK, C.J. 1978. Catalog of Alaskan seabird colonies. Washington, D.C.: U.S. Fish and Wildlife Service. 252 p.

STISHOV, M.S., PRIDATKO, V.I., and BARANYUK, V.V. 1985. Novye materialy o ptitsakh ostrova Wrangelya [New data on birds on Wrangel Island]. Bulletin of Moscow Naturalist Society 90:42–48.

———. 1991. Ptitsy ostrova Wrangelya [Birds of Wrangel Island]. Novosibirsk: Nauka. 253 p.

SUDILOVSKAYA, A.M. 1951. Otryad trubkonosye ili burevestniki [Order Tubinares or Procellariformes]. In: Dement'ev, G.P., and Gladkov, N.A., eds. Ptitsy Sovetskogo Soyuza. Moscow: Sovetskaya Nauka. 2. 287–340.

TOMKOVICH, P.S., and SOROKIN, A.G. 1983. Avifauna Vostochnoy Chukotki [The bird fauna of eastern Chukotka]. In: Flint, V.E., and Tomkovich, P.S., eds. Rasprostranenie i sistematika ptits. Moscow: Moscow University Press. 77–159.

TRUKHIN, A.M., and KOSYGIN, G.M. 1987. Raspredelenie morskikh ptits vo ldakh zapadnoy chasti Beringova i Chukotskogo morey [Distribution of seabirds in ice of the western part of the Bering and Chukchi Seas]. In: Litvinenko, N.M., ed. Rasproctranenie i biologiya morskikh ptits Dalnego Vostoka. Vladivostok: Far East Science Center, Academy of Sciences of the USSR. 6–21.

TRUKHIN, A.M., and KUZIN, A.E. 1996. Mnogoletnyaya dinamika vidovogo sostava i chislennosti morskikh ptits, gnezdyashchikhsya na ostrove Tyulenii (Okhotskoe more) [Long-term dynamics of abundance and species composition of seabirds nesting on Tyuleniy Island (Sea of Okhotsk)]. In: Litvinenko, N.M., ed. Ptitsy presnykh vod i morskikh poberezhii yuga Dalnego Vostoka Rossii i ikh okhrana. Vladivostok: Dalnauka. 214–221.

TUCK, L.M. 1961. The murres. Canadian Wildlife Service Monograph Series No. 1. 260 p.

USPENSKI, S.M. 1972. K avifaune Zemli Frantsa Iosifa [On the avifauna of Franz Josef Land]. Ornitologiya 10:123–129.

VELIZHANIN, A.G. 1978. Razmeshchenie i sostoyanie chislennosti koloniy morskikh ptits na Dalnem Bostoke [Distribution and number of seabird colonies in the Far East]. In: Aktualnye voprosy okhrany prirody na Dalnem Vostoke. Vladivostok: Far East Science Center, Academy of Sciences of the USSR. 154–172.

VERMEER, K., BROGGS, K.T., MORGAN, K.H., and SIEGEL-CAUSEY, D., eds. 1993. The status, ecology, and conservation of marine birds of the North Pacific. Special Publication. Ottawa, Ontario: Canadian Wildlife Service.

ZUBAKIN, V.A. 1985. Parallelizmy v razvitii kolonialnosti u ptits [Parallels in bird coloniality development]. In: Zubakin, V.A., ed. Teoreticheskie aspekty kolonialnosti u ptits. Moscow: Nauka. 42–47.

ZUBAKIN, V.A., and ZUBAKINA, E.V. 1992. Ritmika aktivnosti bolshoi konyugi (*Aethia cristatella*) [The activity rhythms of the crested auklet (*Aethia cristatella*)]. In: Tschernyavsky, F.B., and Kondratyev, A.Y., eds. Pribrezhnye ekosistemy cevernogo Okhotomorya. Ostrov Talan. Magadan: Institute of Biological Problems of the North. 165–181.

ZUBAKIN, V.A., KONDRATYEV, A.Y., KHARITONOV, S.P., and KONYUKHOV, N.B. 1992. K metodike ucheta konyug v mestakh ikh gnezdovaniya [On the survey methods of auklets at their breeding colonies]. In: Kondratyev, A.Y., ed. Izuchenie morskikh kolonialnykh ptits v SSSR. Magadan: Institute of Biological Problems of the North. 41–45.