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Did the 1982–1983 El Niño-Southern Oscillation affect seabirds in Alaska?—The causes and effects of the oceanographic and atmospheric phenomena known as El Niño and the Southern Oscillation (ENSO) have been studied intensively in recent years (Cane 1983, Rasmusson and Wallace 1983, Barber and Chavez 1983, Cane and Zebiak 1985). ENSOs occur at semiregular intervals of 3–4 years, and the stronger events have important biological consequences, including reduced breeding success and survival of seabirds in the central and eastern tropical Pacific (Boersma 1978, Barber and Chavez 1983, Schreiber and Schreiber 1984, Duffy 1986). The ENSO event of 1982–1983 was perhaps the strongest of this century (Cane 1983), and there is evidence that seabird populations as far north as the Oregon coast (42–46°N) were adversely affected (Hodder and Graybill 1985, Bayer 1986). Here I examine evidence for similar effects on seabirds along the Alaskan coast.

In 1983 there was widespread breeding failure among some surface-feeding seabirds in the Gulf of Alaska and eastern Bering Sea. The phenomenon seemed to be most pronounced in the Black-legged Kittiwake (*Rissa tridactyla*). Essentially, total breeding failure occurred at four kittiwake colonies visited in the Gulf of Alaska (Fig. 1) (Table 1), and at two colonies in the Bering Sea (Table 2). A few young were raised at a colony in Norton Sound, however, and production appeared to be about average at Cape Lisburne in the Chukchi Sea.

In addition to the observed breeding failure, there was widespread mortality of adult Black-legged Kittiwakes and Short-tailed Shearwaters (*Puffinus tenuirostris*) in Alaskan waters during August and September 1983 (D. R. Nysewander and J. L. Trapp, unpubl. data).

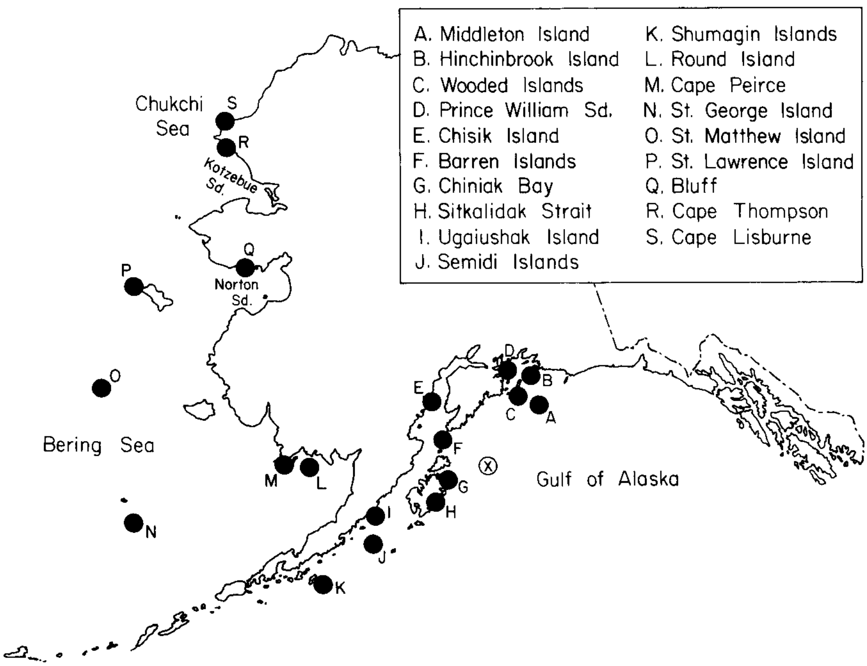

FIG. 1. Locations of Black-legged Kittiwake colonies studied in Alaska between 1976 and 1985. The circled "X" denotes the location in the Gulf of Alaska for which sea surface temperature data are plotted in Figure 2.

TABLE 1
NUMBER OF YOUNG PER PAIR FOR BLACK-LEGGED KITTIWAKES AT COLONIES IN THE GULF OF ALASKA, 1976–1985 (MISSING VALUES INDICATE NO DATA)[a]

Location	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	$\bar{x}$	N
Middleton[b]	—	—	0.14	—	—	≥0.47	0.30	0.03	0.67	0	0.27	6
Hinchinbrook[c]	≤0.03	≤0.51	≤0.04	—	—	—	—	—	0.28	—	0.22	4
Wooded Is.	0.33	0.63	—	—	—	—	—	—	—	—	0.48	2
Prince Wm. Sound[c]	—	—	—	—	—	—	—	—	0.31	0.15	0.23	2
Chisik[d]	—	—	0.01	0.36	—	—	—	0	—	—	0.12	3
Barren Is.[e]	—	0.08	0.14	—	—	—	—	—	—	0	0.07	3
Chiniak Bay[f]	—	1.23	0.61	—	—	—	—	0	0.42	0	0.45	5
Sitkalidak	—	0.74	0.17	—	—	—	—	—	—	—	0.46	2
Ugaiushak	0.07	0.77	—	—	—	—	—	—	—	—	0.42	2
Semidi Is.[g]	0.29	0.62	0	0.36	0.30	1.04	—	0	—	0	0.33	8
Shumagin Is.[h]	0.60	—	—	—	—	—	—	—	—	0	0.30	2
$\bar{x}$	0.26	0.65	0.16	0.36	0.30	0.76	0.30	0.01	0.42	0.03	0.30	
N	5	7	7	2	1	2	1	4	4	6		39

[a] All data for 1976–1978 included in Baird et al. (in press). Other sources as noted below.
[b] P. J. Gould, D. R. Nysewander, B. Roberts (pers. comm.).
[c] D. B. Irons (pers. comm.).
[d] R. D. Jones, M. R. Petersen, G. Mulberg (pers. comm.).
[e] S. A. Hatch (unpubl. data).
[f] L. D. Krasnow, D. R. Nysewander (pers. comm.).
[g] S. A. Hatch (unpubl. data).
[h] E. P. Bailey (pers. comm.).

TABLE 2

NUMBER OF YOUNG PER PAIR FOR BLACK-LEGGED KITTIWAKES AT COLONIES IN THE EASTERN BERING AND CHUKCHI SEAS, 1976–1985 (MISSING VALUES INDICATE NO DATA)

Location	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	$\bar{x}$	N
Round Island[a]	—	—	—	—	—	—	—	—	—	0	0	1
Cape Peirce[b]	0.25	0	—	—	—	0.16	—	—	0.01	0	0.08	5
St. George[c]	0.62	0.45	0.22	0.40	0.38	0.07	0.01	0.01	0.14	0.12	0.24	10
St. Matthew[d]	—	—	—	—	—	—	0	0	—	0.19	0.06	3
St. Lawrence[e]	0	—	—	—	—	0.86	—	—	—	—	0.43	2
Bluff[f]	0.04	0.11	0.82	1.05	0.85	0.91		0.29	0	0	0.45	9
Cape Thompson[g]	0	0.50	0.50	1.10	—	—	1.15	—	—	—	0.65	5
Cape Lisburne[h]	0.14	0.61	0.78	1.70	1.53	1.36	—	0.61	0	0.20	0.77	9
$\bar{x}$	0.18	0.33	0.57	1.06	0.91	0.67	0.39	0.23	0.04	0.09	0.41	
N	6	5	4	4	3	5	3	4	4	6		44

[a] J. Sherburne (pers. comm.).
[b] Lloyd (1985, pers. comm.), M. R. Petersen (pers. comm.).
[c] Hunt et al. (1981), Lloyd (1985), G. V. Byrd (pers. comm.).
[d] Springer et al. (1985a), E. C. Murphy (pers. comm.).
[e] Searing (1977), Springer et al. (1985b).
[f] Drury et al. (1981), E. C. Murphy (pers. comm.).
[g] Springer et al. (1985c).
[h] Springer et al. (1985b), G. V. Byrd (pers. comm.).

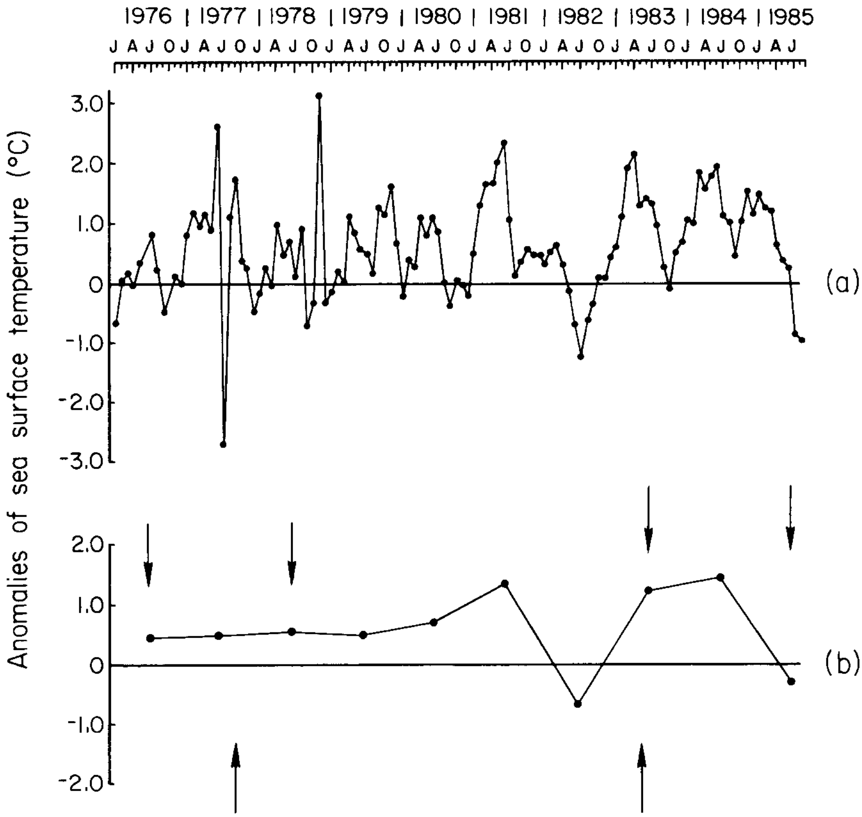

FIG. 2. Sea surface temperatures recorded near Kodiak (58°00'N, 150°00'W) expressed as deviations from the long-term mean: (a) mean monthly deviations, 1976–1985; (b) 4-month mean deviations during the seabird breeding season, May–August. Upper arrows indicate years of widespread breeding failure of kittiwakes in Alaska. Lower arrows show the timing of two major El Niño events in the southern hemisphere. Temperature data for 1976 to 1980 are from the Navy Fleet Numerical Oceanography Center, Monterey, California (courtesy D. R. McLain); data for 1981–1985 are from the Oceanographic Monthly Summary (National Oceanic and Atmospheric Administration, Washington, D.C.).

Large numbers of birds were found dead or dying, apparently from starvation, on beaches from the central Gulf of Alaska to Kotzebue Sound on the northwest coast.

Water temperatures in the Gulf of Alaska were above normal beginning in December 1982 and reached positive anomalies of 2°C or more during the spring and summer of 1983 (Royer and Xiong 1984, Xiong and Royer 1984) (Fig. 2). Niebauer (1980, 1983, 1984) has found significant correlations of air and sea temperatures in the Bering Sea with some large-scale atmospheric fluctuations, including the Southern Oscillation.

When viewed out of context, the above observations suggest an effect of the 1982–1983 ENSO on seabirds in Alaska. The inference, however, must be put in perspective by noting that poor production of kittiwakes has occurred repeatedly in Alaska since at least 1976, with no clear relationship to major ENSO events. Overall, the annual production of kittiwakes in Alaska is low (compared with colonies in the northeastern Atlantic; Coulson and Porter 1985, Coulson and Thomas 1985), and failure of a colony to produce any young in a given year is common. If we define a colony failure as any instance of less than 0.1 young per pair being produced in a colony, there have been 15 such failures (38%) in 39 colony-years of observations in the Gulf of Alaska and 15 (34%) failures in 44 colony-years of study in the Bering and Chukchi Seas (Tables 1 and 2).

Although breeding failure was reported for at least one locality in all years except 1979 and 1980, it was especially prevalent in four years during the last decade: 1976, 1978, 1983, and 1985. Colonies in the Gulf of Alaska and Bering and Chukchi seas were affected in 1976, whereas the 1978 failure was largely confined to the Gulf. The 1983 and 1985 events involved colonies throughout Alaska, although the northernmost colonies seem to have fared somewhat better in both years.

The observation of higher than normal sea surface temperatures in 1983 must also be considered in context. Summer surface temperatures in the Gulf of Alaska have tended to be higher than the climatological mean during the last 10 years, and they were subject to wide annual variation during the last 5 years (Fig. 2B). Near Kodiak, the positive anomalies in 1983 were no greater than during the same periods in 1981 and 1984; years when kittiwake production was relatively good. Furthermore, production was extremely poor in 1985 (possibly worse than in 1983), when water temperatures were slightly cooler than normal. The failures of 1976 and 1978 were not obviously associated with changes in surface conditions, as the 1976–1977 El Niño produced no discernible signal in summer surface temperatures near Kodiak. Thus there has been no consistent relationship of kittiwake productivity to sea surface temperature in the Gulf of Alaska.

The environmental correlates of breeding failure are clearer, perhaps, in the colder seas north of the Alaska Peninsula and Aleutian Islands, but the relationships there are not consistent among areas. For instance, warmer springs in Norton Sound and the Chukchi Sea seem to promote successful breeding (Springer et al. 1985b), whereas colder temperatures favor breeding in the southeastern Bering Sea (Lloyd 1985). The evidence casts much doubt whether any single environmental factor will prove to be a good predictor of seabird breeding success in different years or regions.

Against this background, the widespread breeding failure of kittiwakes in 1983 cannot be taken as strong evidence of El Niño effects in Alaska. More compelling perhaps was the large die-off of adults that occurred in late summer and fall that year. The number of birds involved was not determined, but crude estimates ranged from tens of thousands to hundreds of thousands of dying seabirds (Nysewander and Trapp, pers. comm.). In addition to the two species most affected (Black-legged Kittiwakes, Short-tailed Shearwaters), lesser numbers of Northern Fulmars (*Fulmarus glacialis*), Glaucous-winged Gulls (*Larus glaucescens*), Pelagic Cormorants (*Phalacrocorax pelagicus*), and other species appeared on beaches. All carcasses examined were greatly emaciated, suggesting that starvation was the primary cause of death. The magnitude of summer mortality in 1983 appears to be unprecedented in recent years; A. L. Sowls (pers. comm.) reported that adult kittiwakes were again dying in considerable numbers near St. Matthew Island, Bering Sea, in July 1984.

The marked annual variation of kittiwake productivity and survival in Alaska may result from this species' specialized summer diet (Sanger, in press) and its limitation to surface feeding. The productivity of Northern Fulmars, a more omnivorous surface-feeder, has closely paralleled that of kittiwakes since 1976, but the annual fluctuations tend to be smaller (Hatch 1985). The annual production of diving seabirds, moreover, appears to bear little relationship to that of the surface feeders, despite wide overlap in summer diets. For instance, in both 1983 and 1985, Common Murres (*Uria aalge*), Thick-billed Murres (*U. lomvia*), and puffins (*Fratercula* spp.) had good to excellent breeding success at the Semidi Islands; 1983 was in fact the most productive year for Horned Puffins (*F. corniculata*) of the six years studied since 1976 (Hatch, unpubl. data). Thus, environmental effects on seabird productivity in Alaska appear to differ among species with different foraging styles.

To summarize, the occurrence of widespread adult mortality in summer suggests an effect of ENSO on Alaskan seabirds in 1983. However, an overview of breeding performance in recent years reveals that: (a) some subsurface-foraging seabirds were unaffected during the 1983 event, (b) annual variation in the breeding success of one surface-foraging species has shown no consistent relationship to warm-water anomalies in the Gulf of Alaska, and (c) there may be marked regional differences in the effect of a given set of oceanographic conditions. These points are all in need of further understanding before the question of ENSO effects on high latitude seabirds can be resolved with confidence.

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