Palmer LTER: Seabird research undertaken during 1991-1992 at Palmer Station, Antarctic Peninsula

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The long-term ecological research (LTER) program at Palmer Station proposes to investigate how interannual variability in winter pack ice affects the physical and biological processes that link various trophic levels in the marine environment. To represent upper-trophic-level predators, we selected Adélie penguins (*Pygoscelis adeliae*) and south polar skuas (*Catharacta maccormicki*), two of the area's dominant consumers in terms of both abundances and biomass. Approximately 12,000 pairs of Adélie penguins and 750 pairs of south polar skuas breed on islands within 2.5 kilometers of Palmer Station. These species were also attractive as LTER representative species because of the availability of long-term, comparative data sets. South polar skuas, for example, have been the subject of various studies at Palmer Station since the mid-1970s (Parmelee et al. 1977), while Adélie penguins have been intensively studied in the area since 1987 (Fraser and Ainley 1988) as part of the CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources) Ecosystem Monitoring Program (CEMP). The U.S. component of CEMP, known as AMLR (Antarctic Marine Living Resources), is funded through NOAA (National Oceanic and Atmospheric Administration) and managed by the National Marine Fisheries Service (NMFS). AMLR shares many objectives with the LTER and continued cost-sharing is expected to facilitate long-term data collection on Adélies that will be mutually beneficial to both programs.

Our approach capitalizes on long-term research on a host of ecological variables that in these seabirds are likely to be sensitive indicators of change in the marine system (table 1). This approach is ultimately designed to test the following four hypotheses:

- Winter-over survival and physiological conditions of adult Adélie penguins upon their return to the natal rookery to breed is a function of winter and early spring food availability in the pack ice and of the location of winter pack ice relative to the rookeries (extant of winter pack ice). Adult winter-over survival, physiological condition, and the percent of young birds that attempt to breed will be higher when pack ice extent is greater during winter.
- Breeding success of Adélie penguins, barring the effects of spring snow conditions and catastrophic summer storms, is linked to the extent of sea ice because of its effects on spring and summer food availability. During cold summers, krill (*Euphausia superba*) availability will be higher. As a result, breeding success (chicks creched per pair) and chick fledgling weights will increase, while the duration of foraging trip will decrease.
- Physiological conditions of south polar skuas during the pre-egg stage is a function of the availability of the antarctic silverfish (*Pleuragramma antarcticum*) within the skua spring foraging range. Territory occupancy will be earlier and more constant, and the onset of reproduction earlier when silverfish are more available.
- Breeding success in south polar skuas will exhibit different cycles than those of Adélie penguins. Recruitment in their primary prey, the antarctic silverfish, negatively affected by heavy pack ice during the spring cold years. Because south polar skuas primarily eat subadult silverfish, their breeding success will be a function of ice conditions 8-10 years before the current breeding season.

Although the LTER is in its second year of funding by the National Science Foundation, 1991-1992 was the first year of field

Table 1. Parameters for which data sets are being developed as part of the LTER seabird component. SS and SF refer to 1991-1992 sample sizes (number of breeding pairs) and sampling frequency, respectively. SF is coded as 1) sampled daily; 2) every two days; 3) every three days; 5) every five days; 6) once per season; 7) twice per season; 8) every 20 minutes (automatic data logging devices); 9) opportunistically. ND indicates the parameter was not measured; * before a number indicates the number of independent N used rather than the number of breeding pairs.

Parameter	Adélie Penguins SS	Adélie Penguins SF	South Polar Skuas SS	South Polar Skuas SF
Reproductive biology				
Breeding population size	9,319	6	736	6
Arrival dates/chronology	200	1	55	1
Onset of reproduction	200	1	55	1
Egg weights and volume	50	6	55	3
Ratio of 1:2 chick broods	3,030	7	55	3
Chick growth	50	5	*66	3
Chicks fledged/pair	200	2	55	3
Chicks fledged/colony	*7,072	7	ND	
Chicks fledging weights	*391	2	ND	
Chick fledging chronology	*391	2	*66	3
Breeding colony	200	2	55	3
Foraging ecology				
Adult diet composition	ND	55	9	
Chick diet composition	40	5	*66	9
Prey caloric value	40	5	ND	
Prey characteristics	40	5	55	9
Foraging trip duration	40	8	15	8
Ptylochronology	*20	6		ND
Demographic studies				
Adult overwinter survival	200	1	70	1
Annual cohort survival	*77	2	736	6
Recruitment	*28	2	736	6
Cohort banding	*1,000	6	*66	3

Table 2. Aspects of the ecology of Adélie penguins and south polar skuas during the 1990-1991 and 1991-1992 breeding seasons. ND indicates the parameter was not measured.

	Adélie Penguins 1990-1991	Adélie Penguins 1991-1992	South Polar Skuas 1990-1991	South Polar Skuas 1991-1992
Percent breeding pairs with eggs by 20 Nov. (Adélies) and 20 Dec. (skuas)	61	72	48	30
Chicks fledged/pair	1.00	1.39	1.21	1.22
Percent 2-chick broods	54	70	82	79
Mean foraging trip duration (hrs) during peak chick growth	32.54	14.69	ND	ND
Mean fledging weights (kg)	3.10	3.16	ND	ND

work under this award. As a result, our research activities focused primarily on expanding the scope of our ongoing work on seabirds under the AMLR and other awards to accommodate the hypotheses being tested by our LTER component. These activities included the development of additional study sites, increasing sample sizes and sampling frequency of some parameters to better represent Palmer seabird populations, and adding several research protocols to the suite of data being collected to provide a more comprehensive look at aspects of these species' behavior, demography, foraging ecology, and reproductive biology (table 1).

Our field work began on 13 October 1991 and ended on 7 March 1992. Some preliminary results of this first LTER field season are shown in table 2, which compares aspects of the ecology of Adélie penguins and south polar skuas during summers following cold (1991; heavy sea ice development) and warm (1990; light sea ice development) winters. In contrast to south polar skuas, Adélie breeding success and foraging efficiency improved during the summer season following the 1991 winter. Although heavy ice during the spring after the 1991 winter delayed reproduction in skuas (table 2), breeding success was not affected, indicating the availability of silverfish did not change (cf. Trivelpiece et al. 1990). This would suggest that approximately 8-10 years prior to the 1991 winter, sea-ice conditions were light and favored high silverfish recruitment. That such winter conditions did in fact occur a decade ago has been shown by Fraser et al. (1992), who also discuss how changing sea-ice conditions might influence the biology of Adélie penguins. These very preliminary data thus suggest that our LTER component's hypotheses are both testable and appropriate as a vehicle for guiding our research.

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