Palmer LTER: Seabird picket-line sampling and Zodiac tracking during the January 1995 cruise

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A key objective of the annual January Long-Term Ecological Research (LTER) cruises is to characterize the mesoscale physics, optics, chemistry, and biology (POCB) of Adélie penguin foraging areas during the critical chick-growth period of their reproductive season. During this few-week period, typically in mid to late January, the food/energy demands of the chicks are at their highest, and both adults must forage to supply their chicks with adequate nutrition. It is therefore the period when variability in krill availability is likely to produce the greatest ecological signal in terms of adult foraging strategies, chick growth, fledging weights, and ultimately, cohort survival (Fraser et al. 1988; Fraser and Ainley 1989). Because the foraging range of the Adélie is thought to be as far as 200 kilometers (km), a systematic sampling strategy is required to window this large area efficiently to locate foraging areas for more intensive POCB sampling. Using our experience from previous years, we modified the radial transect sampling strategy used by Hunt, Heinemann, and Iverson (1992) to create a "picket-line" sampling strategy. This picket-line-plus-Zodiac-tracking sampling strategy allowed direct observations of penguin routes and swimming behavior between rookeries and foraging areas. The at-sea abundance and distribution of Adélie penguins were studied during *PD*95-1 (Smith, *Antarctic Journal*, in this issue) in close coordination with penguin observations based on Torgersen and Humble Islands.

The objective of the picket-line seabird census sampling strategy was to determine statistically (i.e., "vector") both direction and distance of Adélie penguins leaving on foraging trips from the Palmer area rookeries. The sampling included three complimentary components: picket-line bird observations, Zodiac observations to vector Adélie foraging areas, and then high-density sampling within identified foraging area (Quetin et al., *Antarctic Journal*, in this issue).

Two types of picket lines were run. The first (figure 1) comprised semicircular tracks centered on Palmer Station at radii of 3.7 km, 10 km, and 30 km. These semicircular tracks were broken into 30° segments, indicated by plusses on figure 1. Seabird observations were made for each individual segment. Ship speed was adjusted, depending on the radius of the picket line, so that a full semicircular track (180°) could be completed in 2 to 3 hours (taking 20 to 30 minutes per individual 30° sectors) and, generally, the lines were repeated the same day to reduce timing bias in our sampling. An effort was made, via communication with observers at the nesting sites, to time picket lines to match the maximum excursion activity of the Adélies from and back to their nesting sites. Adélies sighted within the individual sectors of the picket lines provided statistical evidence to identify preferred directions between the nesting site and foraging areas. Once a preferred direction had been determined, a "multipicket" strategy was used to estimate the foraging range of the Adélies. This seabird observation strategy consisted of rapidly linking a series of short radial arcs, typically one or two 30° sectors, at increasing distances from the rookery (figure 2).

Complementing the semicircular picket-line sampling, Zodiacs equipped with portable global positioning system (GPS) units tracked groups of penguins departing nesting sites on Torgersen and Humble Islands. Swimming speed, heading, behavior, and precise location of various Adélie activities were noted. Figure 3 shows a series of tracks for groups of Adélies leaving Torgersen and Humble, where the dots indicate positions of rafting and diving activity. When swimming, the penguins maintained relatively constant heading and speeds of 5–6 knots whether porpoising or diving. Penguins from the two islands followed two different directions (figure 3); those from Humble headed west, and those from Torgersen followed a heading between Janice and Spume Islands. The direct Zodiac tracking provided independent evidence of the direction between rookery and foraging area and helped to

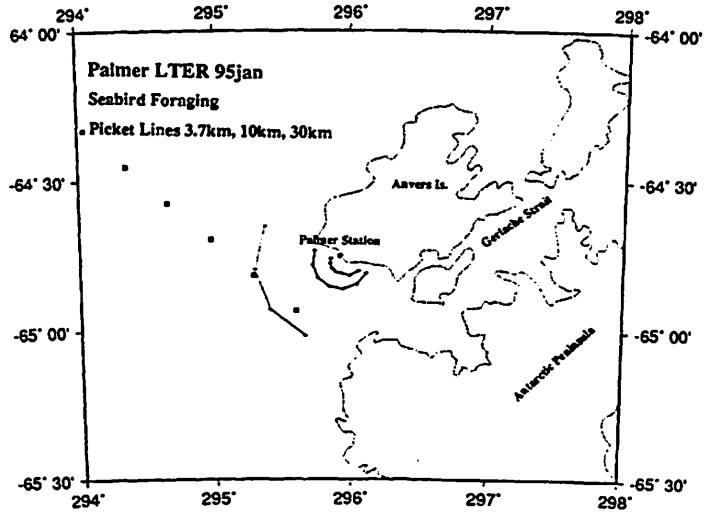

Figure 1. Seabird picket lines at radii of 3.7 km, 10 km, and 30 km centered on the Torgersen and Humble Islands Adélie penguin nesting sites. A plus (+) indicates 30° sectors of the picket lines; solid squares show the locations of cardinal stations within the LTER sampling grid. The peninsula end of the 30-km picket line was terminated at shallow depths surrounding the Myriad and Danneborg Islands, which are not shown at the scale of this figure.

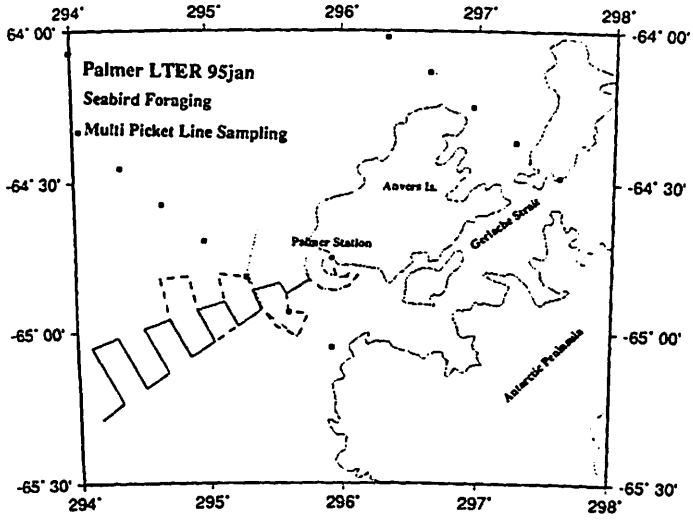

Figure 2. Example of multipicket line for 15° pie-shaped sector between 235° true and 250° true which was run on 25 January 1995 (solid line). The combined multipicket line run on 5 February 1995 (dotted lines) covered from 115°T to 235°T out to 30 km and from 235° true to 265° true from 30 km to 60 km. Radial arcs are every 10 km from 10 km to 90 km. Squares represent standard Palmer LTER grid-line stations. The 3.7-km, 10-km, and 30-km picket lines are shown for reference. For the 25 January multipicket line, 130 Adélies were sighted within a 40-km radius, and only four unidentified penguins were seen from 50 km to 80 km.

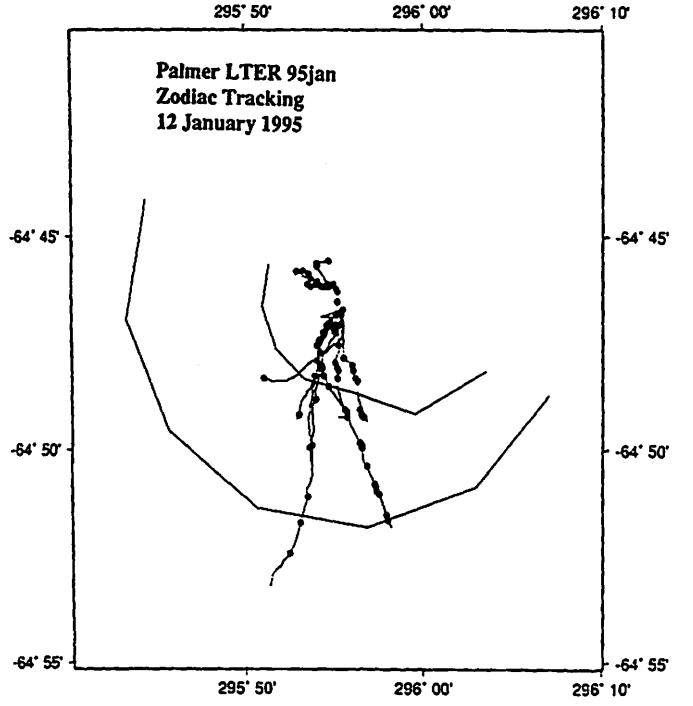

Figure 3. At-sea tracks of groups of Adélie penguins, with location of diving activity shown by filled circles, as determined from direct tracking via Zodiac and recording of locations by means of portable GPS units.

optimize selection of areas for high-density POCB sampling. Once a probable foraging area had been identified, a high-density, 10 km × 20 km sampling grid (Quetin et al., *Antarctic Journal*, in this issue) was run to characterize the POCB, to carry out simultaneous seabird censuses, and to make acoustic transects for krill biomass.

Close teamwork between ship- and shore-based seabird observations is an essential element of the picket line, Zodiac tracking, and high-density sampling strategy. It is probable that the birds do not forage the same location (direction and distance) throughout the foraging season or from year to year. We have shown, however, that picket-line sampling successfully provides a systematic strategy to determine quickly the birds' foraging direction and thus to reduce the area selected for subsequent sampling aimed at a detailed understanding of the linkages between penguins, their prey, and the POCB parameters that characterize the foraging area. During *PD*95-1, over 1,400 Adélies were sighted within three areas selected for high-density sampling, and repeated observations suggest that, this year, on the multipicket lines (figure 2) the Adélies were foraging within 30 km to 50 km of their nesting sites.

Successful implementation of this sampling plan was a team effort with the support and participation of *all* members of the science team and ASA personnel, both on ship and ashore. The captain and crew of the R/V *Polar Duke* were especially helpful. This research was supported by National Science Foundation grant OPP 90-11927 and is Palmer LTER contribution number 61.

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