Palmer LTER: Seasonal process sea-ice cruise, June-July 1999 (NBP99-06)

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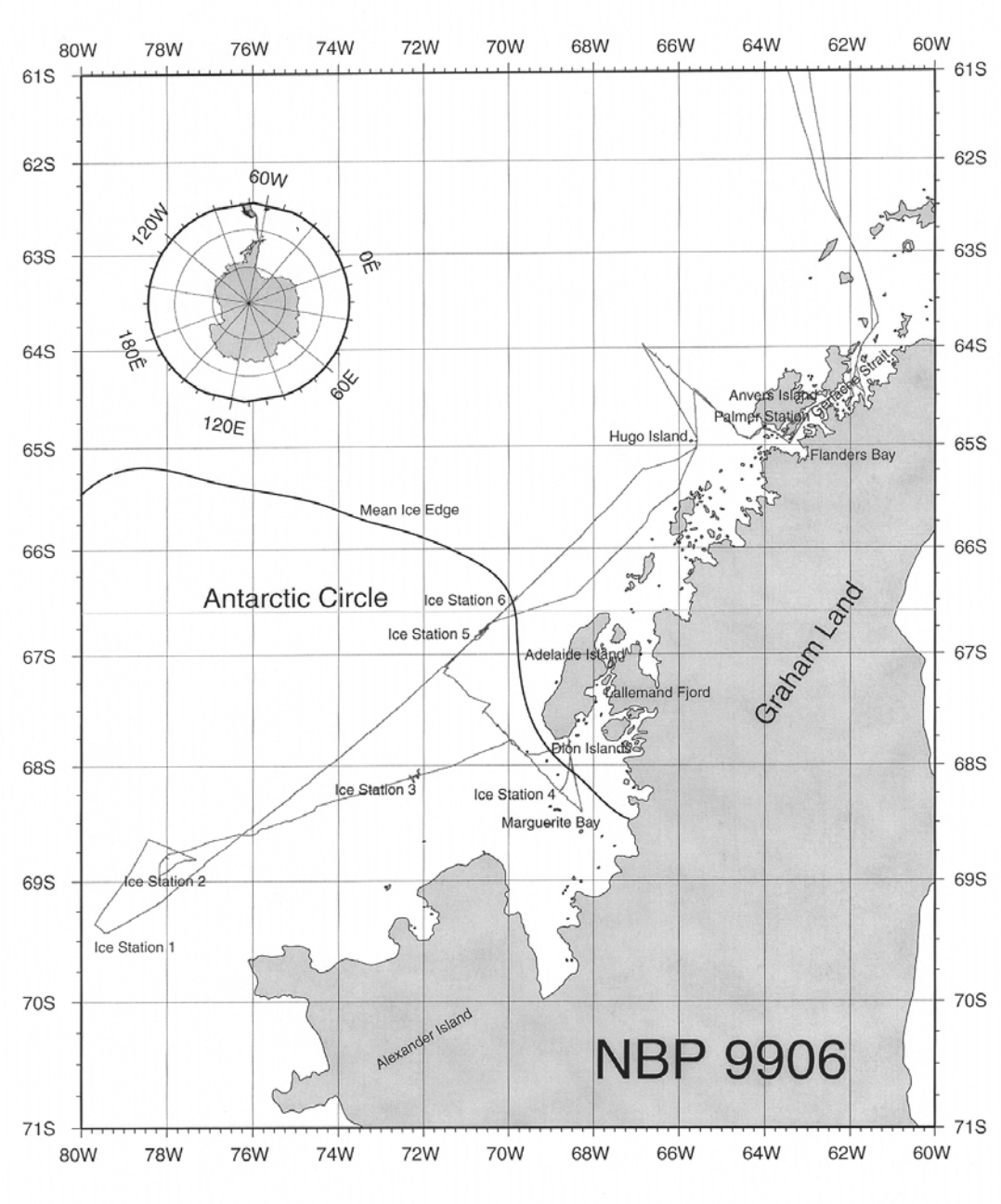
The overall objective of the Palmer Long-Term Ecological Research (PAL LTER) early winter sea-ice cruise (NBP99-06, 11 June-15 July 1999) was to investigate and understand sea ice growth processes and the relationship of these processes to the biota during the period of sea ice growth. We made physical, optical, chemical and biological observations in representative sea ice stages including open water, frazil, grease, nilas, pancake and young first year sea ice as the ship transected from the marginal ice zone into close pack ice.

Key goals of the Palmer LTER sea ice cruise were to study

1. processes associated with sea ice formation, linkages between the various stages of sea ice growth and the associated biological, chemical, optical and physical characteristics, and
2. winter abundance and distribution of Adélie penguins in association with sea ice habitat.

The research ship *Nathaniel B. Palmer* crossed the ice edge on June 18 at 66º 22.00 S and 69º 32.00 W and continued heading south approximately 540 km. Near our most southern location, three ice buoys were deployed in 10/10 pack ice in a 100km triangular array for Dr. Hartmut Hellmer (Alfred-Wegener Institute, Bremerhaven). On our return, transect back to the ice edge a series of multi-day stations were held in various sea ice regimes. Sea Ice Station #1 was held initially in closely packed deformed first-year sea-ice that had a mean thickness of 53cm. By the end of our second day on this station, a long-period swell was visible in the pack ice, and by the third day at this station, the swell had increased such that the 100-500m floes had been broken up into 10-50m floes. Sea Ice Station #2 was held for 5 days in closely packed deformed gray-white sea-ice with mean thickness of 27cm and floe sizes 100-500m. During the middle of this 5-day period, we experienced a warming from -18C to -5C and a drift speed of 2-3 knots. Ice Station #3 was occupied for 3 days in open pack ice that consisted of gray and gray-white sea-ice with mean thickness of 22cm and floe sizes of 20-100m.



NBP99-06 cruise track showing the locations of the ice stations, the mean ice edge, and the transects in/out of the pack ice with respect to the ice edge.

A deviation was made from our north-easterly transect (i.e., parallel to the Antarctic Peninsula) that involved a south-easterly transect along our 200 line into Marguerite Bay. Here we successfully deployed a landing party at Dion Island to carry out a sea bird census in this Special Permit Area (SPA), which is the most northern location of an emperor penguin colony. There we also held Ice Station #4 in brash/young ice conditions where we observed and sampled nilas over a 2-day period. Returning to our north-easterly transect, stations five and six were held within 20-40km of the ice

edge. At Ice Station #5 we encountered rounded cake ice (20cm thick, 1-2m diameter) heavily topped with flooded slush and surrounded by a thick slurry of floating slush (10-15cm thick). Both the rounding of the cakes and the slush were presumably caused by the swell-induced jostling of cakes against each other. At Ice Station #6 we observed very young pancake ice, 0.5-2 cm thick and 10-20 cm in diameter. We crossed the ice edge back into open water on July 6 at 66º 29.48 S and 69º 50.89 W. During our 18 days in the seasonal sea ice zone, the ice edge had advanced and retreated several times (as indicated by satellite imagery), but by the time we exited it, it was within 20km of where we first encountered it. Note that the location of the ice edge for this time of year was at least two degrees south of where it can be found during an average sea-ice extent year. Table 1 summarizes the ice station information.

Table 1. Summary of Ice Stations on LTER Cruise NBP99-06

Ice state	Grid location	Dates (jd)	Ice type sampled	Sea ice conditions	Mean thickness (cm)
1	-220.100	171-173	fy/deformed fy	close pack	53
2	-100.100	173-177	grey-white/fy	close pack	27
3	100.040	178-180	grey/grey-white	open pack	22
4	200.-100	182-183	nilas	dynamic/miz	2
5	280.100	186	old pancake	miz	20
6	300.100	187	young pancake	miz/ice edge	2

The science activities at these stations included:

1. snow/ice transects (either by foot in close pack ice or by zodiac in open and young sea-ice) for snow depth, snow-ice interface temperature and ice thickness and freeboard;
2. ice cores or blocks for physical analysis (temperature, salinity, delta18O and stratigraphy);
3. ice cores and/or blocks for chemical and biological measurements (PC, PN, PP, P-Si, DOC, DON, DOP, inorganic nutrients, bacteria and phytoplankton biomass, photosynthetic pigments, taxonomic composition and potential primary production);
4. CTD (temperature, conductivity, depth, transmittance, O2, fluorescence and water samples for LTER core measurements);
5. optical observations (profiling reflectance radiometer, spectral radiometer for light transmission through snow & ice);
6. 1 m net zooplankton tows and diver observations beneath the ice for collection of krill and larvae; and
7. sea bird observations.

This is the third seasonal process cruise for the Palmer Long-Term Ecological Research (PAL LTER), which together with seven annual January cruises, adds to our growing observation of the area west of the Antarctic Peninsula (Smith et al., 1995; Ross et al, 1996). In addition to the six multi-day ice stations, we held stations along the 200 and 600 LTER cardinal lines perpendicular to the coast as well as along a line 100km from the coast but parallel to the WAP as we transited in/out of the sea ice. During our in/out transits we made two unsuccessful attempts to go ashore to repair the AWS unit on Hugo Island. Tables 2a and 2b summarize the chronology and sampling division of the cruise, respectively.

Table 2a. Overview of the LTER Cruise NBP99-06 where the day of the month and activities are listed including LTER grid locations (xxx.xxx) and ice station number. Activities while at an ice station included ice sampling for physics and biology, ice/snow depth transects, CTD, optics, dives for zooplankton, nets, and bird observations.

Date	Activity
June	
11	Punta Arenas depart, Transect, Straits of Magellan
12	Transect, Drake Passage, BirdObs
14	Transect, Drake Passage, BirdObs, ATChl
13	Transect, Drake Passage (rough weather)
15	Gerlache Strait, BirdObs, Dive(Training), ATChl
16	Palmer Station, CTD(600.040), Dive(Training)
17	CTD(600 line & 500.100), BirdObs, 1mNet(500.100), HugoAWS (abort)
18	CTD(xxx.100, 400 to 150), BirdObs, IceEdge, Optics, IceSample
19	CTD(xxx.100, 100 to -100), BirdObs, lmNet(-50.100), Drifter#1
20	CTD(-160.100), 1mNet, Drifter#2, IceStat#l(-220.100)
21	IceStat#l(-220.100)
22	Drifter#3, IceStat#2(-100.100)
23	IceStat#2(-100.100)
24	IceStat#2(-100.100)
25	IceStat#2(-100.100)
26	IceStat#2(-100.100)
27	IceStat#3(100.040)
28	IceStat#3(100.040)

Date	Activity
29	IceStat#3(100.040)
30	CTD(200 line, 000 to -070), BirdObs
July	
01	CTD(200 line, -080 to -100), BirdSurv(Dion Is), IceStat#4(200.-100)
02	IceStat#4(200.-100), BirdSurv(Dion Is)
03	IceStat#4(200.-100), BirdSurv(Ginger Is), CTD(200 line, -020 to -010)
04	CTD(200 line, 000 to 100, 240.100), BirdObs, MocNet
05	IceStat#5(280.100)
06	IceStat#6(300.100), CTD(260.100), BirdObs, Optics, MocNet, IceEdge
07	CTD(xxx.060, 350 to 550), MocNet, BirdObs, HugoAWS (abort)
08	CTD(600 line, 200 to 140), 1&2mNets, BirdObs, Optics
09	XBT(600.040), bad weather
10	Palmer Basin, bad weather
11	Gerlache Strait
12	Transect, Drake Passage
13	Transect, Drake Passage
14	Transect, Straits of Magellan
15	Punta Arenas arrive

Table 2b. Summary of Events on LTER Cruise NBP99-06

Parameter	Number of events	Number of days per event	Number of days	Percentage of cruise time
CTD transect	101	0.069	7	20.0
Ice station 1	19	0.105	2	5.7
Ice station 2	57	0.088	5	14.3
Ice station 3	26	0.115	3	8.6
Ice station 4	13	0.231	3	8.6
Ice station 5	5	0.200	1	2.9
Ice station 6	4	0.250	1	2.9
AWS Hugo	2	0.500	1	2.9
Tests	3	0.677	2	5.7
Weather	2	1.000	2	5.7
Transect	8	1.000	8	22.9
Total	239	—	35	100.0%

The life histories of various polar marine species are synchronized with the seasonality of sea ice. Thus any temporal shifting of the annual cycle or regional sea ice coverage will significantly change the physical environment of any given season and, consequently also affect those ecosystem variables that are timed to the mean annual cycle of sea ice. In the WAP area the mean annual cycle is characterized by a relatively short (about 5 months) period of ice advance, with peak ice extent occurring in August, followed by a longer period (about 7 months) of sea-ice retreat. However, there is also significant interannual variability about the mean, and in 1999 sea ice reached maximum extent one month later, had a short peak duration and retreated rapidly. It is within this context of a late and short winter that the NBP99-06 Sea Ice Cruise was conducted.

As part of the Palmer LTER Education Outreach, Ms. Dominique Sonier, a middle school teacher from Santa Barbara, was aboard ship. She communicated to online classrooms through real time field reports and photographs posted on the World Wide Web.

This research cruise was composed of the Palmer LTER research team including team leaders E.Woehler (Fraser, BP-013), M.Vernet (Vernet, P-016), D. Martinson (Martinson, BP-021), L.Quetin (Quetin/Ross, BP-028), R. Smith (Smith, BP-032), and D. Karl (Karl, BP-046). Special thanks to the Palmer LTER research team members, to the

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