# Research on Antarctic Coastal Ecosystem Rates

## RACER: An interdisciplinary study of spring bloom dynamics

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The Research on Antarctic Coastal Ecosystem Rates (RACER) pilot program (Huntley et al. in press) studied mesoscale physical and biological dynamics in the western Bransfield Strait region during and following the austral spring bloom from December 1986 through March 1987. Extraordinarily high planktonic biomass and rates of primary production were found covering an area of approximately 5,000 square kilometers in the northern Gerlache Strait with a clear gradient extending northward for the entire study period (Holm-Hansen and Mitchell in press; Karl, Tilbrook, and Tien in press a). Therefore, we resolved to study the onset of the spring bloom in this region during the RACER-I program, which was conducted in the 1989–1990 field season.

Our research was focused on two principal questions:

- Which biological and physical mechanisms cause the Gerlache Strait region to be highly productive, and how do they function?
- Are gradients of biomass radiating from the Gerlache Strait due to mass transport from the Strait or to actual gradients in local production?

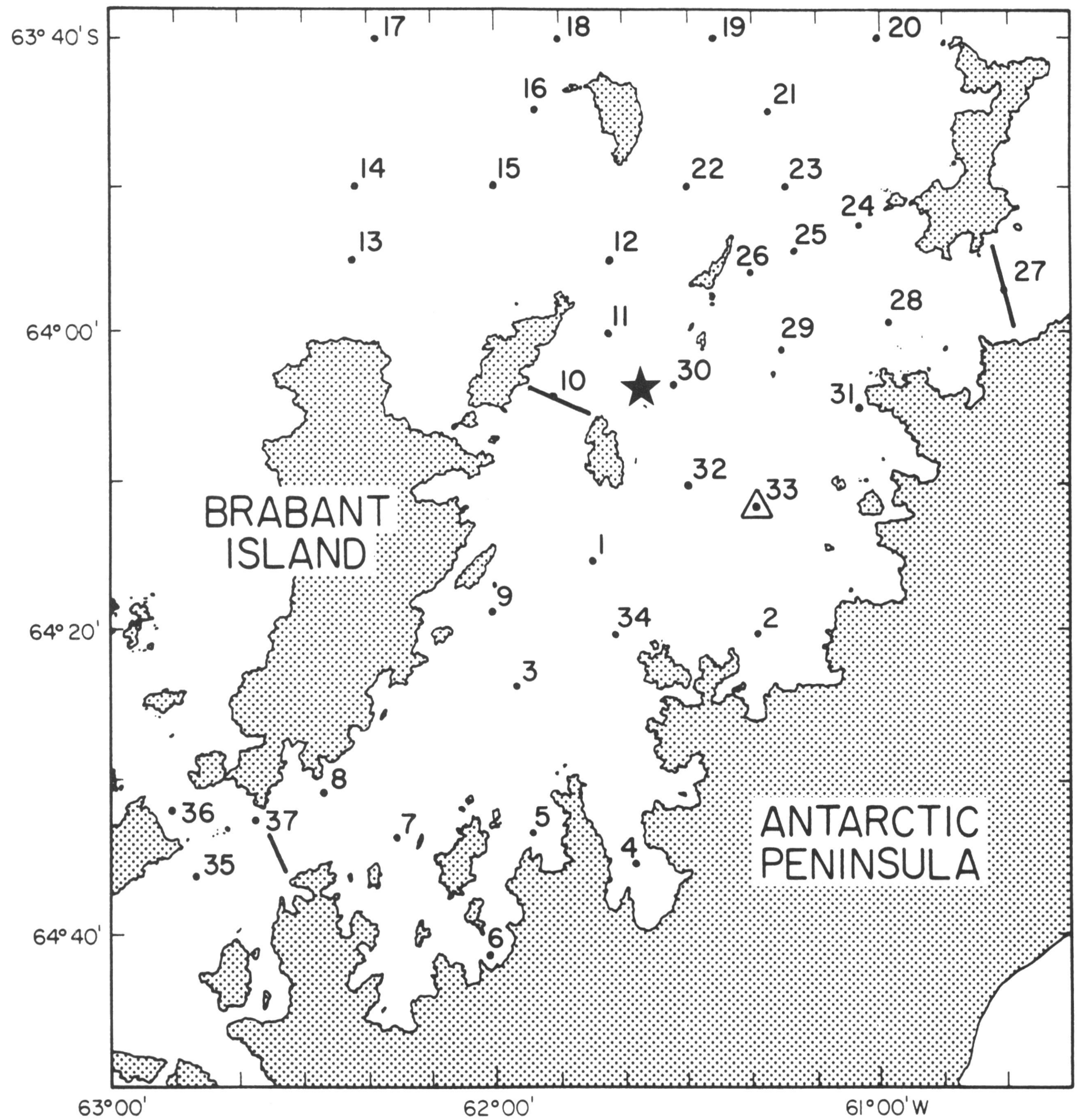
The study area covers approximately 4,000 square kilometers of the northern Gerlache Strait and southwestern Bransfield Strait (figure). Geographically, it incorporates open waters of the Bransfield Strait, a deep-water region (Croker Passage), coastal shelves, and several large embayments; dynamically, it embraces the gradient of planktonic biomass (Holm-Hansen and Mitchell in press; Karl et al. in press b; Huntley and Brinton in press) as well as Bransfield Current and an intense frontal region projecting across the northeastern portion of Gerlache Strait (Niiler, Amos, and Hu in press).

We conducted four consecutive 5-day cruises, back-to-back, from 30 October through 24 November 1989. Sampling was accomplished in two modes: (1) a time-series station ("A") occupied for four 3-day periods separated by (2) periods of 2.5 days for a "fast" sampling grid, comprising 37 stations, and during which we covered the study region four times. Station locations are shown in the figure. A scientific crew of 22 maintained a 24-hour sampling schedule at all times.

At the time-series station, we made conductivity-temperature-depth casts to the bottom (approximately 350 meters), accompanied by continuous vertical profiles of beam attenuation. Water samples were routinely taken from 10 depths to 200 meters for measurements of chlorophyll, phaeopigments, major nutrients (nitrate, silicate, ammonia, phosphate), accessory photosynthetic pigments, heterotrophic activity, microbial carbon production, dissolved inorganic nitrogen, dissolved nucleic acids, particulate adenosine triphosphate (ATP), and abundance of bacteria, protozoa and phytoplankton. Zooplankton tows (330-micrometer mesh) were made with a MOCNESS, at nine depth intervals to a depth of 300 meters; the 0–300-meter sample was taken with a 180-micrometer-mesh net. Additional oblique tows were made with a "fast net" towed at approximately 4 knots from 0–300 meters, expressly for the purpose of catching late juvenile and adult krill. All water-column collections were made at a frequency of at least 6 hours.

Additional studies at the time-series station included measurements of *in situ* carbon-14- and nitrogen-15-primary productivity determined from samples allowed to incubate at eight depths on a free-floating line, and measurements of sedimentation rates at five depths based on collections of free-floating sediment traps deployed for a period of 2 days. At a distance of approximately 3 kilometers south-southeast from the time-series station, we deployed a MK5-13 large aperture time-series sediment trap (Honjo and Doherty 1988) which collected 13 samples equally spaced in time from early October through mid-March, 1990, when it was recovered and redeployed. Two focused studies were conducted on zooplankton distribution, one on horizontal patchiness at the 100-meter scale and the other a 48-hour study of zooplankton vertical migration. Experiments were conducted to determine egg production, hatching, and naupliar development rates of several species of copepods.

At each fast-grid station, we performed the same water-column measurements as at the time-series station; MOCNESS and fast net tows were routinely made at 16 stations. Surface seawater was collected at each station for measurements of particulate ATP, radiolabelled glutamic acid turnover rate determination, and bacterial uptake of radiolabelled leucine. Additional studies performed during fast grids included the deployment of 18 ARGOS-linked drifter buoys, several high-resolution hydrological transects across openings to the Ger-




**RACER study area, October through November 1989. Closed circles indicate fast grid station locations, triangle indicates time-series station A, solid lines show location of high-resolution hydrological sections, and star shows location of the "RACER Rock" meteorological station.**

lache Strait which allowed us effectively to close off all entrances and exits, and continuous underway measurements of air temperature, relative humidity, barometric pressure, incident solar radiation and true wind velocity. An ARGOS-linked meteorological station, relaying the same data as those collected aboard ship, was placed on a presumably unnamed island at 64°04.021'S 61°36.485'W; the group of islands was christened "RACER Rock."

Measurements made at station A, thus, provided four sets of continuous 3-day measurements at the same location, yielding a highly resolved time-series. Measurements made during the fast grid provided a quasi-synoptic view of the entire study region throughout the month while the spring bloom developed. Additional studies permit the evaluation of air-sea interaction, fluid dynamics of the Gerlache Strait, and biological dynamics in space and time.

The 1989 field program incorporated the following investigations:

- meteorology and upper ocean physics (P. Niiler and A.F. Amos);
- microbiology and particle sedimentation (D.M. Karl);
- phytoplankton processes (O. Holm-Hansen and M. Vernet);
- dynamics of zooplankton (M. Huntley and E. Brinton).

The field scientific crew of 22 included participants from 10 nations, representing eight institutions. Results and acknowledgments of support are presented in the following 19 articles appearing in this issue.

## References

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# RACER: Meteorological conditions during the spring bloom in the Gerlache Strait


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This study of the local meteorological conditions in the Gerlache Strait was done as part of the RACER (Research on Antarctic Coastal Ecosystems and Rates) study (Huntley et al., *Antarctic Journal*, this issue). The goal was to aid in answering the two questions posed by the RACER investigators; namely, what physical mechanisms account for the productivity of the Gerlache Strait, and what role mass-transport plays in determining biomass gradients there. Two weather stations were installed, one aboard the R/V *Polar Duke* and the other on an island near Lobodon Island, which we have named "RACER Rock," pending formal acceptance of that name by the Geographic Board of Names.

*Shipboard weather system.* The underway system consisted of an RM Young vane/anemometer, and Weathermeasure barometric pressure, air and sea temperature, relative humidity sensors, and three solar radiation detectors (two Eppley pyranometers and a Biospherical Instruments (cosine) meter. The wind, air temperature, and humidity sensors were mounted atop the Ice Pilot Station at a height of 23 meters above the waterline. Barometric pressure was measured at 7 meters above sea level and sea temperature measured at the outflow of the uncontaminated seawater supply to the ship's aquaria. Later, Sea-Bird Electronics temperature and conductivity sensors were installed in these lines as part of the underway system. The light sensors were installed at a height of 9 meters on the helicopter deck.

Data were acquired using a combination of Weathermeasure signal conditioners, a Hewlett-Packard multiplexer, the ship's SAIL system (for navigation and bottom depth data), and a COMPAQ 286 computer. Recording interval was 10-minutes, with a 1-minute averaging period. Daily files were stored on disk in such a way that in case of a power failure, the most that could be lost would be one recording interval.

*Automatic weather station on "RACER Rock."* A Stearns automatic weather station (Stearns and Savage 1981) was installed on "RACER Rock" (64°06'S 61°35'W) on 6 November 1989. It measures wind speed and direction, air temperature, relative humidity and barometric pressure, and transmits data to the ARGOS satellite link. The original plan to monitor the mean windfield was to place the automatic weather station near the sea level, close to the main RACER station "A" (Huntley et al., *Antarctic Journal*, this issue), in the central Gerlache Strait away from obstructing terrain. To this end, Moreno Rock (64°03.9'S 61°35.6'W) was the site of choice, but repeated attempts to land there in October and early November proved futile due to rough seas, extensive snow cover, and lack of a suitable site for unloading heavy equipment.

"RACER Rock" is one of a group of islets between Lobodon and Auguste Islands (DMAHC chart 6944, 1967). On the summit (17 meters), snow cover was nearly 2 meters thick in early November, but by digging to bedrock and anchoring the automatic weather station guy wires with expansion bolts, the station was well secured even though all snow had melted by March (D. Karl personal communication). The site is somewhat shadowed by Two Hummock Island (both peaks 669 meters in altitude), 5.9 kilometers to the west. As of this writing (June 1990) the "RACER Rock" automatic weather station (number 9301), is working well, except for barometric pressure output, which became increasingly intermittent until by December 1989, it ceased functioning.

*The windfield in the Gerlache and Bransfield Straits.* Figure 1 shows a time series of the meteorological conditions from the underway system on *Polar Duke* compared with that on "RACER Rock," when they were operating simultaneously. Dates are in universal standard time. The hour angle at "RACER Rock" is −61.35°, putting local apparent noon −4.1 hours from times given in the figure. During November, *Polar Duke* made four circuits of the RACER grid, designated FA through FD (Huntley et al., *Antarctic Journal*, this issue). Thus, conditions are not directly comparable because *Polar Duke* was in the adjacent Bransfield Strait during some of November. Nonetheless, it is revealing to note the following: winds on "RACER Rock" were less energetic than in the whole RACER study area; diurnal humidity and temperature variations were much greater on "RACER Rock," indicating a less "maritime" regime there than over the open waters; there was a gradual rise in air and sea temperature as the month progressed over the open water; air