Deep-Sea Research, Vol. 38, No. 8/9, pp. v–vii, 1991.
Printed in Great Britain.

0198–0149/91 $3.00 + 0.00
© 1991 Pergamon Press plc

RACER: Research on Antarctic Coastal Ecosystem Rates

Preface

The Southern Ocean, defined here as that body of water south of the Antarctic Convergence, covers an area of 35×10^6 km^2, nearly 10% of the World Ocean. The Southern Ocean is an important site for deep ocean ventilation and bottom water formation and for the exchange of gases and heat between the ocean and atmosphere. It is also the major surface ocean repository of unused plant nutrients.

Southern Ocean environments range from the oligotrophic regions of the southern Drake Passage to the productive coastal embayments of the Antarctic Peninsula. Numerous localized frontal zones, gyres and eddies support enhanced biological production at all levels of the marine food web. Superimposed on this habitat mosaic is an intense seasonal and interannual variability in environmental conditions. For example, the seasonal cycle of sea-ice formation and ablation affects >60% of the total surface area of the Southern Ocean. Furthermore, the marked seasonality in incident solar radiation and variability in wind- and density-induced upper ocean mixing comprise primary controls on ecosystem productivity.

The last few years have seen the development of numerous national and international programs addressing fluxes of biogenic materials in the oceans with special reference to the importance of the World Ocean as a sink for combined natural and anthropogenic atmospheric CO_2. The Joint Global Ocean Flux Study (JGOFS), an international project of the Scientific Committee on Oceanic Research, is designed to increase understanding of the processes controlling interannual to decadal marine biogeochemical cycling at regional, basin-wide and global scales. The overall goals of the study are to identify and quantify the physical, chemical and biological processes governing the production and fate of biogenic materials in the sea, and to model and predict their influences on the responses to global perturbations. Key scientific goals are: to determine the mean and fluctuating components of Southern Ocean productivity and rates of export production; to assess, through observation and models, the role of the Southern Ocean as a sink for CO_2; to measure bioelement recycling rates and processes; and to understand the processes controlling particle fluxes and sediment accumulation rates.

This special issue of *Deep-Sea Research* presents the results of a comprehensive, 4-month field study conducted in a 25,000 km^2 region of the western Bransfield Strait, Antarctica during the 1986–87 austral summer. The RACER (Research on Antarctic Coastal Ecosystem Rates) program was designed to test several hypotheses regarding the interaction of biological and physical processes in Antarctic coastal regions in general, and the importance of the study area as a nursery ground for antarctic krill (*Euphausia superba*) in particular. In so doing, the RACER program contributed knowledge on most of the important scientific issues of the JGOFS program. While the majority of our 1986–87 RACER program field results are presented herein, other specialized portions have been

published elsewhere or are currently in preparation. A few salient results of the RACER program are summarized below.

During the RACER program, we documented an extensive phytoplankton bloom in the northern Gerlache Strait with biomass estimates >750 mg Chl *a* m^{-2} and primary production rates in excess of 4 g C m^{-2} day^{-1}. The massive phytoplankton bloom declined abruptly by February–March 1987, despite adequate light and nutrient conditions. From comprehensive measurements of upper ocean physics in combination with studies of the distribution and abundance of phytoplankton cells, it was concluded that the initiation, continuation and, perhaps, even the demise of the spring bloom is controlled largely by the physical conditions of the water column and, specifically, by the depth of the surface mixed layer. A model of phytoplankton growth based on mixing depth, pigment specific light attenuation and *in situ* photosynthesis–irradiance relationships indicated that the depth of the mixed layer can be used to predict ecosystem productivity.

Microheterotrophic processes were low during the initial phase of the bloom. For example, bacterial populations at the height of the algal bloom were approximately 3 orders of magnitude lower than predicted based on empirical relationships from other well-studied marine and freshwater ecosystems. As a result of this autotroph-dominated system, dissolved nutrient concentrations were substantially depleted in surface waters (e.g. $[NO_3 + NO_2] \leq 3\,\mu M$, $[PO_4] \leq 0.5\,\mu M$ and $[\Sigma CO_2] \leq 1900\,\mu M$). Consequently, in those regions of extensive bloom formation the partial pressure of CO_2 (pCO_2) in the surface ocean was reduced to $\leq 100\,\mu atm$, thereby comprising a potentially large sink for atmospheric CO_2. During the period of our field study we estimated the air-to-sea CO_2 flux to be approximately 400–1700 mmol C m^{-2}, depending upon windspeed. In coastal regions particulate carbon flux was temporally variable, ranging from >30 mmol C m^{-2} day^{-1} during January to <3 mmol C m^{-2} day^{-1} in March. Based on a seasonally-integrated estimate of particulate export, the 1986–87 spring bloom in the northern Gerlache Strait sustained a new production of 1.3–1.5 mol C m^{-2}, approximately 26% of total production.

Extensive investigations of the population dynamics, distribution, abundance and growth of *Euphausia superba* identified at least two year classes of immature and adult populations in our study area. Three principal biogeographic zones were identified: northern Gerlache Strait, Bransfield Strait and Drake Passage. In the Gerlache Strait, larval abundance reached 12,000 individuals m^{-2} with intermolt periods <8 days for the earliest stages of development. These growth rates are among the highest reported for *E. superba* and serve to emphasize the importance of the productive coastal regions of the Antarctic Peninsula as a nursery area for krill.

Comprehensive hydrographic surveys conducted over the 4-month RACER field program confirmed the presence of several different water masses and two major frontal structures; warm, less saline waters were to the south. A geostrophically-balanced flow from the southwest to the northeast across the RACER study area, the Bransfield Current, has a time-mean current maximum of 8 cm sec^{-1} near the flow axis. From estimates of geostrophic eddy kinetic energy and particle diffusion rates, it is hypothesized that the Bransfield Current may be important for transporting and redistributing biogenic materials from the eutrophic regions of the northern Gerlache Strait to the Drake Passage in a period of 15–30 days.

Based upon the results of our initial field program, we designed a second RACER field experiment (November–December 1989) which focused more closely on the initial stages

of the spring bloom phenomenon in a smaller geographical area centered on the northern Gerlache Strait. Additional research components, including the establishment of a satellite-linked meteorological station, the establishment of a bottom-moored, time series sediment trap station, the release of satellite-tracked Lagrangian drifters for direct measurements of near-surface ocean currents and the use of a multiple-opening and closing net and environment sensing system (MOCNESS) have allowed us to test refinements of our initial RACER program hypotheses. A third cruise, now scheduled for late summer 1992, will provide similar detailed data during the declining phases of the spring bloom in the Gerlache Strait and southern Bransfield Strait regions.

I would like to thank Dr John Milliman for providing us with this opportunity to prepare a special issue of *Deep-Sea Research* devoted to the RACER program, Dr Tom Manley for the preparation of the graphics used on the cover of this volume, the numerous referees and members of the Editorial Board for their careful and critical reviews of our manuscripts, Drs Polly Penhale and Bernard Lettau of the NSF Division of Polar Programs for their interest, encouragement and financial support and, especially, the numerous RACER program participants, R.V. *Polar Duke* officers and crew and ITT–ANS personnel for their contributions to our field program.

David M. Karl
School of Ocean and Earth Science and Technology
University of Hawaii