Surface nutrients in the vicinity of the Prince Edward Islands during April/May 1989

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The micro-nutrients silicate, nitrite, nitrate, phosphate, ammonia and urea were analysed on an ongoing basis during a cruise to the Prince Edward Islands in order to provide a chemical background for the physical and biological studies undertaken concurrently. Preliminary results are presented and discussed. There were marked increases in reduced nitrogen (ammonia and urea), silicate, nitrate and phosphate in the near-shore areas of the island group compared with the surrounding open ocean.

Tydens 'n vaart na die Prince Edward-eilande is deurlopend analises gedoen van die mikrovoedingstowwe silikaat, nitriet, nitraat, fosfaat, ammoniak en ureum in die seewater ten einde 'n chemiese agtergrond te verskaf vir die fisiese en biologiese ondersoeke wat tegelykertyd gedoen is. Die voorlopige resultate word voorgelê en bespreek. In vergelyking met die omliggende oop see kom aansienlik verhoogde hoeveelhede gereduseerde stikstof (ammoniak en ureum), silikaat, nitraat en fosfaat in die gebiede naby die kus van die eilande voor.

Introduction

The Prince Edward Islands (47° S, 38° E), embracing Marion Island and Prince Edward Island, are situated in the Sub-Antarctic Surface water of the Antarctic Circumpolar Current, between the Subtropical Convergence and the Antarctic Polar Front (Deacon, 1983; Lutjeharms, 1985).

The Prince Edward archipelago exhibits an island mass effect that is caused by enhancement of the vertical stability of the upper ocean (Perissinotto *et al*, in press) and high levels of reduced nitrogen nutrients (Perissinotto and Duncombe Rae, in press). This results in higher phytoplankton biomass and production in the vicinity of the islands than in the surrounding open ocean.

In this contribution results of the analysis of the micronutrients carried out during the second and final phase of the Marion Offshore Ecosystem Study cruise of *SA Agulhas* (April/May 1989) are presented. The major objective of this investigation was to provide a chemical background for both the physical and the biological studies. This cruise included tracks between Cape Town and the Prince Edward Islands and measurements in the vicinity of the islands. In particular, data were used to compare the nutrient levels in the near-shore areas of the islands with those of the surrounding open ocean.

Methods

Surface nutrient samples were collected along the cruise track from Cape Town to Marion Island (Fig 1) and in the vicinity of the Prince Edward Islands (Fig 3a-f) from the scientific seawater supply pump (Iwaki Magnet Pump), fabricated from polyvinylidene fluoride and ceramic materials. It drew water from the sea at a level of 3 m above the keel and supplied it to the laboratory through PVC piping. During the voyage the pump ran continuously at slightly less than its maximum capacity of 100 ℓ/m. The quality of the scientific seawater supply had been checked on a previous cruise by Allanson *et al* (1981) and no significant differences were found between this supply and overboard samples.

Water samples were analysed for silicate, nitrite, nitrate, phosphate, ammonia and urea. Nutrient concentrations were determined on board using a Technicon Autoanalyzer II system following DeManche *et al* (1973) and Mostert (1983). Nutrient analyses were done as soon after sampling as possible, samples being kept frozen at −18 °C until analysis. Most analyses were done immedi-

Table 1

Standard deviations and coefficients of variation for the six nutrients determined from analysis of replicates of a single sample

	Silicate	Phosphate	Nitrate	Nitrite	Ammonia	Urea
Replicates (n)	20	20	20	20	49	20
Mean (mmol.m^{-3})	4,762	2.03	23,91	0,236	0,76	1,084
Std deviation	0,279	0,038	0,268	0,008	0,13	0,038
Coefficient of variation	5,86%	1,87%	1,12%	2,39%	17%	3,51%

ately. No samples were kept for longer than 36 hours before analysis. Analysis of the replicates of a single sample established the variation of the determination (Table 1).

A comparable series of replicates for ammonia was done manually and read on a Shimadzu spectrophotometer using 4 cm light path cuvettes. Although the concentrations given by the Autoanalyzer were somewhat higher than with the manual method, the coefficient of variation was more acceptable (17% against 23%).

Results and discussion

Silicate

Fluctuations in silicate concentrations decreased between 41° to 46° S, concomitant with a measurable increase in nitrate and phosphate values (Fig 2). Allanson *et al* (1981) found a similar pattern in this area.

Silicate concentrations (Fig 3a) ranged from 1,98 to 5,31 mmol.m^{-3} at the Prince Edward Islands, with a mean concentration of 3,33 mmol.m^{-3} in the lee of Marion Island. There was a marked decrease in silicate concentration to the east and north of Marion Island.

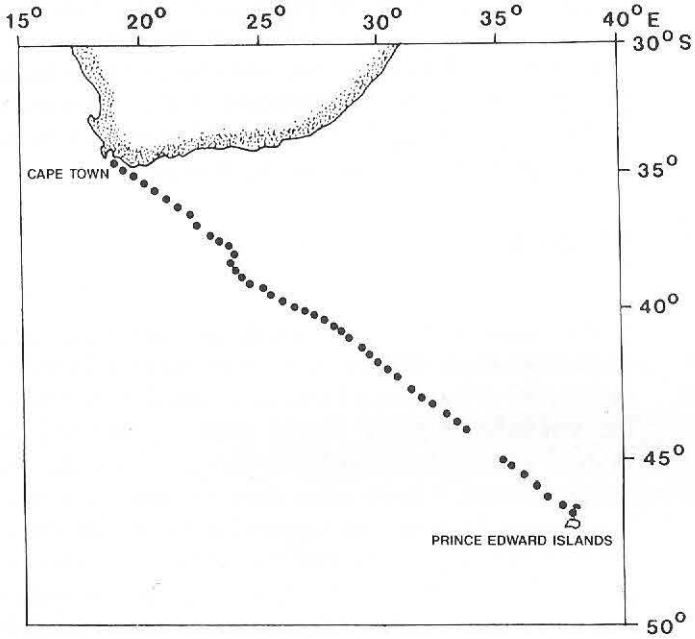

Fig 1: Cruise track of the MV SA Agulhas *between Cape Town and Marion Island during April/May 1989*

Nitrite

The surface nitrite concentration (Fig 2) increased sharply from 0,07 mmol.m^{-3} between 40°49' S to 42°25' S. On the MOES I cruise data collected over the same latitudinal zone followed a similar pattern.

The nitrite concentration averaged around 0,16 mmol.m^{-3}, with a maximum concentration (Fig 3b) of 0,22 mmol.m^{-3} near the south-eastern tip of Marion Island. An increase in concentration in the easterly direction away from Marion Island was evident.

Nitrate and phosphate

There was a large increase from 3,53 mmol.m^{-3} to 14,25 mmol.m^{-3} in the surface nitrate concentration (Fig 2) between 43°17' S and 44°05' S. A maximum concentration of 18,56 mmol.m^{-3} was reached at 46°28' S.

Nitrate concentrations were much higher in the vicinity of the islands and particularly elevated values (Fig 3c) were observed close to the south-eastern tip of Marion Island. The highest nitrate concentration was found in the near shore area, decreasing in concentration away from Marion Island in an easterly direction. This suggests that substantial nutrient run-off from breeding bird colonies on the island (Burger *et al*, 1978, Siegfried *et al*, 1978, Williams *et al*, 1978) may affect nutrient levels close inshore.

There was a measurable increase in phosphate concentration (Fig 2) from 41°37' S to 45°05' S in the range of 1,70 mmol.m^{-3} to 2,03 mmol.m^{-3}, reaching a maximum of 3,31 mmol.m^{-3} at 46°46' S. In Allanson *et al* (1981) a marked increase over the same latitudinal zone

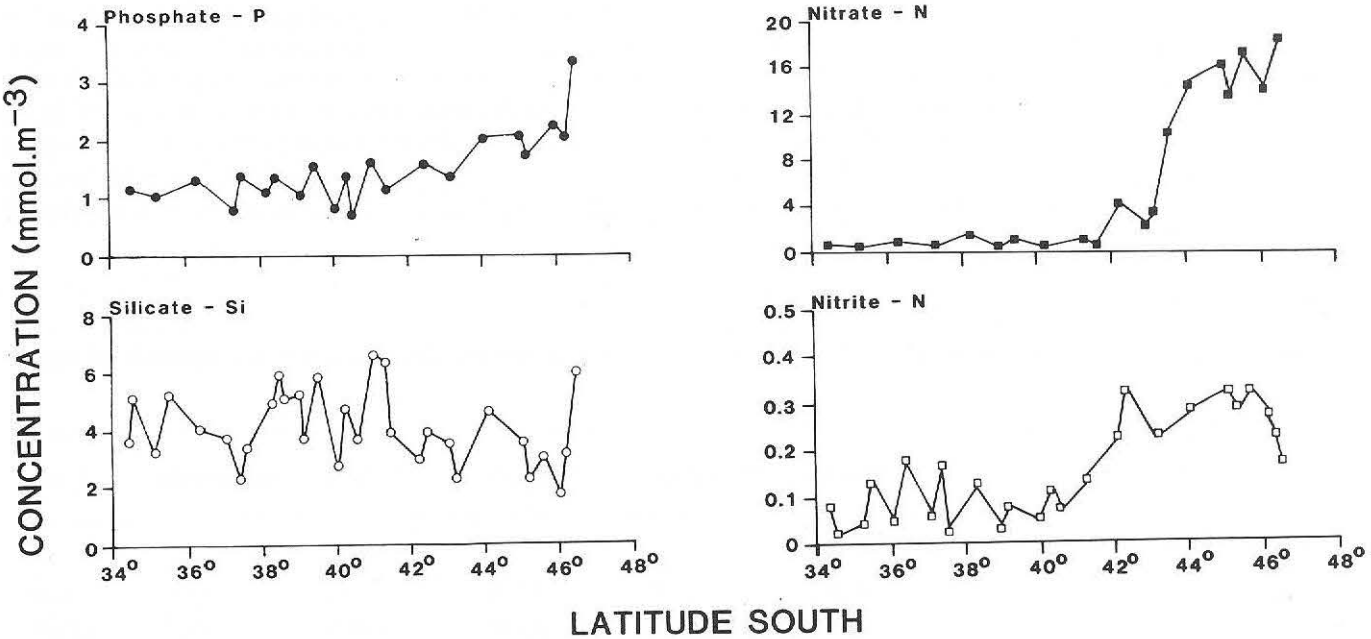

Fig 2: Distribution of the major nutrients phosphate, silicate, nitrate and nitrite at the sea surface along the cruise track shown in Fig 1

was obtained across the Subtropical Convergence south of Africa.

Although phosphate distribution (fig 3d) was patchy, concentrations were generally higher in the west and inshore areas of Marion and the lowest concentrations were north-west of Prince Edward Island. This contrasts with the findings of Allanson *et al* (1985) of a tongue of nutrient-rich water to the east of Marion Island.

The ratio of $NO_3(N)$ to $PO_4(P)$ in the surface waters around the Prince Edward Islands was 9,8:1. This was markedly lower than the ideal of 15:1 claimed by Cooper (1938) and later amended to 16:1 by Redfield *et al* (1963), though a value of 6,5:1 was measured in May 1983 (Allanson *et al*, 1985). The N:P ratio on the MOES I cruise in May 1987 was very close to the ideal, phosphate depletion being evident as discussed by Boden (1988). According to Williams and Berruti (1978), an amount of 428 694 kg (dry wt) of feathers is shed annually on Marion Island alone. About 25% of the total feather mass is shed in March and this, allowing for decomposition, would leach a substantial nutrient contribution which could have affected our results in April/May, 1989. Guano and land run-off from decomposing bog (land plants) are also likely to contribute significantly to the phosphate and nitrate levels.

Ammonia and urea

The ammonia concentration (Fig 3e) north of Marion Island was very much lower than the mean concentration of 0,35 $mmol.m^{-3}$ in the lee of the island. A definite decrease in concentration was noticeable away from Marion Island.

The urea concentration (Fig 3f) varied from 1,15 $mmol.m^{-3}$ to 2,89 $mmol.m^{-3}$ in the southerly and northerly direction away from Marion Island.

Guano production at the islands has been estimated to be of the order of 33 x 10^3 tons of fresh guano per year (Burger *et al*, 1978). The islands receive a high annual rainfall, a mean precipitation in excess of 2 500 mm x yr^{-1} was measured by Smith (1987), with the result that the guano does not accumulate on the islands themselves. Most of it is dissolved and carried into the sea via run-off spreading out from the islands, giving rise to high amounts of reduced nitrogen in the near shore sea areas. Urea concentration measurements obtained in 1987 and 1989 in the near-shore environment seem to indicate that this nitrogen nutrient is quite abundant in the area. In spite of the domination of the nitrogenous nutrient pool by nitrate and nitrite, ammonia and urea are the preferred nutrients used by phytoplankton of all size classes (Probyn and Painting,

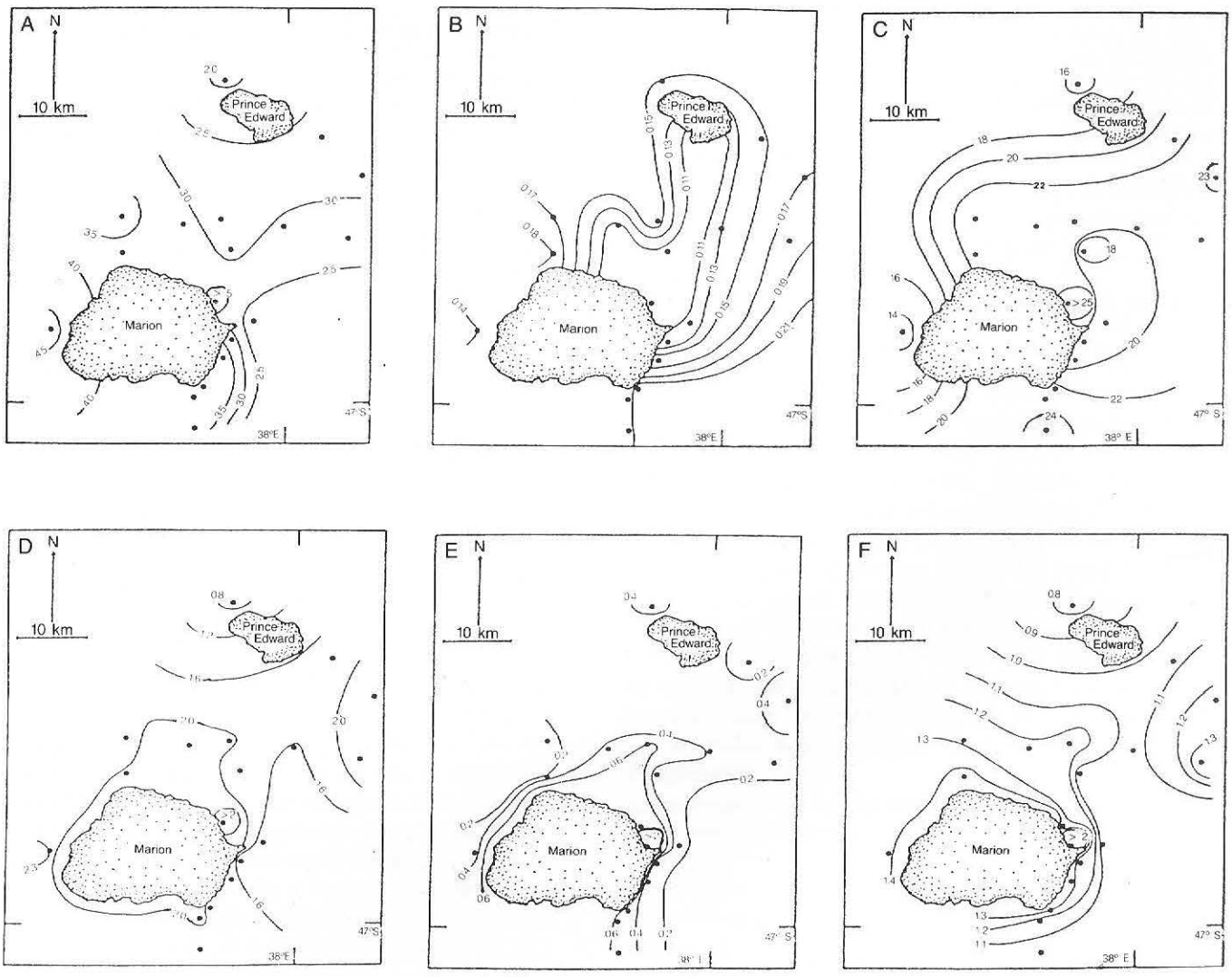

Fig 3a-f: *Contoured surface values of silicate, nitrite, nitrate, phosphate, ammonia and urea in $mmol.m^{-3}$ indicated by a, b, c, d, e and f, respectively, around the Prince Edward Islands during April/May 1989*

1985). Very high ammonia and urea concentrations of 16,69 mmol.m^{-3} and 2,89 mmol.m^{-3}, respectively, (Fig 6a, b) were found off the penguin colonies in the nearshore area.

From these results it is evident that freshwater run off from the islands enhances the amount of reduced nitrogen in the immediate vicinity of the Prince Edward Islands, with possibly important biological implications.

Acknowledgements

This research was sponsored by the South African Scientific Committee for Antarctic Research and the Department of Environment Affairs. Dr CD McQuaid and Mr R Perissinotto commented very constructively on the manuscript in its draft form. Thanks are due to Capt Toxopeus, master of the *SA Agulhas*, his officers and crew for help at sea.

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