Offshore measurements late in the river plumes associated with cyclone Sadie

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Abstract

Cyclone Sadie caused a large rain depression over most of the north Queensland catchment area, with river runoff creating a complex plume that stretched to the outer reefs. On the 4th of February 1995, the Long Term Monitoring Program (LTMP) collected water quality samples along a transect between the Brook Islands and the Mulgrave river in the aftermath of cyclone Sadie. Water quality parameters measured included dissolved nitrogen and phosphorus species, chlorophyll a, suspended solids and salinity, which were sampled at four depths through the water column.

While the concentrations of nutrients, suspended solids and chlorophyll were found to be higher than 'normal' they were lower than other recorded flood events. As the minimum salinity was 29 ‰ for all of the sites, it is probable that mixing processes had returned salinity to near 'normal' levels. Elevated ammonia concentrations were recorded at all sites, though some surface levels were low indicating that phytoplankton activity had taken up much of the available ammonia. High NO_3-NO_2 *levels were only recorded at one site. Dissolved organic nitrogen (DON) concentrations were generally similar to non-flood levels. High values were recorded at sites which corresponded to high levels of silicate, indicating that the high DON water had a terrestrial origin. Levels of dissolved inorganic and organic phosphorus remained relatively low at all sites, suggesting that most phosphorus coming from the rivers was transported and remained as particulate matter. Chlorophyll levels were generally high across the sites with the most elevated levels recorded where ammonia levels were low.*

The low concentrations of dissolved nutrients associated with the cyclone Sadie plume may be either related to the two day time lag between the rain event and actual sampling or the plume characteristics itself (weather or catchment affected). This discrepancy will only be completely resolved as more cyclone datum, comparing different events and different catchments, becomes available.

Introduction

The Long Term Monitoring program (LTMP) based at the Australian Institute of Marine Science (AIMS) has a water quality component which monitors a range of water quality parameters over a whole-Great Barrier Reef (GBR) spatial scale, once to several times per year. Comprehensive hydrographic, nutrient (dissolved organic and inorganic forms) and chlorophyll measurements are made at each site.

The LTMP emphasis on broad-scale spatial monitoring does not generally allow sampling of flood events which episodically occur in the central and southern Great Barrier Reef. These events induce dramatic regional-scale changes in water quality (Furnas 1993). Typically, increased river runoff results in nutrient and phytoplankton levels far in excess of those measured under non-flood conditions. In order to enhance our knowledge of the complex spatial and temporal properties of the GBR shelf water, it is essential that any monitoring program must include sampling to measure variability associated with freshwater plumes or other large-scale disturbances.

During February 1994, the opportunity arose for the LTMP to take water samples along the central Great Barrier Reef coastline between the Brook Islands and the Mulgrave River (Fig. 1). The geographic extent of the bio-physical impacts arising from cyclone Sadie was largely restricted to rivers between Cairns and Cooktown. Because of time constraints, sampling was initiated on the February, two days after the main flood peak had occurred. The rain depression caused by the cyclonic low pressure system caused a rapid increase in river water levels and discharge into the Great Barrier Reef lagoon. The plume was visible for approximately four to five days, and eventually reached the outer reefs. The volume of river discharge was not large in comparison to other cyclonic events and there was essentially no sediment re-suspension caused by heavy winds within the lagoon. This lack of re-suspension, coupled with the time lag involved before commencement of sampling, may cause the concentrations of dissolved nutrients measured within this plume to be lower in comparison to other plumes (Furnas and Mitchell 1986; Brodie and Mitchell 1992).

Methods

Water samples hourly while the research vessel was steaming. Sampling consisted of either depth sampling stations (1, 4, 7 and 10) or a single surface sample. Sub-surface sampling consisted of three Niskin bottles spaced out over the depth profile with a surface sample taken by bucket (Figs. 2, 3). In situ temperatures were recorded by digital reversing thermometers attached to the Niskin bottles. At all other sites, surface water was collected with a bucket. At each station, cloud cover, wind speed, wind direction, tide and acoustic depth were recorded Water transparency was measured by secchi disk, and the presence of *Trichodesmium spp.* noted visually.

Sample processing was carried out using a work station which included a vacuum pump, vacuum reservoir, and filtration manifold. Sub-samples were dispensed from the Niskin bottles into appropriate containers. Filtration of water samples for chlorophyll analyses and suspended solids was carried out on the filtration manifold and nutrient and silicate samples were filtered with a 50 ml plastic syringe and individual 0.45 µm membrane disposable filters. Discrete sub-samples were retained for salinity measurements.

Water samples for nutrient analysis were analysed according to the Standard Operational Procedure (AIMS 1994) for inorganic ammonia (NH_4), nitrite (NO_2), nitrate (NO_3), total dissolved nitrogen (TDN), dissolved organic nitrogen (DON), dissolved inorganic phosphorus (PO_4), total dissolved phosphorus (TDP), dissolved organic phosphorus (DOP) and silicate (Si). Analysis of chlorophyll, suspended solids and salinity were carried out at AIMS according to Standard Operational Procedures (AIMS 1994).

Results and Discussion

Values for oceanographic and nutrient parameters within the plume were generally higher than values recorded in non-flood conditions (Furnas 1990), though concentrations of the parameters were lower than those taken in studies of other plumes (Brodie and Mitchell 1992; Furnas 1990). Water quality data available for the area, between Cape Grafton and Dunk Island, include nutrients, chlorophyll and transparency parameters (Furnas 1990; Furnas et al. 1993). Depth weighted average concentrations for midshelf water in this area (10 - 30 metres) in normal (non-flood) conditions are given in Table 1 and are compared with samples taken during flood conditions in the present study.

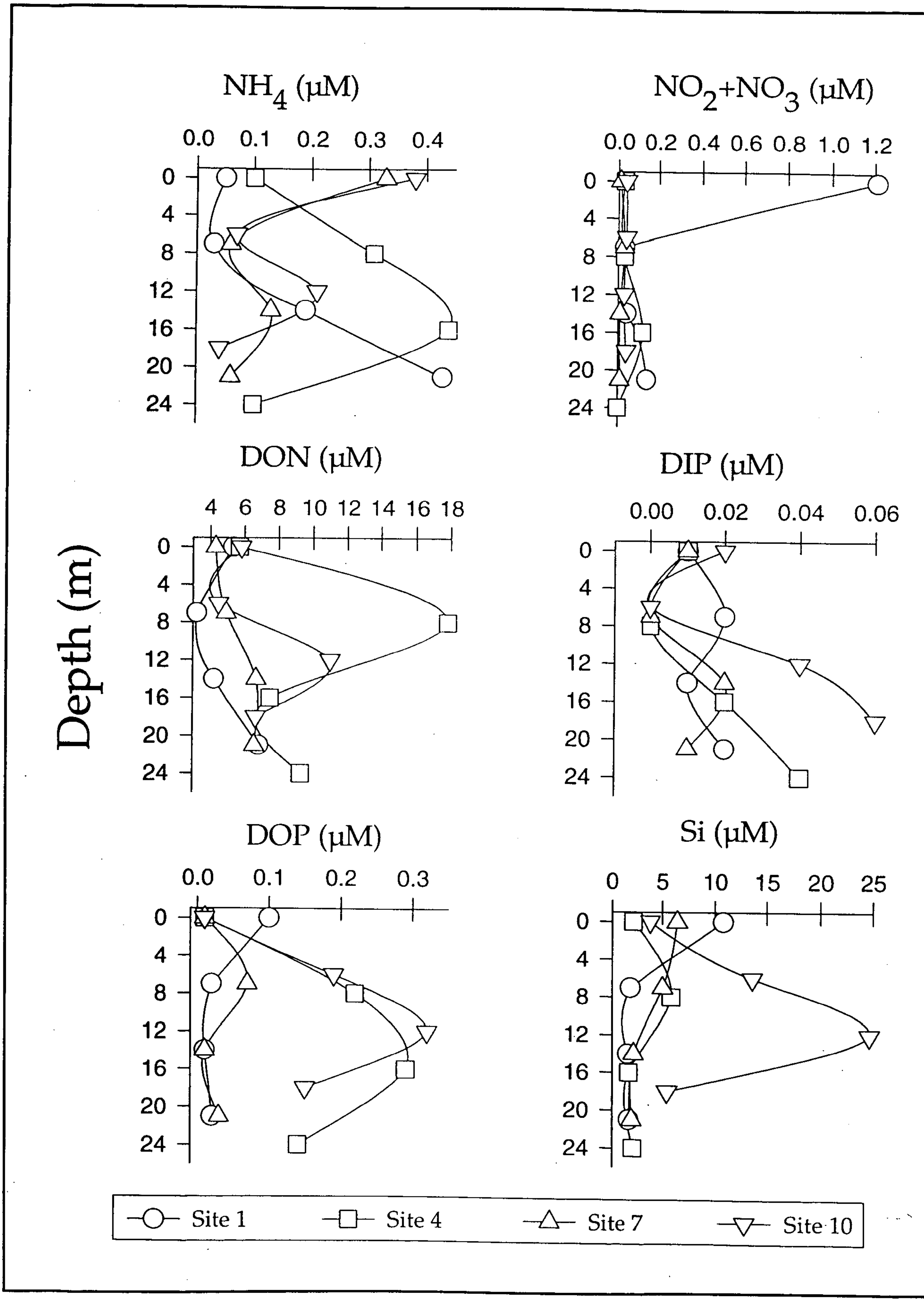

Fig. 2. Depth profiles of dissoved nutrients in the cyclone Sadie plumes at sites 1, 4, 7 and 10

Table 1. Summary statistics for mean water column concentrations of dissolved nutrients for theTully area (depth 10 to 30m) (Furnas 1991).

	NH_4 µmol/L	NO_2 µmol/L	NO_3 µmol/L	DON µmol/L	PO_4 µmol/L	DOP µmol/L	SiO_4 µmol/L	Chl µg/L
Mean	0.220	<0.010	0.040	5.260	0.140	0.180	0.3480	0.330
Std Dev	0.290	0.007	0.021	1.888	0.052	0.079	1.873	0.160
No. Sta.	27	27	27	12	27	12	27	26

Near surface salinity was diluted with freshwater at sites 1, 2 and 8 north of the Herbert, South and North Johnstone rivers (Fig. 4). Surface salinities ranged from 29 to 36 ‰, whereas in other studies freshwater influences have caused surface salinities to drop below 10 ‰ (Brodie and Mitchell 1992; Furnas 1990). This indicates that mixing processes between the surface and bottom layers had, within two days, returned salinity to near normal levels.

The chlorophyll levels measured in this study were higher than values recorded under non-flood conditions, indicating an increased level of phytoplankton growth. Chlorophyll concentrations were highest at site 1, approximately three times that of normal midshelf levels. The lower phaeophytin values confirm that most of chlorophyll detected was associated with new algal biomass rather than terrestrial or marine detrital material (Brodie and Mitchell 1992).

Table 2. Oceanographic data from cyclone Sadie sampling along coastline

Stn	Depth (m)	Temp °C	Salinity (ppt)	Chloro (µg/L)	Phaeo (µg/L)	SS (mg/L)
1A	0	-	29.2007	1.326	0.596	2.54
1B	7	28.94	35.3339	0.868	0.491	0.89
1C	14	-	35.5238	1.403	0.565	1.28
1D	21	28.70	35.3704	0.984	0.448	1.48
2	0	-	30.1633	-	-	-
3	0	-	35.5116	-	-	-
4A	0	-	35.3504	0.598	0.355	1.17
4B	8	29.43	35.3304	0.587	0.233	0.82
4C	16	-	35.397	0.796	0.311	1.12
4D	24	28.86	35.3911	0.934	0.378	1.41
5	0	-	35.4327	-	-	-
6	0	-	35.2484	-	-	-
7A	0	-	35.2594	0.574	0.182	1.43
7B	7	29.43	35.2261	0.564	0.211	1.5
7C	14	-	35.3131	0.962	0.225	1.16
7D	21	29.06	35.3123	0.752	0.355	1.29
8	0	-	34.2927	-	-	-
9	0	-	35.1034	-	-	-
10A	0	-	35.1881	0.565	0.278	1.73
10B	6	28.88	35.1371	0.644	0.315	1.19
10C	12	-	35.1763	0.730	0.357	0.93
10D	18	28.48	35.23	0.215	0.133	2.13
11	0	-	35.2723	-	-	-

NH_4 concentrations are low at the surface with an increase in concentration in the sub-surface samples. The surface NO_3 levels at site 1 are high with a sharp decrease down the water column. NO_2 levels stay constant throughout sites and depths at levels similar to non-flood values. Ammonia concentrations at the other sites are only slightly higher than the non-flood values recorded by Furnas

(1990) suggesting that though the plume was still visible the available dissolved nitrogen has to a large extent been assimilated into the phytoplankton. The highest chlorophyll reading was recorded in the surface layer at site 1.

As inorganic nitrogen species (NH_4, NO_2, NO_3) are quickly taken up by benthic or pelagic plants even eutrophic systems may not show high levels of dissolved inorganic nutrient species despite high inputs (Brodie and Mitchell 1992). During the two days between the flood event and the sampling, nutrient concentrations may have decreased from initial high flood levels. In a fairly brief time, some portion of terrestrial sediment would have fallen out of the water column, allowing greater light penetration. This, combined with the clearing of cloud cover, would allow the phytoplankton to take up the elevated concentrations of dissolved nutrients.

The dissolved nitrogen pool is dominated by dissolved organic nitrogen (figure 2). DON values are generally similar to non-flood events with the high concentrations recorded at sites 4 and 10. Cosser (1989) suggests that most phosphorus transported to the sea by Queensland river systems is bound to particulate matter. This is supported by the low dissolved inorganic phosphorus (DIP) levels recorded in the present study. DIP concentrations recorded in the Sadie plume are similar to non-flood values recorded for the Tully area (Furnas 1990). High concentrations of dissolved organic phosphorus (DOP) were recorded only in sub-surface samples at sites 4 and 10 which are slightly north of the Tully and Mulgrave-Russell rivers respectively. At all other sites, including the surface samples at sites 4 and 10, there were very low concentrations of DOP. These low values could have resulted from dilution processes of the seawater with the low organic levels contained in the freshwater plume. Future river plume sampling should include the measurements of particulate nutrient species to fully assess the transport of nutrients into the reef lagoon from rivers.

Table 3. Nutrient concentrations (μM) from cyclone Sadie plume sampling

STN	Depth	NH_4	NO_3	NO_2	DON	PO_4	DOP	Si
1A	0	0.05	1.20	0.01	5.34	0.01	0.10	10.8
1B	7	0.03	0.02	0.01	3.21	0.02	0.01	1.8
1C	14	0.19	0.03	0.01	4.23	0.01	0.18	1.5
1D	21	0.43	0.13	<0.01	6.85	0.02	0.06	1.6
4A	0	0.10	0.02	0.01	5.69	0.01	0.01	2.1
4B	8	0.31	0.02	<0.01	17.83	<0.01	0.22	5.8
4C	16	0.44	0.10	0.02	7.50	0.02	0.29	1.6
4D	24	0.10	<0.01	<0.01	9.30	0.04	0.14	2.0
7A	0	0.33	0.01	<0.01	4.31	0.01	0.01	6.4
7B	7	0.06	0.02	0.01	4.94	<0.01	0.07	5.0
7C	14	0.13	<0.01	0.01	6.70	0.02	0.01	2.1
7D	21	0.06	<0.01	0.01	6.60	0.01	0.03	1.9
10A	0	0.38	0.02	0.02	5.82	0.02	0.01	3.8
10B	6	0.07	0.03	0.01	4.49	<0.01	0.19	13.6
10C	12	0.21	0.01	0.02	10.98	0.04	0.32	24.6
10D	18	0.04	0.03	0.01	6.68	0.06	0.15	5.4

Despite time limitations, this small study has led to some interesting conclusions about the fate of dissolved nutrients in a freshwater plume. Generally the concentrations of dissolved nutrients (Table 2) and phytoplankton (Table 3) in the cyclone Sadie plume were higher than non-flood periods with high variability between sites and position in the water column. The variability between sites may be related to catchment characteristics and the specific upstream activities connected with each catchment. The low concentrations of some dissolved species in the plume indicates that the uptake of the dissolved nutrients by the phytoplankton may have occurred within a relatively short time.

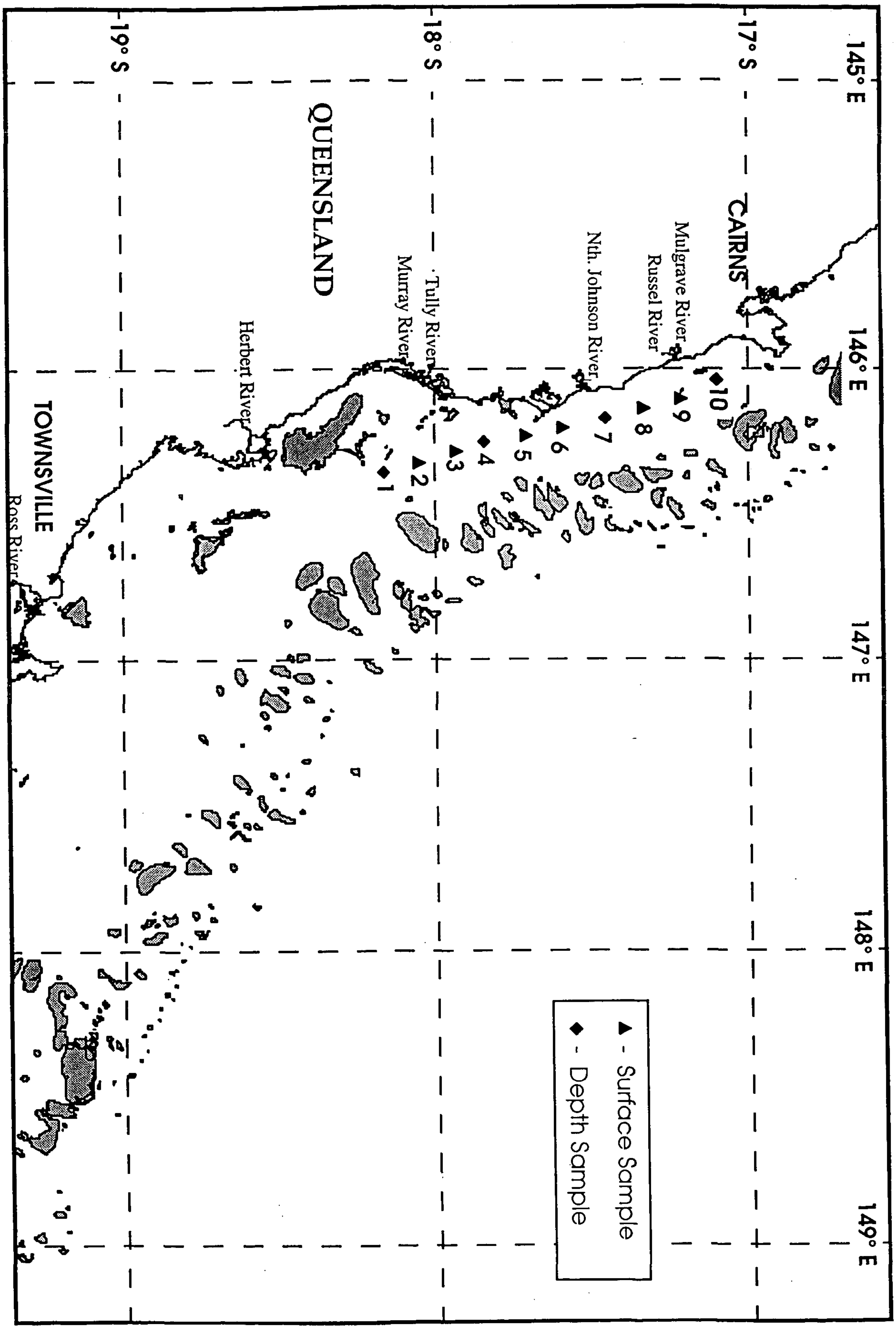

Fig. 1. Location of sampling sites taken by the R.V. Sirius on 4th February 1994

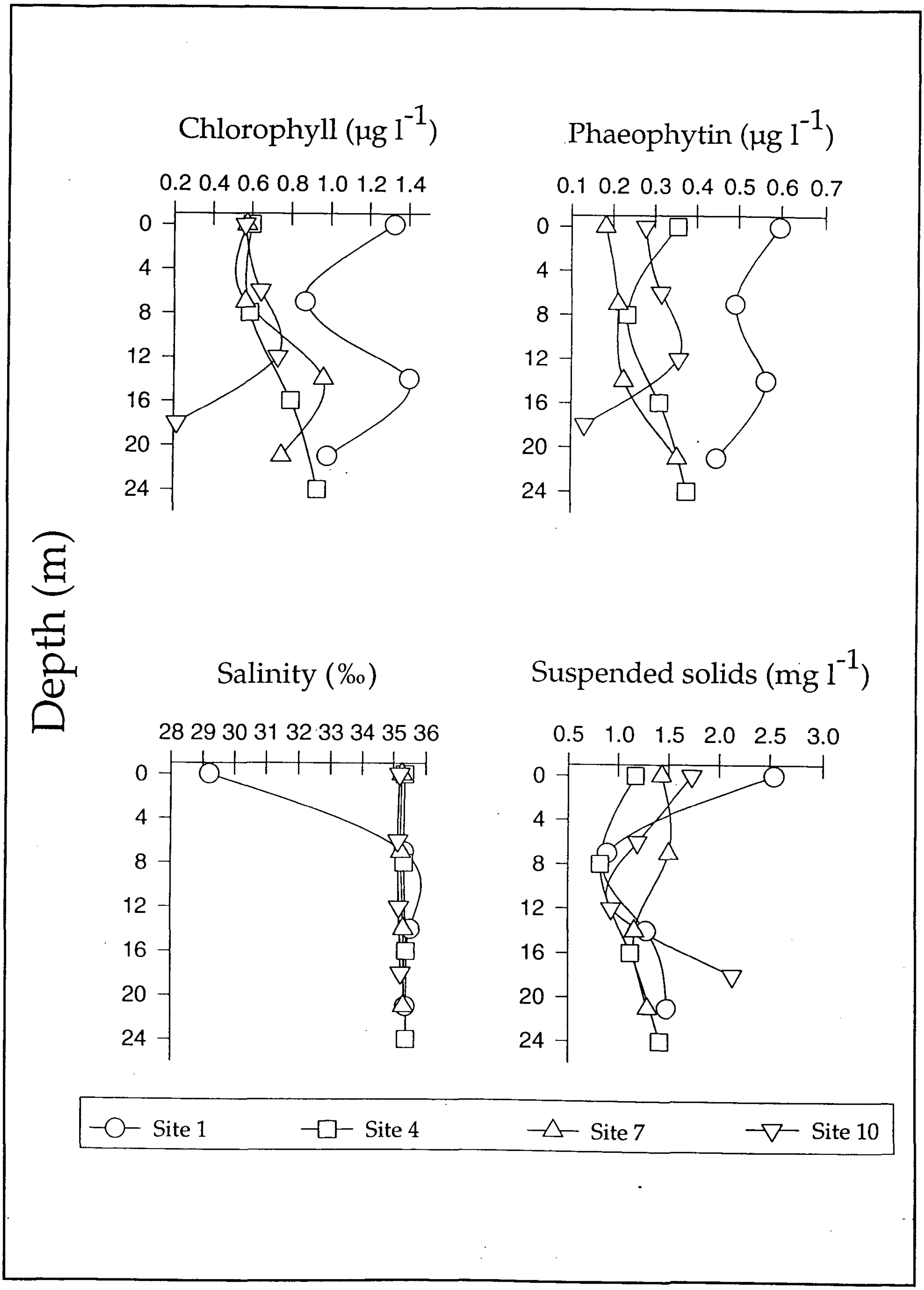

Fig. 3. Depth profiles of oceanographic data sampled in the cyclone Sadie plume at sites 1,4, 7 and 10

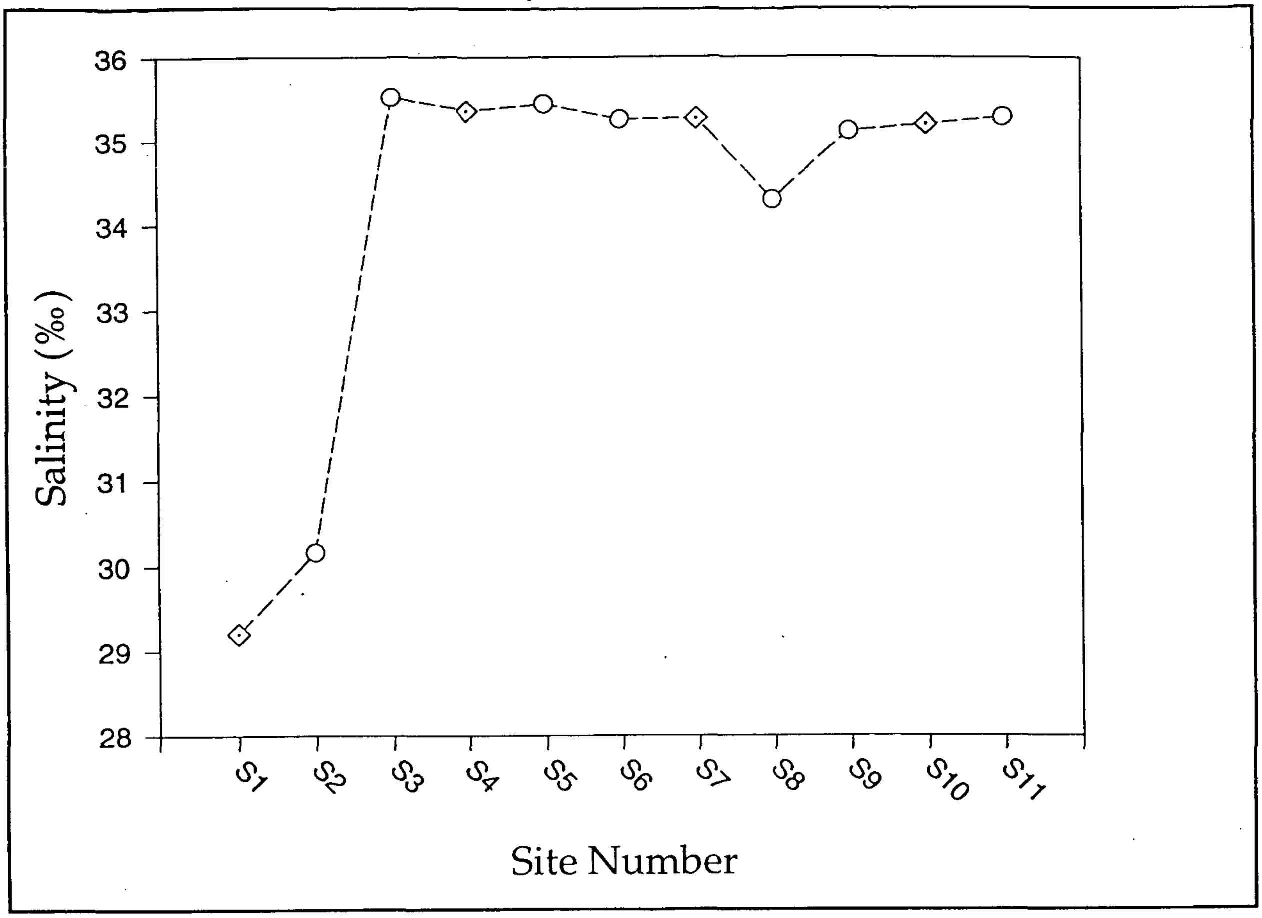

Fig. 4. Salinity surface levels across the sampling site

Clearer resolution of flood waters effects in the GBR lagoon would involve increased sampling of all dissolved and particulate nutrient species and the initiation of sampling as close as possible to the start of the flood event. The successful monitoring of any large flood event could only be improved by rapid and intensive sampling techniques and greater awareness of the individual characteristics of each catchment.

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