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Biomass and distribution of macroalgae in Oyster Harbour, Western Australia, in late summer following a high winter rainfall

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Preface

This study was conducted by the Centre for Water Research, Murdoch University and forms part of the Albany Harbours Environmental Study (1988-1989). A summary of the Albany Harbours Environmental Study (1988-1989) findings, and the recommendations of the Technical Advisory Group to the Environmental Protection Authority, can be found in Albany Harbours Technical Advisory Group (1990) Bulletin 412 of the Environmental Protection Authority.

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1. Introduction

Previous work has shown that accumulations of macroalgae have been associated with the loss of seagrasses in Oyster Harbour, near Albany in Western Australia (Bastyan, 1986; Kirkman, 1987). This observation prompted further studies into the water quality, seagrasses and macroalgae of the harbour, including an intensive sampling program in February 1988 to determine the size of the nutrient pools in water, sediments and plants (Hillman *et al*, 1990).

The year preceding the 1988 sampling program had the lowest rainfall in sixteen years, and this would have resulted in low runoff and low stream nutrient loading. However, the next winter (1988) was the wettest in ten years, with consequent increased river flow. It was suggested that macroalgal biomass might have increased in summer 1988/1989, in response to a presumably increased nutrient load. A survey was therefore carried out in March 1989 to check this hypothesis, using the same techniques as those employed in the previous summer.

2. Methods

Survey methods and data processing were identical to those used in summer 1988 (Hillman *et al*, 1990). However, it became clear that significant changes had occurred in the distribution of the algae, and so the survey data were again supplemented by inspections carried out at other areas, and by inclusion of five additional sites (Figure 1).

Direct comparison of data between years was only made from the same sites since, although the absolute estimates are inevitably prone to inaccuracy because of the rather small number of sites, adoption of the same sites and statistical techniques for analysis should disclose trends between years (Lukatelich and McComb, 1988).

3. Results

3.1 Comparison of biomass between years

Macroalgal biomass was dominated by *Cladophora prolifera*, which accounted for approximately 90% of total biomass (Table 1). This species also accounted for some 90% of biomass in the 1988 survey. There was a reduction of some 12% in the biomass of both this species and macroalgae in general, but this was probably not significant in view of the sampling method. The hypothesis that an increased macroalgal biomass might be expected following a winter season with heavy runoff was not supported.

Table 1. Macroalgal biomass in Oyster Harbour, February 1988 and March 1989, estimated from 15 sites.

	February 1988 Biomass		March 1989 Biomass	
	Tonnes	% of total	Tonnes	% of total
Cladophora	1107.0	92.50	972.0	93.10
Chaetomorpha	13.0	1.10	12.0	1.10
Enteromorpha	0.5	0.04	0.1	0.01
Red algae	3.0	0.20	0.5	0.05
Brown algae	0.5	0.04	0.4	0.04
Cyanophyta Blue-Green algae	73.0	6.10	59.0	5.70
Total	1197.0	100.00	1044.0	100.00

Of the other prominent algae, the biomass of *Chaetomorpha* was unchanged and there was little evidence of change for *Enteromorpha*. The decrease in biomass of red algae, approximately 80%, may well have been significant. Macroscopic accumulations of blue green algae with erect filaments making up a layer up to 20 cm thick were present on the sediment surface and dead seagrass rhizomes. There was an apparent decrease of 20%, but the errors in sampling and calculation were less accurate than for the macroalgae, and this change was probably not significant. The genus of blue green was probably *Lyngbya* (D. Walker and V. Hosja, pers. comm.).

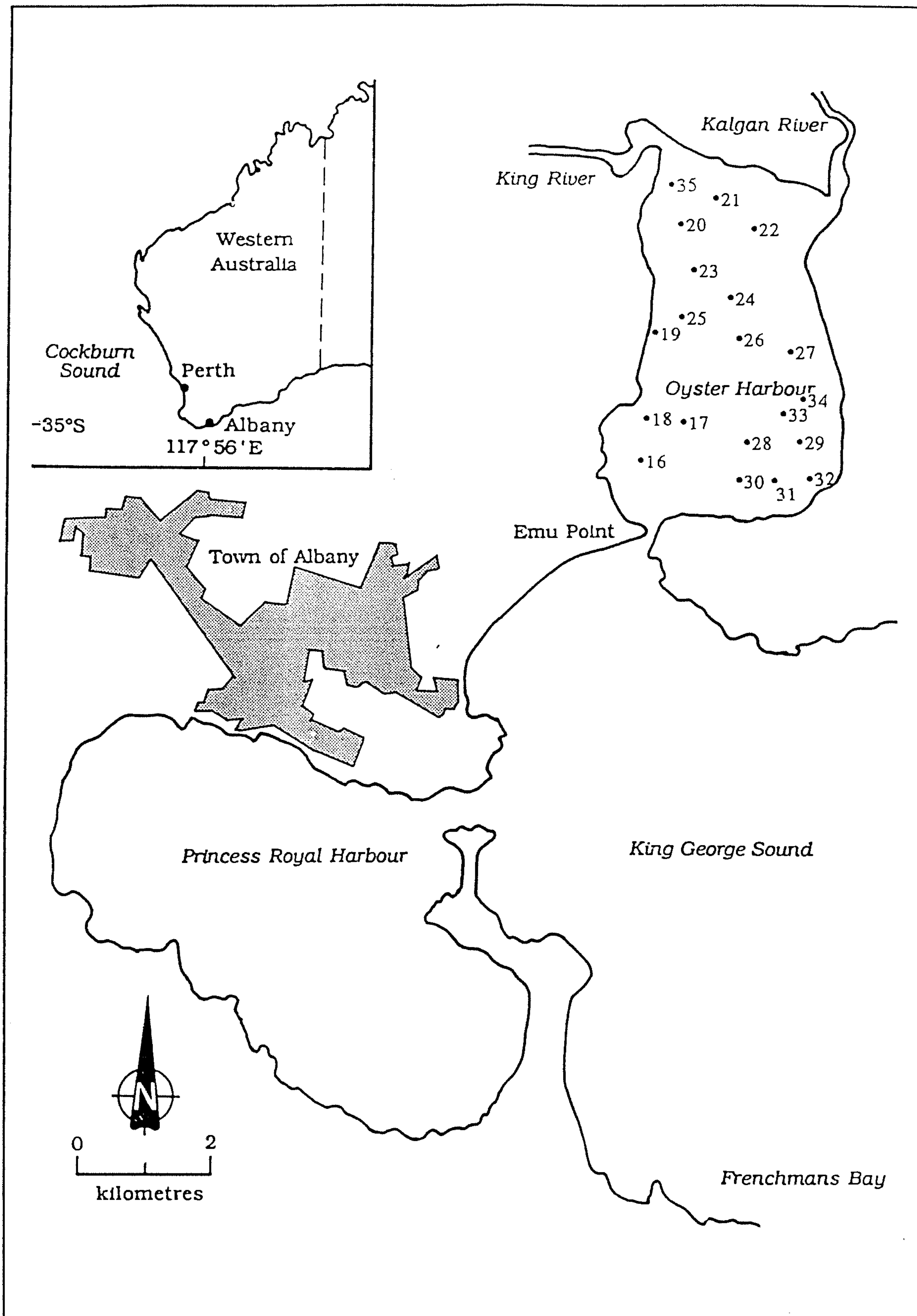

Figure 1. Oyster Harbour study area with grid study sites shown.

3.2 Changes in distribution between years

Although there was little change in total biomass, there were changes in the distribution of biomass. A marked reduction in area occupied by the highest biomass category (located between sites 27 and 29) occurred between 1988 (Figure 2) and 1989 (Figure 3). A relatively large biomass of *Enteromorpha* (several species) was observed on the shallow flats near the two rivers at the north of the estuary, and especially the Kalgan River. *Enteromorpha* accounted for much of the biomass seen in that region (Figure 3). In the previous year there were no areas of algal abundance in that area, which had been closely inspected; an additional site was included there in the survey of biomass reported below.

Chaetomorpha linum also showed a more extensive distribution in 1989, and was more abundant on the shallow (less than two metres) flats to the east of site 22 near the Kalgan River (Figure 1).

The distribution of red algae and blue-green accumulations had not changed significantly; both were largely confined to the southern half of Oyster Harbour, where the red algae were in deeper water and the in shallower water (to a depth of about three metres).

3.3 Biomass estimated from 20 sites

Because of the altered distribution of macroalgae, five additional sites (sites 31 to 35 inclusive) were included in the 1989 survey. Estimates of biomass resulting from all twenty sites are given in Table 2. It would not be appropriate to use these data in detailed comparison with the previous year, since as noted above only comparable sites can be used for that purpose. Nevertheless some useful points can be made. The estimated 120 tonnes of *Enteromorpha* is almost entirely accounted for by the area noted above, the shallow flats near the mouth of the two rivers, areas in which extensive field work in 1988 revealed no stands of this genus. The increase in biomass of this algae is therefore undoubtedly significant between the two years, and is sufficient to raise the percentage of macroalgal biomass contributed by *Enteromorpha* very markedly, from 1% to 7% of the total. The additional sites also raised the biomass estimates for *Cladophora*, *Chaetomorpha* and macroalgae in general, when compared to those based on 15 sites.

Table 2. Macroalgal biomass in Oyster Harbour, March 1989, estimated from 20 sites.

	Tonnes	% of total
Cladophora	1449.0	88.00
Chaetomorpha	18.0	1.10
Enteromorpha	120.0	7.30
Red algae	0.5	0.06
Brown algae	0.4	0.04
Cyanophyta		
Blue-Green algae	58.5	3.50
Total	1646.0	100.00

Small quantities of another genus of green alga, *Ulva*, were present in both surveys. They occurred with *Enteromorpha* but were more readily seen as beach drift.

4. Discussion

The total biomass of macroalgae was approximately the same in 1989 as in 1988. The general hypothesis that there might be an increase in biomass in the whole estuary following a year of winter inflow must be rejected.

There was no obvious increase in the biomass of the dominant macrophyte, *Cladophora prolifera*. The physiology of this mainly marine species may well resemble that of the species *Cladophora montagneana*, which has been extensively studied from Peel Inlet (eg. Gordon *et al*, 1985). *C. montagneana* shows distinct seasonality in growth, with negative growth rate during winter resulting from low temperatures and especially

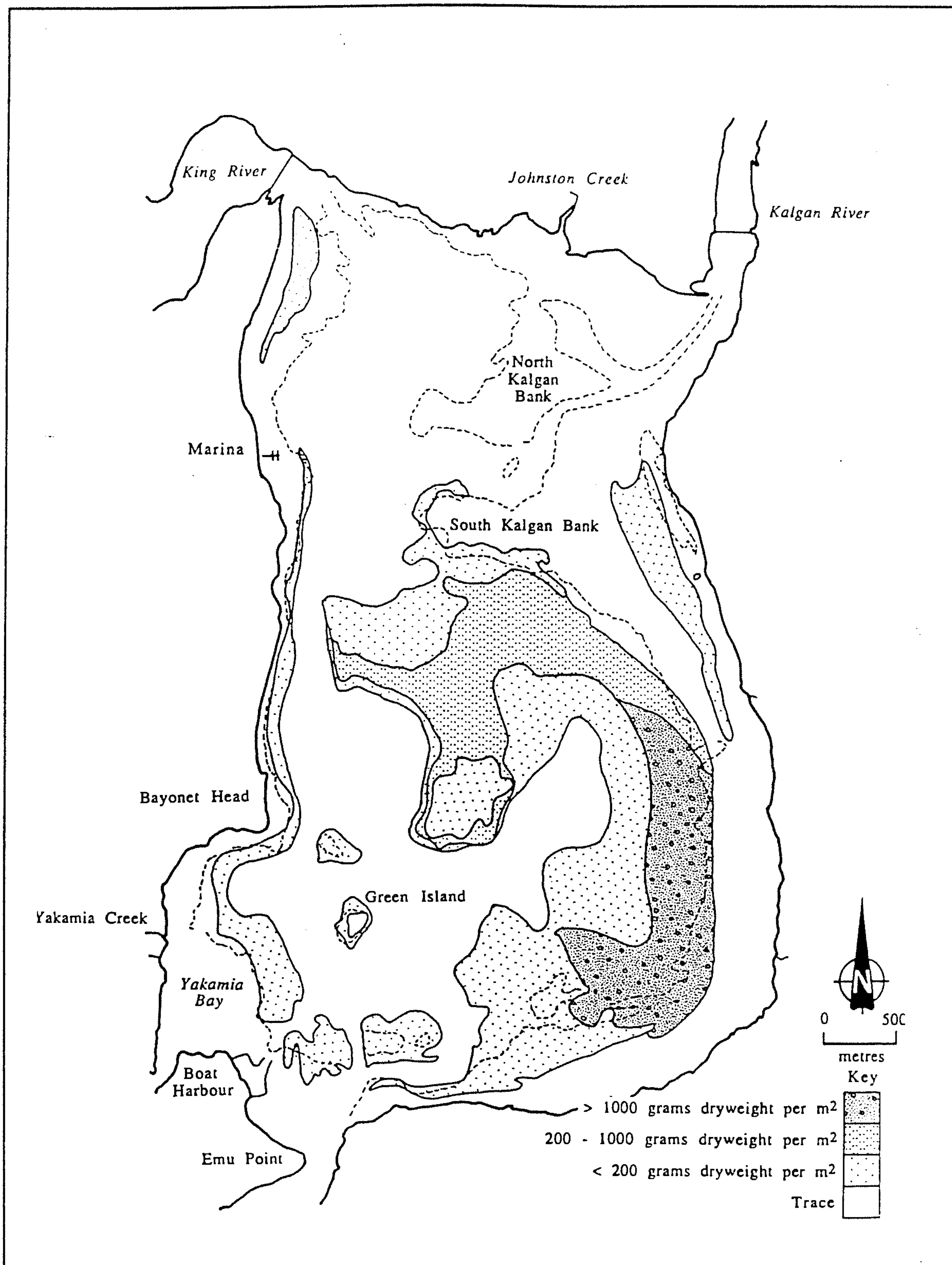

Figure 2. Distribution of macroalgae biomass in Oyster Harbour, February 1988.

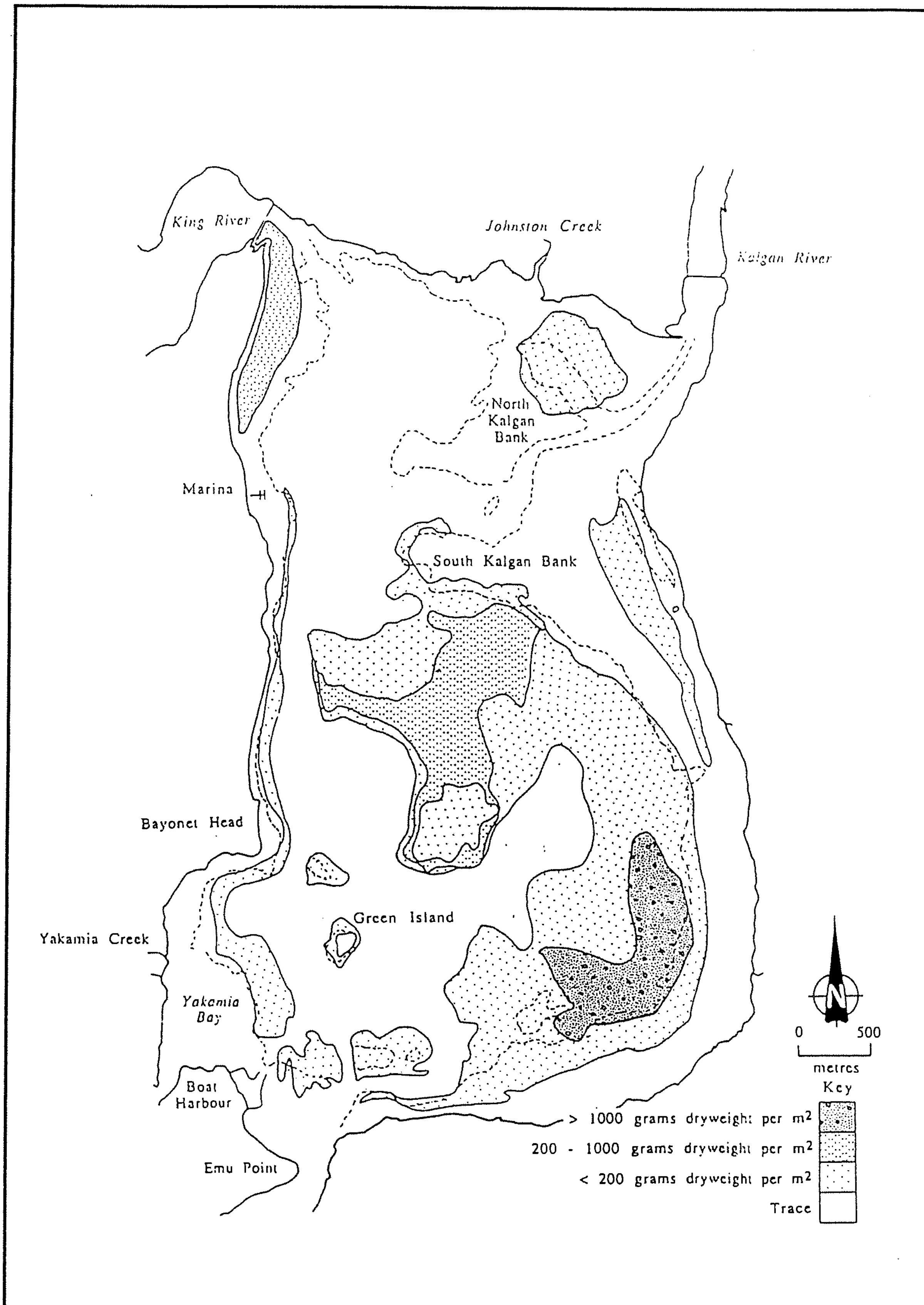

Figure 3. Distribution of macroalgae biomass in Oyster Harbour, March 1989.

from light attenuation. The growth period of *C. montagneana* is spring and early summer, when light intensity is critical in the achievement of high growth rates (Gordon *et al*, 1980); there is a close correlation between the biomass of the macroalgae in Peel Inlet, and light attenuation through the water column during the growth period (Lukatelich and McComb, 1985). On the other hand *C.montagneana* is insensitive to change in salinity (Gordon *et al*, 1980). Presumably light attenuation may be the factor which largely restricts *Cladophora* to the southern part of Oyster Harbour, as the light attenuation in the northern part is typically double that of the southern section (Hillman *et al*, 1990). It is possible that light conditions following the wet winter continued to be unfavourable to *Cladophora* growth in the north.

The situation appears similar to that in Peel Inlet, where the biomass of macroalgae is related to light attenuation during the growth season, rather than to nutrient loading from the river during a particular winter (Lukatelich and McComb, 1988).

On the other hand, there was a marked increase of *Enteromorpha* on the shallow flats adjacent to the points of river discharge into the estuary. This increase was most likely due to the high river flow and presumed increased nutrient loading in 1988. Similar trends for this opportunistic alga have been documented for the Peel Harvey system, where in February 1988 *Enteromorpha* constituted some 14% of total biomass, but increased to 48% in February 1989 (Lukatelich and McComb, 1988).

Although not a large component of total biomass (the species of *Enteromorpha* represents only 7% of the total), the increase in biomass indicated nutrient enrichment of the shallow flats. These were not sampled quantitatively in the earlier survey because it was clear that macroalgae were not prominent there, but additional sites recorded in the present work will enable the distribution in this area to be studied if necessary in future years.

Like *Enteromorpha, Chaetomorpha* was more widely distributed on the shallow flats to the east of site 22, near the mouth of the Kalgan River, in the present survey. This species has been found by Lavery (1988) to take up more phosphorus and nitrogen per unit dry weight than *Cladophora*, and maintain a relatively fast growth rate throughout the year, compared with *Cladophora*. Both *Enteromorpha* and *Chaetomorpha* are opportunistic, competitive genera, presumably able to utilise nutrients derived from the river systems in Oyster Harbour.

Surveys undertaken in 1981 and 1984 by Bastyan (1986) disclosed very little *Enteromorpha*, *Chaetomorpha* and *Ulva*, but these algae had accumulated to appreciable levels of biomass in the summers of 1987 and 1988. Although present even after winters of below-average rainfall, their biomass and distribution have increased following the wet winter of 1988. As these algae presumably grow most rapidly in spring and summer, the mechanism of nutrient accumulation following winter river flow is of some interest and would be usefully investigated. In the Peel Harvey system (Lukatelich and McComb 1986) and possibly Wilson Inlet (Lukatelich et al., 1987) the uptake of nutrients by phytoplankton provides the primary nutrient-trapping mechanism, and this may be the mechanism in Oyster Harbour.

5. Conclusions

Total algal biomass in Oyster Harbour in 1989 remained at a level similar to 1988, despite significant differences in rainfall and presumably in nutrient inputs.

Cladophora continues to be the dominant macroalga in Oyster Harbour, making up some 90% of biomass. There were some alterations in its distribution.

There was a marked increase in *Enteromorpha*, especially near to the river mouths, and a smaller increase in the area occupied by *Chaetomorpha*. These changes are consistent with the suggestion that these opportunistic algae have increased in response to increased nutrient loading during a winter of high rainfall.

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