SUMMARY

In 1992 the Great Barrier Reef Marine Park Authority initiated the Great Barrier Reef Nutrient Status Monitoring Network (hereafter the Network). The broad objectives of the Network are to document the nutrient status of regional waters within the Great Barrier Reef lagoon using chlorophyll *a* concentration as a proxy nutrient bioindicator. Chlorophyll *a* is used in preference to routine nutrient analysis because (a) chlorophyll *a* integrates change in nutrient availability over time; (b) samples are comparatively simple to collect; and (c) chlorophyll *a* is comparatively inexpensive to analyse. The Network was conceived to be ongoing, and to complement and collaborate with a number of other existing monitoring programs to ensure comprehensive reporting of the status of the Great Barrier Reef (GBR).

The purpose of this status report is twofold: (1) to detail the objectives, the design and sampling protocols of the Network, and (2) to describe the results from the first three and one-half years of data collection, and identify the major spatial and temporal trends in chlorophyll *a* concentrations. The report is descriptive, but provides a basis for further analysis of the data and reconsideration of the efficacy of the current Network design.

The Network initially commenced in late 1992 with five regional (quasi-latitudinal) clusters: Lizard Island (14°S), Port Douglas (15°S), Cairns (16°S), Keppel Bay and Capricorn (23°S). Monitoring of further clusters of stations commenced off Townsville (18°S) in 1995, and off the Whitsundays (21°S) and in the Far Northern Section (13°S) in 1996. These clusters are not interconnected, nor spatially representative; some extend from close to the coast to the shelf-break, while others are confined to either inshore (< 20 km from the coast) or offshore waters. The choice of clusters was primarily dictated by the availability of personnel who were contracted to undertake routine, long-term sampling.

Within each cluster, five to eight GPS fixed stations are sampled at approximately monthly intervals. Two water samples are collected from near-surface waters for chlorophyll *a* determination. Concurrent near-bottom samples were also collected until mid-1994, but discontinued on the basis of initial data analysis and increased operating costs. At each station, temperature, salinity and Secchi depth measurements are made and weather conditions noted.

The results presented in this report cover the period January 1993 to July 1996, except for the Townsville cluster. To identify cross-shelf patterns, stations were nominally divided into inshore and offshore groups. Chlorophyll *a* concentrations at inshore stations were ~twofold higher than offshore, but also much more variable. Inshore, median chlorophyll *a* concentrations in Keppel Bay and off Townsville were greater than 0.5 $\mu g\ L^{-1}$ and often exceeded 1 $\mu g\ L^{-1}$ at stations within 2 km off the coast. Offshore, median chlorophyll *a* concentrations varied between 0.17 $\mu g\ L^{-1}$ at Cairns and 0.36 $\mu g\ L^{-1}$ in the Capricorn cluster.

Chlorophyll *a* concentrations, averaged over all stations within a cluster, were greatest in Keppel Bay (0.76 $\mu g\ L^{-1}$) and the Capricorn (0.62 $\mu g\ L^{-1}$) clusters. High chlorophyll *a* concentrations were very patchy even between replicate samples; they probably result from *Trichodesmium* aggregations which were present in over 30% of observations. In all other clusters, mean chlorophyll *a* concentrations were 0.26–0.42 $\mu g\ L^{-1}$, and *Trichodesmium* was observed in less than 8% of sampling events. Why these blooms are more frequent in southern GBR lagoon waters is unknown. Given the paucity of oceanographic data in this region, this finding is significant.

Chlorophyll *a* concentrations were generally greater in summer (October–April inclusive) than winter (May–September). Seasonal differences were discernible at offshore stations, but were obscured by high temporal variability inshore. Chlorophyll *a* concentrations in the Lizard, Port Douglas, Cairns and Capricorn clusters were greatest in 1993 and decreased in the following two years. In contrast, chlorophyll *a* concentrations in the Keppel Bay cluster were greatest in 1995. Preliminary trend analyses found no significant changes in mean chlorophyll *a* concentration for any cluster. Consistent with the observed interannual patterns described above, a negative slope estimate at offshore stations indicated a decline in chlorophyll *a* concentration from 1993 to 1995. A drought persisted through 1991–95 and regional run-off was considerably below the long-term average. This may have contributed to the

observed temporal trends. However, it must be noted that several more years of data will need to be collected before trends can be reliably estimated.

Lack of reliable hydrographic instrumentation and regular calibration prevented examination of the relationship of these observed spatial and temporal patterns in chlorophyll *a* concentration with temperature and salinity changes. Generally, short-term phytoplankton blooms rapidly followed changes in salinity resulting either from rainfall or riverine discharge, or from intrusions of upwelled water masses. No significant relationship between chlorophyll *a* concentration and Secchi depth was identified in any cluster.

In summary, the routine collection of chlorophyll *a* data over such a large and important geographic area is an invaluable dataset. The data collected in the first three and one-half years demonstrate persistent cross-shelf and regional differences in chlorophyll concentration. Seasonal and interannual trends are generally consistent between regions. The nutrient status of GBR waters cannot, however, be inferred from these data, as clusters are not explicitly linked to regional nutrient input data. The spatial and temporal patterns identified do, however, provide a basis for redesign of the Network and reallocation of sampling effort. This is essential if the Network is to infer long-term changes in the nutrient status of the GBR lagoon. Specific recommendations include:

- Clear, explicit objectives are needed before any redesign takes place. These should include both broad strategic objectives for the maintenance of 'water quality' within the GBR lagoon, as well as specific technical objectives for the measurement of chlorophyll and inference of nutrient status.
- Explicit links to putative nutrient sources should be made. Monitoring stations should be linked to other ongoing catchment and river monitoring (e.g. Queensland Department of Environment and Heritage, Queensland Department of Natural Resources, Australian Institute of Marine Science).
- Techniques linking chlorophyll *a* concentrations to nutrient status have not been defined. This has been a major hindrance to the interpretation of the data. Technical expertise should be sought in developing these relationships and models.
- Other bioindicator techniques such as primary productivity estimates should be considered as part of the Network. These measurements could be carried out most routinely by research station staff.
- Size fractionation of samples into picoplankton (< 2 μm) and phytoplankton (> 2 μm) would provide greater inference as to which species respond most readily to changes in nutrient availability.
- Remote sensing has the capacity to greatly extend the inferences made about spatial dynamics of regional chlorophyll *a* patterns. Both SEAWIFS and AIDOS will provide high-frequency coverage of the GBR region. The integration of this technology into the Network is recommended.
- Several specific changes to the clusters are recommended: (1) within the Lizard cluster, additional stations closer to the coast and to the shelf-break are needed; (2) Keppel Bay and Capricorn clusters should be linked with fewer stations concentrated around Keppel Bay and more between Keppel Bay and the Capricorn stations; and (3) initiation of a sampling cluster adjacent to the Johnstone and Russell–Mulgrave rivers should be considered. Intensive agriculture occurs on these catchments which are also the focus for a number of pilot land-use and run-off studies.

A number of operational protocols need to be improved to ensure the integrity of the data collected and the continued participation of stakeholders. Specifically:

- All clusters need to be provided with reliable equipment for the routine measurement of temperature and salinity. Regular recalibration is essential to ensure data integrity.
- Samples should be transferred by collectors to AIMS for analysis more frequently. Samples should not be left any longer than one to two months before transfer.
- Although publication of data and reports on the World Wide Web may be desirable, more rigorous quality assurance procedures need to be developed beforehand to ensure the integrity of the data; in particular the temperature and salinity data collected to date.
- Future results need to be more readily available. Annual summaries of spatial and temporal patterns and quinnenium status reporting are recommended.