Response to “Selective Evidence of Eutrophication in the Great Barrier Reef” by Furnas et al.

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Furnas et al. (2014) suggest that our conclusions are based upon limited sampling programs. However, we note that our principal conclusions, namely, (i) that hard coral cover in the Great Barrier Reef (GBR) has reduced by >70 % over the past century and (ii) that most GBR regions are characterized by Chl *a* values exceeding the defined chronic-eutrophic state (i.e., >0.2 mg m⁻³), are based on the extensive AIMS assembled data sets (e.g., see Fig. 3 in Bell et al. 2014).

Furnas et al. note that the ocean color data presented in Figs. 4 and 5, and in particular the data in the near-shore regions, do not represent accurate levels of Chl *a*. We generally agree with this assessment but note that we have not used these data in deriving the Eutrophication Threshold Model (ETM). We note that offshore CZCS data sets were calibrated against field data from the late 1970s and early 1980s, and these calibrated data sets were used to demonstrate that elevated Chl *a* values occurred in the central and outer GBR lagoon and in remote GBR regions (e.g., see Bell and Gabric 1990; Gabric et al. 1990). The CZCS data also show that elevated phytoplankton productivity occurs “downstream” of reef complexes; this information can be used to assess the importance of N-fixation. Figures 4 and 5 are given in the Review paper (Bell et al. 2014) to illustrate these points and to show that more than three decades ago enough information was available for one to recognize the synoptic-scale chronic-eutrophic state of the GBR; this information was largely ignored by the marine-science community.

Furnas et al. note that some GBR regions characterized by annual mean Chl *a* > 0.3 mg m⁻³ have healthy reefs and

hence the setting of the trigger-value range of 0.40–0.45 mg m⁻³. However, we note that many unhealthy reefs exist in regions where the annual mean Chl *a* is <0.3 mg m⁻³. For example, the Lizard Is region has an annual mean Chl *a* value of ~0.25 mg m⁻³ but has a median coral cover of 10–20%; far below that expected for a healthy reef (AIMS 2012). We note that various factors need to be considered when defining trigger values. In particular, the observation that COTS larvae and coral skeletal diseases (CSDs) will probably proliferate in waters characterized by Chl *a* < 0.3 mg m⁻³ suggests that lower trigger values need to be set. We note that the recommended Chl *a* values for the outer Florida Keys lie essentially within the lower ETC-Chl *a* range i.e., 0.2–0.3 mg m⁻³ (McGee 2010).

Furnas et al. state there is no evidence of increases in the fertility of the GBR lagoon. This comment ignores the results from the Low Isles studies which suggest that there have been significant increases in various phytoplankton populations since 1928–1929 (Bell and Elmetri 1995). We support the inference that the Low Isles studies should have been extended over a number of years to better validate the data; the original plan was to conduct a multi-year monitoring program but funds initially approved by GBRMPA were cut after the first year.

Furnas et al. note there is no evidence of increased *Trichodesmium* populations in the GBR. This observation ignores the work that suggests that *Trichodesmium* populations have increased significantly in the Low Isles region and that *Trichodesmium* growth is far more prolific in the P-PO₄ rich GBR regions (Bell and Elmetri 1995; Bell et al. 1999).

Furnas et al. state that it is very unlikely that nutrients from sewage treatment plants (STPs) near Brisbane affect water quality in the GBR as there is a general southward

flow through the southern GBR reef matrix, and the East Australian Current (EAC) flows southward along the coast south of 25°S. However, we note that the EAC does not generally flow along the coast between 25°S and Brisbane and that transport alongshore in this region and in the Southern GBR is often in a Northerly direction e.g., see Middleton et al. (1994) and Fig. 1 in Bell et al. (2014).

Furnas et al. suggest that there is no evidence of increased gelatinous zooplankton in GBR waters. However, we note that AIMS data collected more than three decades ago (Fig. 6 in Bell et al. 2014) support the hypothesis that increased growth of jellyfish will be promoted in eutrophic conditions.

Overall, Furnas et al. suggest that there is a lack of relevant data to support some of our assertions/hypotheses. We agree that more data should be collected to better assess the impacts of STP discharges and links between eutrophication and the proliferation of the COTS larvae, jellyfish, diazotrophs, and CSD precursors. The current GBR research/monitoring programs are incapable of doing this; we recommend that a series of regular cross-shelf water-quality/ecological monitoring programs be established to collect the required data.

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