Selective Evidence of Eutrophication in the Great Barrier Reef: Comment on Bell et al. (2014)

Miles Furnas, Britta Schaffelke, A. David McKinnon

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Comment to: Bell, P.R.F., I. Elmetri, and B.E. Lapointe. 2014. Evidence of Large-Scale Chronic Eutrophication in the Great Barrier Reef: Quantification of Chlorophyll *a* Thresholds for Sustaining Coral Reef Communities. *AMBIO*. doi:[10.1007/s13280-013-0443-1](https://doi.org/10.1007/s13280-013-0443-1).

In a recent article, Bell et al. (2014) misrepresent the current state of knowledge regarding water quality within the Great Barrier Reef (GBR) and the processes that influence it. To sustain the current high level of public and political support for maintaining the health of the GBR, it is important that scientists provide credible evidence of man's effects on the GBR system. We believe the information provided by Bell et al. (2014) to support their strong assertions is lacking in rigor, and in some cases, erroneous:

- Bell et al.'s (2014) conclusions are based upon a small number sampling programs from the 1920s, 1970s, and 1990s, which are restricted to a few sites and are of relatively short duration (ca. 1 year). A very large body of data (>5000 stations) covering the entire GBR in all seasons since the early 1980s is only superficially considered. Summaries and subsets of this data set are published and well known (De'ath and Fabricius 2008; Schaffelke et al. 2012). The effects of water quality on coral reefs have been extensively reviewed (Fabricius 2011). There is no state of denial.
- Ocean color data presented by Bell et al. (2014) to support their conclusion that current GBR chlorophyll *a* trigger values ($0.45 \mu\text{g L}^{-1}$; GBRMPA 2010) are exceeded in the coastal zone is based on CZCS imagery derived from obsolete sensors and algorithms that cannot discriminate chlorophyll from suspended particulate matter or bottom reflectance (e.g., Antoine et al. 1996). While chlorophyll concentrations are generally higher inshore, the very high coastal chlorophyll concentrations suggested in their Figs. 4 and 5 are not supported by extensive manual sampling over several decades (Brodie et al. 2007), long-term deployments of in situ chlorophyll loggers in coastal waters (Schaffelke et al. 2012) and validated ocean color imagery produced with modern sensors and physics-based algorithms (e.g., Brando et al. 2012).
- Bell et al. (2014) propose that Eutrophication Threshold Concentrations for chlorophyll should be set at $0.2\text{--}0.3 \mu\text{g L}^{-1}$. In fact, annual mean chlorophyll concentrations in sections of the GBR negligibly affected by human activities such as offshore reef waters (e.g., their Fig. 3) and the far northern GBR are naturally higher than this level and have healthy reefs. Accordingly, the Water Quality Guidelines for the GBR have chlorophyll trigger values of $0.45 \mu\text{g L}^{-1}$ in open coastal and midshelf waters, and $0.4 \mu\text{g L}^{-1}$ offshore (GBRMPA 2010).
- There is no empirical evidence of modern increases in the "fertility/productivity" of the GBR lagoon. Episodes of elevated production are associated with disturbance events (shelfbreak upwelling, river runoff), but indications of coastal "eutrophication" are documented only during river floods (McKinnon et al. 2013).
- The assertion that phytoplankton biomass and community structure have changed due to eutrophication is not robust. The Bell et al. use data from 1-year studies separated by periods of 10–70 years. Inter-annual variability is a well-known feature of planktonic systems world-wide (Cloern and Jassby 2010 and references therein).
- While N-fixing *Trichodesmium* blooms have been associated elsewhere with increased nutrient availability (Rodier and Le Borgne 2008), there are no data

series to establish whether highly variable *Trichodesmium* populations have increased in the GBR. Large blooms in GBR waters were described by Cook in 1770 (Beaglehole 1955), well before any significant human activity in the adjacent catchment.

- Nutrient inputs to the GBR from sewage treatment plants, urban areas and island resorts are a small contributor (<4 %; Waters et al. 2013) to total inputs from land and oceanic sources. Continuous effort has been made over the last several decades to further reduce this input through increasing tertiary treatment of sewage and land disposal of effluent.
- It is very unlikely that nutrients from the Luggage Point Sewage Treatment Plant, near Brisbane, affect water quality in the GBR. Brisbane is >500 km south of the southern-most reefs in the GBR. There is a general southward flow through the southern GBR reef matrix and East Australian Current (EAC) flows strongly (20–30 Sv) southward along the coast south of 25°S. Intrusive upwelling occurs along the shelf margin to the south of the GBR (Weeks et al. 2010). The “high chlorophyll” areas shown in Bell et al.’s (2014) Fig. 1 are most likely derived from this upwelling.
- There is no empirical evidence of increased gelatinous zooplankton in GBR waters. A recent meta-analysis of the global literature questions the role of nutrification in causing jellyfish outbreaks (Condon and Duarte 2013).
- Higher chlorophyll concentrations increase the potential for increased survival of crown-of-thorns seastar (COTS) larvae during their short (ca. 1 month) pelagic larval stage. There is strong circumstantial evidence for the hypothesis that COTS outbreaks are associated with major river floods (Fabricius et al. 2010). Phytoplankton biomass does not influence COTS growth and survival at other times.

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Miles Furnas (✉)

Address: Australian Institute of Marine Science, PMB No 3, Townsville MC, Townsville, QLD 4810, Australia.
Address: School of Marine and Tropical Biology, James Cook University, Townsville, QLD, Australia.
e-mail: m.furnas@aims.gov.au

Britta Schaffelke

Address: Australian Institute of Marine Science, PMB No 3, Townsville MC, Townsville, QLD 4810, Australia.

A. David McKinnon

Address: Australian Institute of Marine Science, PMB No 3, Townsville MC, Townsville, QLD 4810, Australia.

Address: School of Marine and Tropical Biology, James Cook University, Townsville, QLD, Australia.