Water quality

Addendum

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The South Australian monitoring, evaluation and reporting program for aquatic ecosystems: Rationale and methods for the assessment of nearshore marine waters

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EPA 1126/20: This is to be read in conjunction with Rationale and methods for the assessment of nearshore marine waters.

Introduction

The EPA Aquatic Ecosystem Condition Report (AECR) program is intended to be adaptive to new technologies and understanding of pollutant response pathways in temperate marine waters. Additional metrics may offer valuable lines of evidence to determine the nutrient status of waters and identify areas under nutrient stress. Throughout 2014–19 the EPA commenced a trial of the use of microbial and phytoplankton photopigment indicators of nutrient enrichment as a part of the AECR program to understand the usefulness of metrics as indicators of nutrient enrichment, relationship with benthic habitat metrics and cost.

Phytoplankton and microbes play a fundamental ecological role in productivity, degradation and biogeochemical cycling in coastal ecosystems. The EPA are now quantifying and characterising key components of the water column including virus, bacteria and phytoplankton at each site.

Collectively, microscopic organisms comprise most of the biomass, have fast growth rates and are highly sensitive to perturbations (ie eutrophication). Microbes provide useful bioindicators of eutrophication that can be used to characterise impacts (Tanner *et al* 2020). Different microbial functional groups have specific photopigments used for photosynthesis. The photopigments (eg fucoxanthin, peridinin, chlorophyll *b*, zeaxanthin and alloxanthin) are diagnostic of these functional groups (diatoms, dinoflagellates, chlorophytes, cyanobacteria and cryptophytes, respectively) and can be used as sensitive indicators of phytoplankton community structure (Paerl *et al* 2003).

Conceptual model

Bacteria are smaller than phytoplankton and are more efficient at using nutrients in low concentrations as a result of their higher surface area to volume ratio. Higher nutrient concentrations favour the larger sized phytoplankton which can incorporate nutrients quicker when they are abundant (Cole *et al* 1988, Gasol *et al* 1997, Duarte *et al* 2000). The bacteria–to–phytoplankton biomass ratio provides a relatively simple indicator of eutrophication (Paerl *et al* 2003). Moreover, since phytoplankton typically dominate coastal primary production, associated changes in phytoplankton community structure including size fractions, provides a useful and complementary indicator of eutrophication (Paerl *et al* 2003).

Assessing phytoplankton pigment composition as a function of chlorophyll *a* biomass allows a calculation of the Fp ratio (Claustre 1994). The Fp ratio is a measure of the ratio of new to total production using a range of pigments that characterise the phytoplankton community providing a simple indicator of the trophic status. Increasing Fp ratios indicate a shift from oligotrophic through to mesotrophic and eutrophic conditions (Tanner *et al* 2020).

The conceptual models the AECR program uses are based on the assumption that South Australian nearshore marine waters are oligotrophic. This is evidenced by previous water quality monitoring of water chemistry (Gaylard 2004) and phytoplankton (Van Ruth *et al* 2009). A shift into mesotrophic or eutrophic is a negative change as a result of nutrient enrichment. As such, Fp ratios below 0.3 are considered typical of oligotrophic conditions, mesotrophic represents an Fp between 0.3 and 0.6 and above 0.6 represents eutrophic conditions.

Results of the trial suggest that the Fp ratio is a robust and reliable indicator of nutrient enrichment and shows consistent patterns in line with other nutrient enrichment indicators. There are numerous other metrics that can be calculated based on this data and will be investigated for the application in the future, including the development of CHEMTAX libraries (Mackey *et al* 1996).

Methods

At each site, a 2-litre water sample is collected to characterise phytoplankton biomass as indicated by chlorophyll *a* concentration and the corresponding pigment composition of 20 auxiliary photopigments. Water samples are filtered through Whatman 0.7 µm GF/F filters and stored below −80°C until analysis. Samples are analysed using High Performance Liquid Chromatography (HPLC) analysis (Van Heukelem and Thomas 2001).

Three replicate aliquots (1 ml) are taken from water samples and fixed in (10 µL) glutaraldehyde, at 4 degrees for 30 minutes, and then stored below −80°C until analysis. Flow cytometry (FCM) is used for the enumeration of viruses and bacterial abundances according to the methods of Brussaard *et al* (2000) and Brussaard (2004).

Incorporation into AECR results

Deriving a single score describing condition of complex ecosystems is a gross oversimplification of complex processes. However, managers require simple measures to inform decision making without necessarily understanding the complexity inherent in the natural environment, and resultantly report cards are common throughout the world.

The current AECR score is derived from multiple lines of evidence about habitat condition of seagrass, rocky reef or unvegetated sand in waters 2–15 m deep. This score can be considered representative of the benthic component of the ecosystem.

The measure of photopigments is an integrated biological measure of the water column. Used in conjunction with existing measures of benthic habitat condition, the AECR program demonstrates a snapshot of ecosystem condition suitable to measure long term and broadscale condition of nearshore waters in South Australia.

Until further evidence suggests otherwise, the score for habitat condition and score for pelagic water column will be normalised and averaged unweighted to derive the final AECR score of ecosystem condition.

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GPO Box 2607	Facsimile:	(08) 8124 4670
Adelaide SA 5001	Freecall (country):	1800 623 445
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