The state and trends of quality of habitats and communities – Water column, outer shelf (25-250m).

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Current State

The water column is the primary habitat for pelagic communities that are mainly phytoplankton, bacteria, zooplankton and higher predators (in the ratios of ~300:75:10:1, respectively: Marchant 2002) and their biomass declines exponentially with depth (Rex et al., 2006). The major determinants of habitat quality for most pelagic organisms can be considered to be temperature (T), salinity (S), light, nutrients, dissolved oxygen (DO), pH, and food availability. The continental shelf waters around Australia are generally warm, saline, well illuminated, low in nutrients, and abundances of phytoplankton (Fig. 1), zooplankton (Fig. 2) and fish. Relative to the seasonal variability for the majority of the water column on the outer shelf there have been modest long term changes to these components of the habitat and its communities. Overall its current status should be considered good. The major potential threats that could reduce the existing flora and fauna can be considered to be: inputs from the terrestrial environment (sediments, nutrients, carbon), development, warming, declining [DO], decreasing pH and fishing. While there are areas of local habitat degradation (e.g. near ports and harbours) the overall impacts of local pressures tend to be low as Australia is a large area with a relatively sparse human population. There is increasing evidence our shelf waters are experiencing change due to the global pressures; some of which are deleterious. Shelf waters from Port Hedland to Cape Howe have risen ~ 1°C from 1993 to 2013 (Foster et al., 2014), and portions of the SW region were 3°C warmer during February 2011 than normal (Pearce and Feng 2013). There is evidence that dissolved oxygen has declined (Thompson et al. 2009) and continues to decline due to warming (Talley et al., 2016) plus concerns over acidification continue to grow (Mongin et al., 2016). Already there is clear evidence of community responses by phytoplankton, zooplankton and fish to these climatic pressures (e.g. Johnson et al. 2011).

Trends

Temperature, light, salinity, nutrients, DO, phytoplankton, zooplankton and fish, all measures of habitat quality, can have short cycles of variability. For example, at temperate latitudes there are large amplitude cycles in most of these on seasonal time scales. These measures of habitat quality also vary with short term climate cycles such as the 2 to 7 year ENSO cycle. Consider the temporal window for this assessment (2011-2016); it commenced with the La Niña event that ended the Millennium Drought. Between the La Niña of 1999, during the Millennium Drought and prevailing El Niño conditions, diatoms declined significantly along Australia's southeast coast (Ajani et al., 2014). During 2011 the significant rainfall and river run off enriched much of the east coast of Australia with nutrients including silicate for diatoms (Thompson et al., 2015). From 2008 to 2012 diatoms recovered while dinoflagellates declined at all 4 NRS along the east coast (Thompson et al., 2016). The long term trend shows increase phytoplankton (as chlorophyll *a*) along the entire eastern seaboard (Fig. 3). Phytoplankton increased strongly in the southern Tasman Sea since 2011 (Kelly et al., 2015, Fig. 1) possibly due to eddy pumping (Matear et al., 2013). Zooplankton declined around Australia in 2011 (Thompson et al., 2015) but subsequently they have shown increases in biomass at most NRS (Fig. 2) except Port Hacking and North Stradbroke Island. Short term variation such as weekly or monthly weather and short term climate cycles such as ENSO can, however, obscure the longer term trends (Baird et al., 2011) associated with the pervasive effects of rising temperatures, falling DO, declining nutrients and greater acidification.

Uncertainties and Gaps

Past responses by the pelagic communities of phytoplankton and zooplankton to changes in their habitat have been poorly documented with no time series of observations permitting an assessment of trends. In 2008 this situation took a quantum step with greater monitoring through the IMOS National Reference Stations (Table 1). For some species dramatic range expansions have been discovered (e.g. McLeod et al. 2012) where species moved hundreds of km in only a few years. Such an expansion is much faster than expansions of most benthic flora or even more mobile fauna (e.g. fish). This rapid movement by phytoplankton may reflect the strengthening EAC and the fact that the habitat itself is moving south. The lack of a time series of *in situ* observations from large parts of Australia limit the assessment to satellite detection of status and trends for only a few parameters.

Regions

North: Based on the above average rainfall and runoff across much of northern Australia in 2010, 2011, 2014, 2015 it is likely that nutrient inputs to the coastal zone increased promoting local increases in phytoplankton. During 2015 the average zooplankton biomass at the Darwin NRS rose to 180 mg m^{-3}, by far highest in the country.

North-east: This region also experienced high rainfall in 2010, 2011 and 2012 resulting in localized increases in nutrient inputs, phytoplankton biomass and diatoms in the Great Barrier Reef (GBR) Lagoon. Nutrient concentrations were significantly enhanced in 2011 at the IMOS NRS Yongala (19°S, 148°E) inside the GBR Lagoon (Thompson et al. 2015) and there was a positive response in phytoplankton biomass and an increase in diatoms. Near the shelf edge trends were weaker (Fig. 1).

East: Although the east coast shelf saw a general trend towards more phytoplankton both North Stradbroke Island and Port Hacking NRS showed significantly less zooplankton during 2011-2015 than 2010 ($P < 0.001$, Fig. 2, Thompson et al. 2015).

South-east: Regionally there has been a general warming trend (Hill et al., 2011) but there are large areas of increasing phytoplankton (Kelly et al., 2015;, Fig. 1) and locally increasing dinoflagellates (Buchanan et al., 2013). The huge rise in the toxic phytoplankton species *Alexandrium tamarense* has resulted in the closure of harvesting for many species of seafood along the east coast of Tasmania (Campbell et al., 2013).

South-west: The west coast of Australia has been warming strongly (Feng et al., 2013). Long term trends of warming are generally correlated with declining phytoplankton biomass (Siegel et al., 2013) as the low biomass tropical communities move further south (Thompson et al., 2015).

North-west: Since IMOS monitoring at the NRS at Ningaloo ceased in 2013 it is difficult to detect recent trends in pelagic habitat or community.

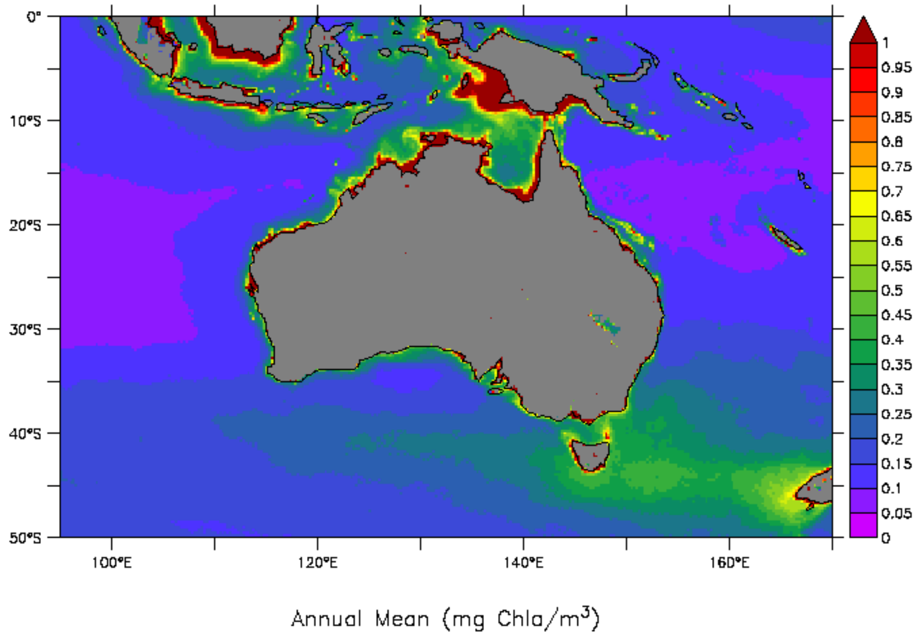

Figure 1. The long term average chlorophyll *a* concentrations derived from satellite detected ocean colour over the period from 1997 to 2015 for the Australian region (Data from http://www.globcolour.info/. Accessed Feb 2016).

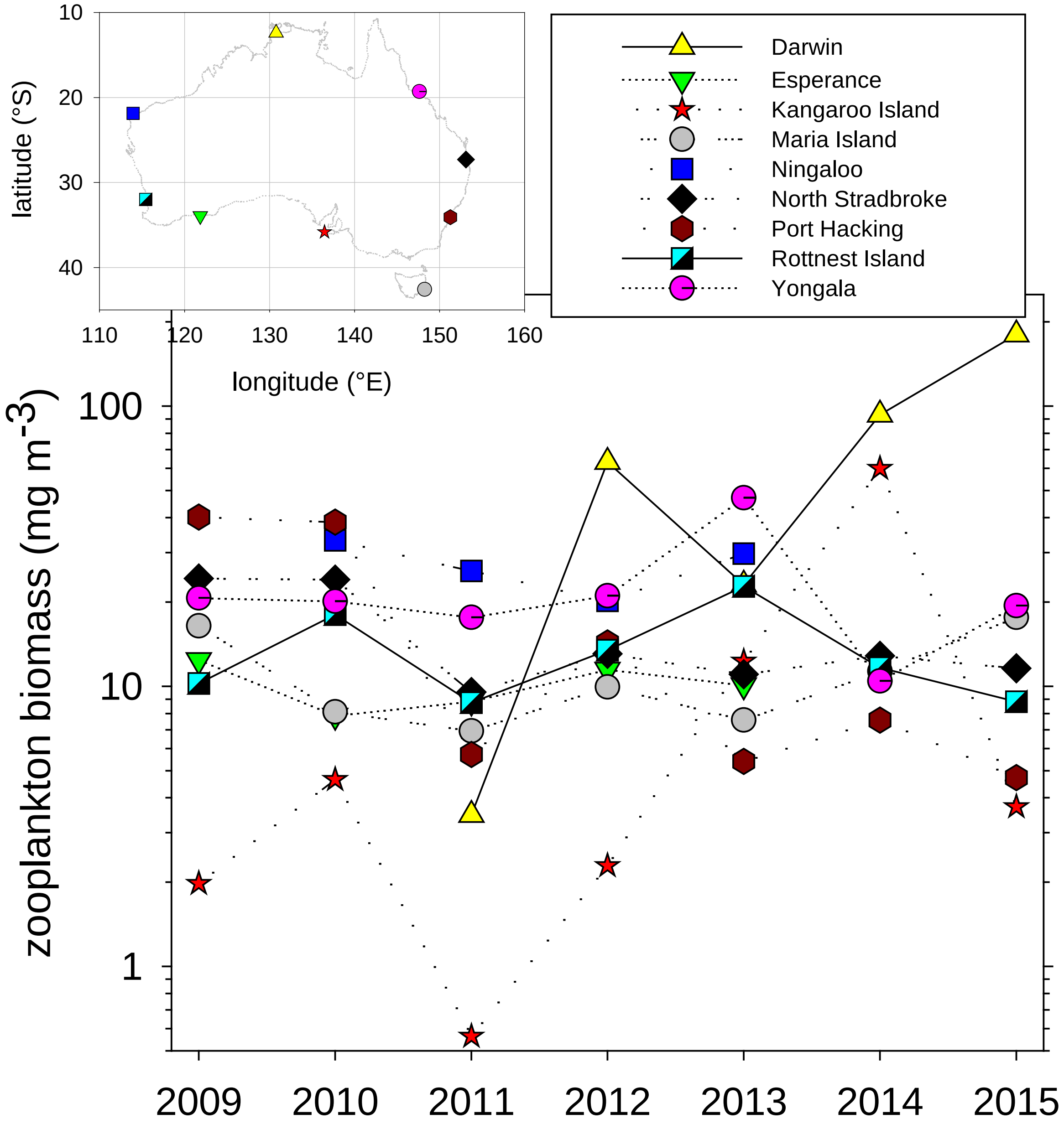

Figure 2. Average annual biomass of zooplankton from the 9 Integrated Marine Observing System's (IMOS) National Reference Stations (NRS). Inset map shows the locations of the IMOS 9 NRS.

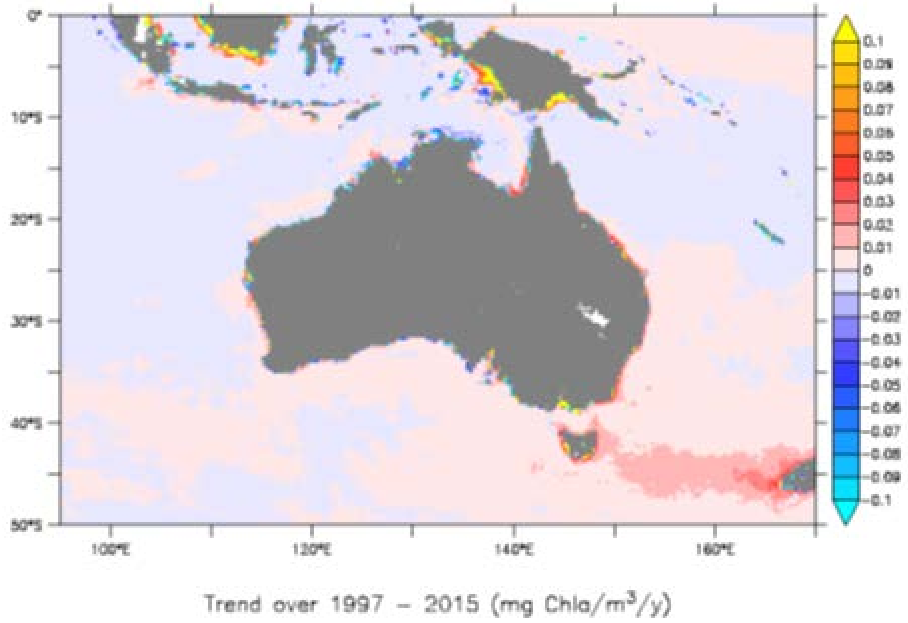

Figure 3. Trends in chlorophyll *a* concentrations derived from satellite detected ocean colour over the period from 1997 to 2015 for the Australian region (Data from http://www.globcolour.info/. Accessed Feb 2016).

Table 1. Location and depth of deployment of the IMOS National Reference Stations

Station	Yongala	North Stradbroke Island	Port Hacking	Maria Island	Kangaroo Island	Esperance	Rottnest Island	Ningaloo	Darwin
Latitude (°S)	19°18.5	27°20.5	34°05.0	42°35.8	35°49.9	33°56.0	32°00.0	21°52.0	12°24.0
Longitude (°E)	147°37.1	153°33.73	151°15.0	148°14.0	136°26.8	121°51.0	115°25.0	113°56.82	130°46.1
SOE region	(GBR)	Temperate east	Temperate east	South east	South west	South west	South west	North west	North
Max depth (m)	27	63	100	90	110	50	50	55	20

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Assessment summary

Year	Assessment grade		Confidence		Comparability
	Grade	Trend	Grade	Trend	
2016	Good	Unclear	Limited evidence or limited consensus	Limited evidence or limited consensus	Grade and trend are somewhat comparable to the 2011 assessment
2011	Good	Stable	Limited evidence or limited consensus	Limited evidence or limited consensus	

Summary assessment text: Localized challenges, considerable regional variability in trends, and evidence of effects due to ENSO dominating over longer term climate impacts.