Effects of shading on health indicators of two branching corals, *Acropora formosa* and *Acropora hyacinthus*, in Central Queensland, Australia: A pilot study

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Summary
This study investigated physiological and growth responses of two species of hard-branching corals, *Acropora formosa* and *Acropora hyacinthus*, common within coastal fringing reefs in the Central Queensland Region, exposed to reduced light thresholds using shading experiments. Three endpoints were examined to determine suitability of light thresholds, including coral apical growth, colour change in the form of pigment change, discolouration and bleaching, and grazing pressure. The results suggest that both coral species were suitable bioindicators for light thresholds when using non-invasive growth, colour change and grazing pressure as suitable endpoints, and can be used for dredge management practices.

Keywords: Coral; Shading; Growth; Bio-indicator, dredging.

Introduction

It is well known that increased turbidity reduces light availability through the water column and can have a negative impact on the health and condition of corals at a biochemical, species and community level. However, very little is known about the physiological responses of corals in general to different light thresholds, which may be useful in determining a measured endpoint for environmental trigger values, and ultimately assist in dredge management decisions.

The specific objectives of the study were to:

a) Determine if two species of hard coral, common to the coastal fringing reefs of the Central Queensland Region, were suitable as bio-indicators of light thresholds, as a function of reduced quantity by shading;

b) Determine if coral apical growth, pigment colour change and grazing pressure are suitable non-lethal endpoints as indicators of environmental stress on corals; and

c) Determine the time scale where these non-lethal triggers begin to indicate environmental stress on the coral.

Materials and Methods

The pilot study was conducted on the coastal fringing reefs adjacent to Facing Island, Queensland, Australia. Two suitable sites, with varying depths, were selected based on the availability of the two species. *A. Formosa* was abundant at depths of 6 to 8 m, whereas *A. hyacinthus* was abundant at depths of 8 to 10 m. Hence, each site was selected based on the optimal depth gradient where each species was abundant. Sites were 700 m apart.

Experimental units were designed from polyethylene boxes (330 x 360 x 270 mm), weighed down and anchored to the sea floor with concrete, and aluminium cross bars set into the concrete so that shades could easily be installed and removed underwater. Shades were constructed from aluminium and 90% light reduction shade cloth. Sections of egg crates were installed into each experimental unit for ease of coral fragment (frags) transplantation. Odyssey data recorder light loggers with integrated Zebra-Tech® hydro-wipers were used to measure Photosynthetically Active Radiation (PAR), every 15 minutes in both treatments. Five coral fragments from each species, 50 to 60 mm in length, were removed from randomly selected natural colonies adjacent to the experimental sites and attached to the egg crates within each experimental unit using non-toxic Tunze® coral gum.

Three replicate boxes were used for each treatment and each species, resulting in 12 boxes overall. Shaded and unshaded treatment boxes for each species were randomly placed within an area of 50 m^2 along un-colonised, level benthos (sand).

Each species of coral was placed into two treatment groups:

- Unshaded (control); or
- Shaded: where shade frames were attached to each box, reducing available benthic PAR (light) penetration by 80 to 95% (PAR as measured by dual Odyssey loggers in shaded and unshaded boxes). An acclimation period of one month was used on the experimental frags in order to adjust to new conditions.

After acclimation, shades were placed over the experimental units in the shaded treatment for a period of 30 to 60 days. Experimental units were monitored every 7 to 14 d (depending on weather restrictions).

Three factors were investigated on all sampling days for each species of coral:

- Coral growth, measured as coral vertical apical growth;

• Coral colour change in the form of pigment change, discolouration or bleaching in relation to the colour of the scale bar; and

• Coral degradation as coral tip erosion, signs of grazer attack or bio-erosion.

Each frag was individually photographed using a specially designed measuring scale. Photographs were used to individually analyse vertical apical growth and colour change of each coral, using image analysis software. Shades were briefly taken off shaded treatments to allow photographs to be taken and then immediately reattached.

Coral frag colour was measured as the ratio of Red Green Blue (RGB) and luminosity colour channels against a standard white scale, integrated into the photograph and compared to each frag colour for each week. This allowed a standardised, non-invasive method of measuring colour change irrespective of visibility issues or changes in light intensity due to cloud cover across each experimental measurement period (every 7 to 14 d).

Coral frags were measured using the ruler tool and standardised to the integrated scale bar on each photograph using Adobe® Photoshop CS6™ Version 6.1. Frag colour was also measured using Adobe® Photoshop. Coral fragments higher in pigment concentrations (darker frags) would have lower luminance than corals that are lighter or bleached.

Coral degradation was measured by visual observation and amount of reduced apical growth during measurement from Day 0 for each species.

Results and discussion

Results showed a significant reduction in growth for both coral species after 14 to 15 days in the shaded treatments when compared to controls. After 60 days, a significant reduction of up to 90% in growth was observed in shaded versus unshaded *A. Formosa* and *A. Hyacinthus* frags. This equated to a growth rate of ~5 mm per annum for shaded experiments compared to >55 mm per annum for control or unshaded corals.

Under higher light concentrations, photosynthesis, respiration and calcification is generally increased, however, under low light scenarios, photosynthesis is reduced, providing only enough productivity for zooxanthellae energy requirements [1,2]. With lower energy output from the zooxanthellae symbiont, coral polyp feeding rates generally increase to compensate for the reduction of energy from reduced photosynthesis, as seen in many different studies [1].

After 14 days, both species exhibited a >8% increase in pigment colour, and >10% increase after 22 days of shading. No differences in pigment colour changes were observed for either species in the unshaded treatment. The fact that changes in pigment colour occurred within a very short period of time (14 days), confirms that both these coral species may be suitable bioindicators.

Figure 1. Example of colour change after 33 days of shaded experimentation in *A. formosa*.

Grazing was only observed in the shaded treatments for both species, with significantly more grazing pressure observed in *A. formosa* compared to *A. hyacinthus*.Significant grazing (>85%) was observed for shaded *A. formosa* frags, compared to 0% for unshaded frags after 60 days. After 22 days, up to 20% of frags in the shaded treatments were partially (<20% of frags missing) grazed. After 33 days, 27% of frags were partially grazed, and 7% were completely grazed (>50% of frag missing). After 60 days, 7% of frags in the shaded treatment were moderately grazed (between 21-50% of frag missing), and 67% of frags in the shaded treatment were completely grazed.

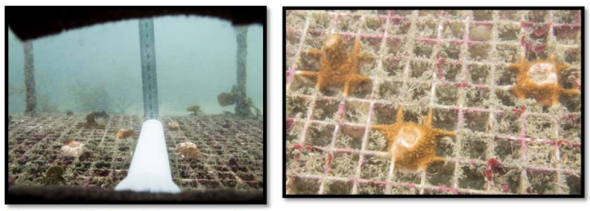

Figure 2. Evidence of animal grazing for shaded *A. formosa* frags.

The results of the current study suggest that both *A. formosa* and *A. hyacinthus* are suitable bioindicators for light thresholds when using non-invasive growth, colour change and grazing pressure as suitable endpoints.

[1] Dubinsky Z, Jokiel PL (1994) Ratio of Energy and Nutrient Fluxes Regulates Symbiosis between Zooxanthellae and Corals. Pacific Science 48:313-324.

[2] Nir O, Gruber DF, Einbinder S, Kark S, Tchernov D (2011) Changes in scleractinian coral Seriatopora hystrix morphology and its endocellular Symbiodinium characteristics along a bathymetric gradient from shallow to mesophotic reef. Coral Reefs 30:1089–1100