Biogeosciences Supplemental Information

Will community calcification reflect reef accretion on future, degraded coral reefs?

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Methods

S.1 Benthic Community Surveys

S.1.1 Point-Contact Surveys

A transect tape was laid along each 200 m transect length and the occupier of benthic space was recorded underneath each 1 m interval (n = 200 transect^{-1}). Categories were divided between coral (hermatypic), coral (soft), algae (fleshy, non-calcifying), other calcifier (e.g., clams, *Halimeda* spp., coralline algae), rubble, and sediment. These surveys were repeated twice per transect at the beginning of the study (Jan 18-20 2020) to provide an initial understanding of the community structure prior to flow-metabolism measurements. Data are presented as relative % cover.

S.1.2 Photo Quadrat Surveys

A transect tape was laid along each 200 m transect length and a 1 m^2 PVC quadrat was placed next to the tape at each 5 m interval (n = 40 transect^{-1}). A photo was taken of the quadrat and analysed using ImageJ (Rueden et al., 2017) to quantify the relative areal coverage per 1 m^2 for the following categories: coral (healthy), coral (unhealthy; paling/bleached), coral (soft) algae (fleshy, non-calcifying), other calcifier (e.g., clams, *Halimeda* spp., coralline algae), rubble, sediment (clean), sediment (red with cyanobacteria growth), and sediment (green with Chlorophyta growth). These surveys were repeated three times throughout the study, at the beginning prior to any observed bleaching (Jan 24 2020), in the middle after the first observed bleaching event (Feb 6 2020), and at the end of the study after several more observed bleaching incidents (Feb 13 2020). Data are presented as relative % cover through time.

S.1.3 Mobile Invertebrate Surveys

A transect tape was laid along each 200 m transect length relatively large, easily visible mobile invertebrates (e.g., sea cucumbers, sea hares, sea urchins) located 1 meter to the left or right along the transect were counted. Surveys were conducted at dawn to ensure a balance of visibility and invertebrate activity and repeated 3 times along each transect (n = 9 site^{-1}). Data are presented as abundance counts per m^2 (individuals m^{-2}). Individuals present at less than 0.1 m^{-2} were excluded from the final data reported but were included as part of the invertebrate taxonomy described below.

S.1.4 Invertebrate Taxonomy

While conducting the survey approaches detailed above, each time a new invertebrate morphospecies was encountered, photographs were taken and uploaded to iNaturalist, a biodiversity citizen science platform where identifications are contributed in real time by both amateur naturalists and professional taxonomists as part of a consensus system (www.inaturalist.org). Using a combination of taxonomic keys and crowdsourcing via iNaturalist, algae, corals, and other sampled marine invertebrates were identified to as fine a taxonomic level as possible. These data are presented as presence/absence across the entire 200 m x 400 m study area. Because sampling was conducted at low tide, most fish usually present in the lagoon were absent and excluded from benthic survey data.

S.2 Lagoon Community Metabolism Measurements

S.2.1 Flow-Respirometry Approach

Flow metabolism transects were established along a reef area previously characterised as degraded, where there is less than 10 % coral cover (Roelfsema et al., 2018). The flow-respirometry measurements were conducted within two designated reef areas (100 m x 200 m; 0.02 km^2) which significantly differed in coral cover. The defined study area was determined based on the necessary transect length to achieve measurable differences in seawater dissolved oxygen (ΔDO = ± 4 – 7 mg L^{-1}) between upstream and downstream locations (~ 200 + m; Langdon et al., 2010). Repeated deployments of fluorescein dye packets across the research zone at differing tidal periods determined a specific 400 m x 100 m area of the reef where flow was unidirectional from east to west during a period spanning from 2 hours before to 1 hour after peak low tide (3 hours total). Outside of this period, the reef lagoon was no longer physically separated from the open ocean, flow became multidirectional, and the defined lagoon area became too deep and diluted with open ocean water to measure significant changes in seawater chemistry. The 400 m x 100 m area was then designated as two,. The spread of the dye path varied ± 25 m in a north/south direction and triplicate 200 m transects were spaced 50 m apart in parallel at each site so that NEC and NEP was averaged across the three downstream locations, representing all potential water flow paths of the overall study site area. Within each area, three 200m transects were established in parallel, 50 m distance from one another (Fig. 1). Water samples were collected as close in time as possible at these fixed upstream and downstream locations (n = 3 area^{-1}) at peak low tide while lagoon currents were unidirectional, running east to west.

$$Equation\ 1: NEP\ = \frac{3600}{100} \times \frac{\Delta DO \times\ \rho\ \times u\ \times d}{l}$$

$$Equation\ 2: NEC\ = \frac{3600}{100} \times \frac{0.5\ \times\ \Delta TA \times\ \rho\ \times u\ \times d}{l}$$

The flow-respirometry approach requires the following measurements: The change in DO and A_T (ΔDO and ΔA_T; mmol kg^{-1}), the mean seawater density (ρ; kg m^{-3}), the mean current speed (cm s^{-1}), the mean depth over the transect (*d*; meters), and the length of the transect (*l*; meters).

Salinity (psu) and dissolved oxygen (DO: mg L^{-1}) was measured with a Hanna HI98194 multimeter and DO converted to µmol kg^{-1} using seawater density. DO probe calibration was performed weekly using a two-point calibration at 0% (sodium thiosulfate) and 100% saturated seawater equilibrated with the atmosphere. Samples for A_T were collected in 60 ml sample polycarbonate sample bottles, preserved with saturated Mercuric Chloride according to CO_2 best practices (Dickson, 2007), and sealed with a screw top lid and parafilm. Seawater A_T was analysed by potentiometric titration using a

Metrohm 848 Titrino plus automatic titrator (~ 40 ml of seawater per sample) in duplicates (SD uncertainty < 2 µmol kg^{-1}). Overall analytical uncertainty for A_T (SD = ± 2.4 µmol kg^{-1}) measurements was estimated from repeated measurements of certified reference materials from the Scripps Institute of Oceanography (CRM; Batch 161).

S.2.2 Slack Water Approach

The slack-water approach was used to estimate rates of NEP and NEC over a relatively larger area of reef (~ 0.3 km^2) during a period of three hours around low tide. This period was chosen based on initial observations of current speed and direction. Starting two hours before peak low tide, the lagoon becomes separated from the open ocean and the current begins flowing unidirectionally toward the lagoon outlet to the west. This unidirectional flow behaviour continues until roughly 2 hours after peak low tide, at which time the flow begins to reverse as the tide fills back in over the reef crest. To avoid dilution with the open ocean and changing current vector directions confounding residence time estimates, water samples were collected from the same three locations (n = 3 day^{-1}) two hours before peak low tide and one hour following.

$$Equation\ 1: NEP = \frac{\Delta DO \times \rho \times d}{\Delta t}$$

$$Equation\ 2: NEC = \frac{0.5 \times \Delta A_T \times \rho \times d}{\Delta t}$$

The slack-water approach requires the following measurements: The change in DO and A_T (ΔDO and ΔA_T; mmol kg^{-1}), the mean seawater density (ρ; kg m^{-3}), mean depth over the transect (*d*; meters), and time between sampling (Δt; hours). Given the time between samples (~ 3 h) and mean current speeds (~ 20 cm s^{-1}), these measurements represent a transect length of roughly 2.5 – 3km of reef.

S.2.3 Approach Comparison

Both approaches to estimate benthic community NEP and NEC provide limitations and advantages with respect to each other (see Langdon et al., 2010). In the flow-respirometry approach, the exact benthic area contributing to measured changes in seawater chemistry is known and its constituents can be quantified and related to the calculated rates of benthic metabolism. This approach, however, measures change in alkalinity over a relatively smaller area and time-period. Resulting fluxes in A_T (± 30 – 60 μmol kg^{-1}) and DO (± 20 – 50 μmol kg^{-1}) are relatively small compared to the slack-water approach, thereby providing less confidence in calculated rates of benthic metabolism.

In contrast, the slack-water approach benefits from the relatively large changes in total alkalinity (A_T: ± 100 – 200 μmol kg^{-1}) and dissolved oxygen (DO: ± 80 – 150 μmol kg^{-1}), which provides more confidence in A_T anomaly calculations and represent a large area of the reef flat relative to this study's flow-respirometry estimates. This approach, however, lacks specificity of the exact area of reef affecting changes in chemistry and DO fluxes are more vulnerable to gas exchange anomalies. As such, relating metabolic rates to the benthic community provides uncertainties given daily changes in mean current speed and, subsequently, the area of benthos reflected in the A_T and DO anomaly.

Overall, the combination of both approaches can work in tandem to compensate for their respective weaknesses. However, neither approach can accommodate dilution with the open ocean and generally need to be conducted in full sunlight or darkness so that community metabolism does not transition between autotrophy and heterotrophy in the middle of the measurements. For this reason, community metabolism estimates were paused from Jan 27 – Feb 2 when peak low tide occurred around dawn and dusk and changes in DO and A_T were negligible.

S.2.4 Air-Sea Gas Exchange Corrections

NEP estimates were corrected for the air-sea gas exchange (F_{O2}) of oxygen using the gas-transfer velocity relationships outlined by Wanninkhof (1992) and Wanninkhof et al., (2009). F_{O2} was calculated with the following equation.

$$F_{O2} = k\,K0\,(fO2_{water} - fO2_{air})$$

where k is the gas transfer velocity (calculated using and averaged daily wind speed from BOM data), K0 is the gas transfer coefficient, $fO2_{water}$ is the concentration of seawater dissolved oxygen (mg L^{-1}) at the time of the downstream measurement, $fO2_{air}$ (mg L^{-1}) was assumed to be 100% saturation at the air temperature over the 3-h measurement period (~ 8.10 mg L^{-1}).

S.3 Statistical Analyses

All statistical analyses were performed with the SPSS statistics software (SPSS Inc. 2013 Version 26.0). To compare measured differences in benthic cover (percent coral, percent algae, percent bleached coral tissue, sediment overgrowth) and community metabolism (Net ecosystem production [NEP] and net ecosystem calcification [NEC]) between triplicate transects, measurement days (n = 12), and Lagoon sites (Lagoon site 1, Lagoon site 2, and Slack Water), a one-way analysis of variance (ANOVA) model was used in which transect, day, or site was a fixed effect and measured values for percent cover, NEP, and NEC were treated as the response variable. Results for percent cover compared among triplicate transects and Lagoon sites are displayed in Tables S1 and S2, respectively. Before community metabolism measurements were compared, assumptions of normality and equality of variance were evaluated with a Shapiro Wilk test (Table S4). Results for community metabolism compared among triplicate transects, measurement days, and Lagoon sites are displayed in Tables S5, S6, and S7, respectively. A Tukey HSD post-hoc test was used to perform pairwise comparisons for measured community NEC between Lagoon site 1, Lagoon site 2, and the slack-water approach (Table S7). To explore relationships between NEC as a function of NEP, Model II regression techniques were used to test for significant linear relationships (cutoff value $p < 0.1$) and an ANCOVA was used to test for differences in NEC vs. NEP slope categorized by Lagoon site (Lagoon site 1 and Lagoon site 2).

Results

S.4 Invertebrate Taxonomy Results

Overall, we found 25 coral species in the lagoonal reef study area, 22 of which were hard corals and three soft corals (Fig. 2; Table S8). Thirteen algae morphospecies were observed, with one identified as species *Valonia ventricosa* and the rest unidentified. Across all other invertebrate taxa, 19 species of echinoderms, bivalves, and polychaetes, and 24 species of crustaceans and gastropods were observed. Of the 43 non-coral invertebrate species, 15 were associated with colonies of *Pocillopora* corals. Sea cucumbers (e.g., *Holothuria* spp., *Stichopus* spp.) were the dominant mobile invertebrate, the Lollyfish sea cucumber (*Holothuria atra*) was the most common across both Lagoon sites (1.2 ± 0.2 individuals m^{-2}). Second in abundance was the Hermann's Sea Cucumber (*Stichopus hermanni*) (0.4 ± 0.1 individuals m^{-2}). Other notable invertebrates included Linckia sea stars (*Linckia guildingia*, *Linckia laevigata*) and white-speckled sea hares (*Aplysia argus*) (all found in abundances < 0.1 individuals m^{-2}). The largest mobile invertebrates observed were Bailer Shell snails (*Melo amphora*) at 30 cm in length and white-spotted hermit crabs (*Dardanus megistos*) occupying Bailer shells (< 0.1 individuals m^{-2}).

Our observations included 8 species with a conservation status of near threatened or higher, including the small giant clam *Tridacna maxima*, Herrmann's sea cucumber (*Stichopus herrmanni*), and 6 coral species (*Porites attenuata*, *Acropora secale*, *Isopora palifera*, *Stylophora pistillata*, *Favites halicora*, *Favites rotundata*). Notably, our observation of the aglajid slug *Tubulophilinopsis gardineri* is one of just 5 from Heron Island, representing the southernmost limit of its eastern coast distribution. We also observed an undescribed nudibranch species, a yellow-brown *Gymnodoris* (Figure 5). A complete list of all species described can be found in the Supplemental Material (Table S8).

S.5 Lagoon Temperature and Light

Temperature across the Lagoon site 1 exhibited a mean value of 28.6 ± 1.5 °C and varied between a minimum of 25.8 °C and a maximum of 34.8 °C (Table 2). Light at Lagoon site 1 exhibited a mean value of 328 ± 247 μmol quanta m^{-2} s^{-1} and maximum values of 1001 μmol quanta m^{-2} s^{-1} (Fig. 1). Temperature across Lagoon site 2 exhibited a mean value of 28.6 ± 1.5 °C and varied between a minimum of 25.9 °C and a maximum of 34.6 °C. Light at Lagoon site 2 exhibited a mean value of 336 ± 254 µmol quanta m^{-2} s^{-1} and maximum values of 969 µmol quanta m^{-2} s^{-1}.

S.6 Lagoon Community Bleaching Extent

Dark-adapted yield was 0.662 ± 0.010 for *Acropora* spp. fragments and 0.576 ± 0.020 for "Other" fragments (mean ± SE, n = 35) on Feb 4th . On Feb 9th , yield declined 35% for *Acropora* spp. to 0.430 ± 0.014 (n = 15) and 25% for "Other" fragments to 0.434 ± 0.018 (n = 20). Symbiodiniaceae densities were 0.976 ± 0.135 x 10^6 cm^{-2} for *Acropora* spp. (n = 15) and 0.507 ± 0.160 x 10^6 cm^{-2} for "Other" fragments (n = 10) on Jan 30th. On Feb 12th, *Acropora* spp. densities had declined by 48% to 0.504 ± 0.0849 x 10^6 cm^{-2} (n = 15) and by 18% for "Other" fragments to 0.414 ± 0.094 x 10^6 cm^{-2} (n = 15) (Fig. 3).

Discussion

S.7 Estimated Organism Contribution to NEC at Elevated Temperatures

To estimate the potential effect of a +1.1 °C change in seawater temperature on coral calcification for corals observed within the lagoon study sites the following aquaria manipulation studies were reviewed: Edmunds, 2005; Anthony et al., 2008; Cantin et al., 2010; Comeau et al., 2013, 2016; and the following meta-analysis and modeling studies were reviewed: Lough and Barnes, 2000; McNeil et al., 2004; Evenhuis et al., 2015; Kornder et al., 2018; Bove et al., 2020.

Tables

Table S1: One-way ANOVA results (p-values) comparing measured percent coral and algae cover between triplicate transects within each Lagoon site (Lagoon site 1, Lagoon site 2). Data were pooled among replicate point-contact survey efforts (n = 2 transect^{-1}). A **bolded** value (p-value < 0.05) indicates that the percent cover significantly differed between transects within each Lagoon site.

Point-Contact Survey Method				
Cover	**Lagoon site 1**		**Lagoon site 2**	
	df	**p-value**	**df**	**p-value**
% Coral Cover	2	0.791	2	0.959
% Algae Cover	2	0.256	2	0.214
% Sediment Cover	2	0.421	2	0.956

Table S2: One-way ANOVA results (p-values) comparing measured percent coral and algae cover between Lagoon site 1 and Lagoon site 2. Data were pooled among replicate point-contact survey efforts and triplicate transects within each Lagoon site (n = 6 site^{-1}). A **bolded** value (p-value < 0.05) indicates that the percent cover significantly differed between Lagoon sites.

Point-Contact Survey Method		
Cover	**df**	**p - value**
% Coral Cover	**1**	**0.001**
% Algae Cover	**1**	**0.011**
% Sediment Cover	1	0.122

Table S3: One-way ANOVA results (p-values) comparing measured percent coral and algae cover between triplicate transects within each Lagoon site (Lagoon site 1, Lagoon site 2). Data were pooled among triplicate photo-quadrat survey efforts over time (n = 120 transect^{-1}). A **bolded** value (p-value < 0.05) indicates that the percent cover significantly differed between transects.

Photo-Quadrat Survey Method				
Cover	**Lagoon site 1**		**Lagoon site 2**	
	df	**p-value**	**df**	**p-value**
% Coral Cover	2	0.469	2	0.818
% Algae Cover	2	0.721	2	0.796
% Sediment Cover	2	0.859	2	0.403

Table S4: One-way ANOVA results (p-values) comparing measured percent coral and algae cover between Lagoon site 1 and Lagoon site 2. Data were pooled among triplicate photo-quadrat survey efforts and triplicate transects within each Lagoon site ($n = 360\ \text{site}^{-1}$). A **bolded** value (p-value < 0.05) indicates that the percent cover significantly differed between Lagoon site 1 and Lagoon site 2.

Photo-Quadrat Survey Method		
Cover	**df**	**p - value**
% Coral Cover	**1**	**0.000**
% Algae Cover	1	0.273
% Sediment Cover	1	0.140

Table S5: One-way ANOVA results for percent bleached coral tissue (Coral Bleaching) and percent sediment exhibiting overgrowth (Sediment Overgrowth) compared over the three survey efforts through time (Jan 24, Feb 6, and Feb12 2020) at Lagoon site 1. Data were pooled among all triplicate transects. Tukey HSD post-hoc test results are to compare differences between each survey effort (n = 3). A **bolded** value (p-value < 0.05) indicates that the difference was significant between time points.

Photo-Quadrat Survey Method: Lagoon site 1			
Lagoon site 1	**df**	**F-value**	**p - value**
Coral Bleaching	**2**	**67.2**	**0.000**
Sediment Overgrowth	**2**	**18.3**	**0.003**

Tukey HSD

Dependent Variable	(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Coral Bleaching	Jan 24	Feb 6	**-16.33**	**4.93**	**.037**	**-31.48**	**-1.18**
		Feb 12	**-55.66**	**4.93**	**.000**	**-70.81**	**-40.51**
	Feb 6	Jan 24	**16.33**	**4.93**	**.037**	**1.18**	**31.48**
		Feb 12	**-39.33**	**4.93**	**.001**	**-54.48**	**-24.18**
	Jan 24	Feb 6	**55.66**	**4.93**	**.000**	**40.51**	**70.81**
		Feb 12	**39.33**	**4.93**	**.001**	**24.18**	**54.48**
Sediment Overgrowth	Jan 24	Feb 6	-2.33	1.36	.275	-6.50	1.84
		Feb 12	**-8.00**	**1.36**	**.003**	**-12.17**	**-3.82**
	Feb 6	Jan 24	2.33	1.36	.275	-1.84	6.50
		Feb 12	**-5.66**	**1.36**	**.014**	**-9.84**	**-1.49**
	Jan 24	Feb 6	**8.00**	**1.36**	**.003**	**3.82**	**12.17**
		Feb 12	**5.66**	**1.36**	**.014**	**1.49**	**9.84**

Table S6: One-way ANOVA results for percent bleached coral tissue (Coral Bleaching) and percent sediment exhibiting overgrowth (Sediment Overgrowth) compared over the three survey efforts through time (Jan 24, Feb 6, and Feb12 2020) at Lagoon site 2. Data were pooled among all triplicate transects. Tukey HSD post-hoc test results are to compare differences between each survey effort (n = 3). A **bolded** value (p-value < 0.05) indicates that the difference was significant between time points.

Photo-Quadrat Survey Method: Lagoon site 2

Lagoon site 2	**df**	**F-value**	**p - value**
Coral Bleaching	**2**	**142.9**	**.000**
Sediment Overgrowth	**2**	**10.5**	**.011**

Tukey HSD

Dependent Variable	(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Coral Bleaching	Jan 24	Feb 6	**-24.00**	**3.88**	**.002**	**-35.92**	**-12.07**
		Feb 12	**-65.00**	**3.88**	**.000**	**-76.92**	**-53.07**
	Feb 6	Jan 24	**24.00**	**3.88**	**.002**	**12.07**	**35.92**
		Feb 12	**-41.00**	**3.88**	**.000**	**-52.92**	**-29.07**
	Jan 24	Feb 6	**65.00**	**3.88**	**.000**	**53.07**	**76.92**
		Feb 12	**41.00**	**3.88**	**.000**	**29.07**	**52.92**
Sediment Overgrowth	Jan 24	Feb 6	-3.00	2.8	.564	-11.59	5.59
		Feb 12	**-12.33**	**2.80**	**.011**	**-20.93**	**-3.73**
	Feb 6	Jan 24	3.00	2.80	.564	-5.59	11.59
		Feb 12	**-9.33**	**2.80**	**.036**	**-17.93**	**-.73**
	Jan 24	Feb 6	**12.33**	**2.80**	**.011**	**3.73**	**20.93**
		Feb 12	**9.33**	**2.80**	**.036**	**.73**	**17.93**

Table S7: One-way ANOVA results for percent bleached coral tissue (Coral Bleaching) and percent sediment exhibiting overgrowth (Sediment Overgrowth) compared over the three survey efforts through time (Jan 24, Feb 6, and Feb12 2020) between Lagoon site 1 and Lagoon site 2. Data were pooled among all triplicate transects. A **bolded** value (p-value < 0.05) indicates that the difference was significant between Lagoon sites.

Photo-Quadrat Survey Method				
	Coral Bleaching		**Sediment Overgrowth**	
Date	**df**	**p - value**	**df**	**p - value**
Jan 24 2020	1	1.00	1	0.899
Feb 6 2020	1	0.067	1	0.692
Feb 12 2020	1	0.256	1	0.231

Table S8: List of invertebrate taxonomy described in section 3.2.4.

Group	**Taxon**	**Common name**
Algae	*Caulerpa* spp.	
	Chlorophyta spp.	Green algae
	Halimeda spp.	
	Laurencia spp.	
	Padina sp.	
	Rhodophyta spp.	Red algae
	Valonia ventricosa	Sailor’s eyeball alga
Corals	*Acropora secale*	
	Acropora millepora	
	Acropora muricata	
	Acropora spp.	Staghorn corals
	Astrea curta	
	Cyphastrea chalcidicum	
	Dipsastraea sp.	
	Favites halicora	
	Favites rotundata	
	Goniastrea edwardsi	Honeycomb coral
	Goniopora sp.	Flowerpot coral
	Isopora palifera	

	Klyxum sp.	
	Lobophyllia agaricia	
	Montipora digitata	
	Montipora grisea	
	Montipora hispida	
	Montipora sp.	
	Platygyra daedalea	Lesser valley coral
	Platygyra spp.	
	Pocillopora damicornis	
	Pocillopora sp.	Cauliflower coral
	Porites attenuate	
	Porites cylindrica	Yellow finger coral
	Porites sp.	Pore coral
	Sarcophyton spp.	Toadstool leather corals
	Stylophora pistillata	Hood coral
Crustaceans	Alpheidae sp.	Snapping shrimp
	Alpheus sp.	Snapping shrimp
	Brachyura spp.	Crabs
	Calcinus latens	Hidden hermit crab
	Caridea sp.	Caridean shrimp
	Clibanarius corallinus	Coral hermit crab
	Dardanus megistos	White-spotted hermit crab
	Majidae sp.	Spider crab
	Stomatopoda spp.	Mantis shrimps
	Thalamita sp.	
	Trapezia serenei	Coral crab
	Zenopontonia soror	Seastar shrimp
Echinoderms	*Culcita novaeguineae*	Pillow cushion star
	Holothuria atra	Lollyfish sea cucumber
	Holothuria edulis	Pinkfish sea cucumber
	Holothuria leucospilota	Black sea cucumber

	Holothuria sp.	
	Linckia guildingi	Guilding’s sea star
	Linckia laevigata	Blue linckia
	Nardoa novaecaledoniae	Yellow mesh sea star
	Stichopus herrmanni	Herrmann’s sea cucumber
	Stichopus chloronotus	Greenfish sea cucumber
Molluscs	*Aplysia argus*	White-speckled seahare
	Atactodea striata	Striate beach clam
	Codakia paytenorum	Payten's codakia
	Chrysostoma paradoxum	Orange-mouthed top shell
	Clypeomorus bifasciata	Double-banded creeper
	Coralliophila sp.	
	Ergalataxinae	
	Gymnodoris sp.	
	Melo amphora	Giant baler
	Pitar sp.	
	Spondylus sp.	Thorny oyster
	Tectus fenestratus	Latticed top shell
	Tonna chinensis	China tun
	Tridacna maxima	Small giant clam
	Tubulophilinopsis gardineri	Gardiner's headshield slug
	Turbo argyrostomus	Silvermouth turban
Polychaetes	*Perinereis* sp.	
	Spirobranchus sp.	Christmas tree worm
	Terebellidae sp.	Spaghetti worm
Sponges	Porifera sp.	

Table S9: Shapiro-Wilk test for normality in reef metabolism. Data are organized by rates of NEP and NEC measured at Lagoon site 1, Lagoon site 2, and the larger lagoon area (Slack Water). Data for each Lagoon site were pooled among triplicate parallel transects. NEP data were not included for the slack-water method. If the significant value (Sig.) of the test is > 0.05 the data exhibit a normal distribution.

		Shapiro-Wilk		
	Site	**Statistic**	**df**	**Sig.**
NEP	Lagoon site 1	.951	36	.112
	Lagoon site 2	.984	36	.857
	Slack Water			
NEC	Lagoon site 1	.967	36	.356
	Lagoon site 2	.952	36	.117
	Slack Water	.962	33	.287

Table S10: One-way ANOVA results (p-values) comparing measured reef metabolism (NEP and NEC) between triplicate transects within each Lagoon site (Lagoon site 1, Lagoon site 2, and Slack Water). Data were pooled among all 11 (Slack water) and 12 (Lagoon site 1 and Lagoon site 2) days of measurements (3 days for Night NEC). A **bolded** value (p-value < 0.05) indicates that the measured response in that specific metabolic parameter significantly differed between triplicate transects.

Metabolism	**Lagoon site 1**		**Lagoon site 2**		**Slack Water**	
	df	**p-value**	**df**	**p-value**	**df**	**p-value**
NEP	2	.471	2	.917		
NEC	2	.169	2	.489	2	.581
Night NEC					2	.617

Table S11: One-way ANOVA results (p-values) comparing measured reef metabolism (NEP and NEC) between measurement days within each Lagoon site (Lagoon site 1 and Lagoon site 2 = 12; Slack Water = 11; Night NEC = 3). Data were pooled among all triplicate transects. A **bolded** value (p-value < 0.05) indicates that the measured response in that specific metabolic parameter significantly differed between triplicate transects.

Metabolism	**Lagoon site 1**		**Lagoon site 2**		**Slack Water**	
	df	**p-value**	**df**	**p-value**	**df**	**p-value**
NEP	11	.181	11	.099		
NEC	11	.506	11	.365	10	.073
Night NEC					2	.083

Table S12: One-way ANOVA results for NEP compared amongst Lagoon site 1 and Lagoon site 2 and for NEC compared amongst Lagoon site 1, Lagoon site 2, and Slack Water. Data were pooled among all triplicate transects and measurements days. Tukey HSD post-hoc test results are displayed for NEC (n = 3). A **bolded** value (p-value < 0.05) indicates that the difference was significant between Lagoon sites.

Metabolism	**df**	**F-value**	**p - value**
NEP	1	3.47	.067
NEC	**2**	**8.17**	**.001**

Tukey HSD						
					95% Confidence Interval	
(I) Site	**(J) Site**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**Lower Bound**	**Upper Bound**
Lagoon site 1	Lagoon site 2	-.8742	1.015	.666	-3.2916	1.5431
	Slack Water	**3.0361***	**1.015**	**.010**	**.6187**	**5.4534**
Lagoon site 2	Lagoon site 1	.8742	1.015	.666	-1.5431	3.2916
	Slack Water	**3.9103***	**1.015**	**.001**	**1.4929**	**6.3277**
Slack Water	Lagoon site 1	**-3.0361***	**1.015**	**.010**	**-5.4534**	**-.6187**
	Lagoon site 2	**-3.9103***	**1.01544**	**.001**	**-6.3277**	**-1.4929**

Figures

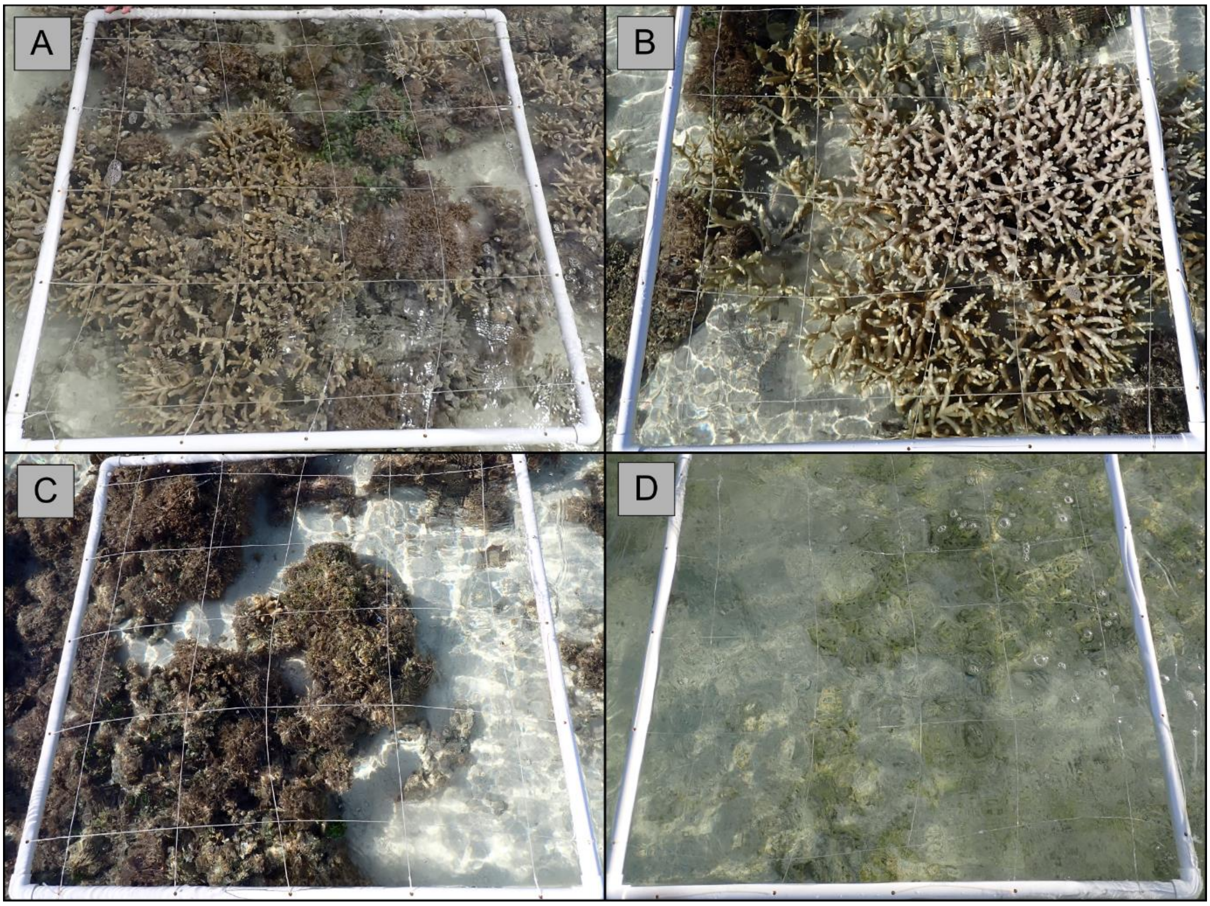

Figure S.1: Photo-quadrat examples of various reef health. A) Healthy *Acropora* spp. coral observed during the first survey effort. B) Bleached *Acropora* spp. observed during the final survey effort. C) Example of fleshy algal growth as the dominant benthic organism D) Example of Chlorophyta overgrowth on the sediment.

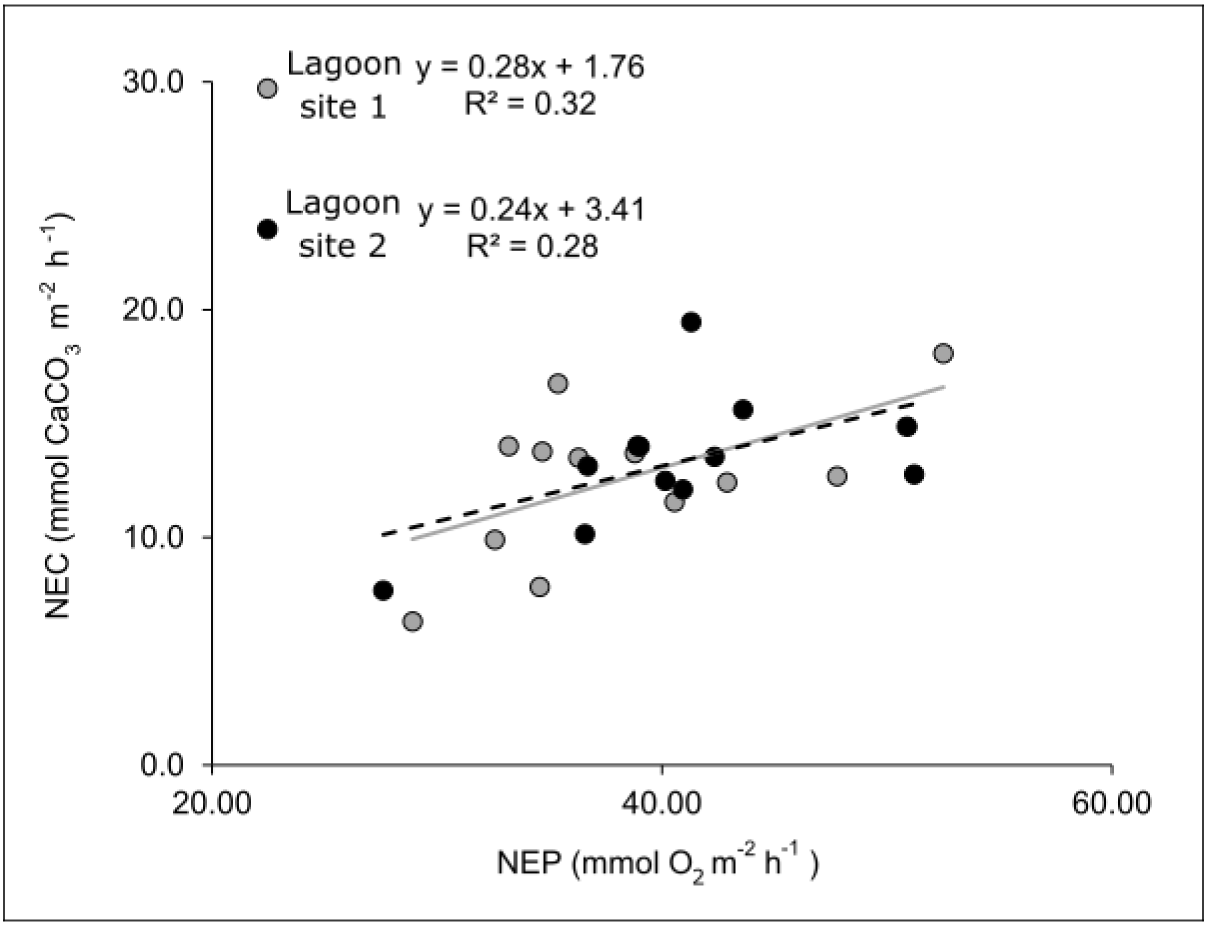

Figure S.2: Rates of net ecosystem calcification (NEC) as a function of net ecosystem production (NEP) separated between study Lagoon site 1 (grey) and Lagoon site 2 (black).

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