

CORAL  
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Region: Pacific: Hawaii, Guam, Palau, Australia  
Dates: June 2016 –May, 2017  
Project website: [https:// coral.jpl.nasa.gov](https://coral.jpl.nasa.gov)

#### PROCESSING UPDATE

Community metabolism (Primary production P and calcification G) was measured using a Lagrangian approach (Langdon et al. 2010), which involves measuring total alkalinity ( $A_T$ ), pH, and dissolved oxygen (DO) of seawater on the upstream and downstream locations on the reef flat community. This method can be used on reefs that experience unidirectional flow of water across the reef flat (Langdon et al. 2010). The distance between the up- and downstream stations varied from 273 m in Lizard Island to 363 m in Palau. In each location, instruments were deployed for 4 to 6 days at up- and downstream moorings and included a SAMIpH (Sunburst Sensors, Missoula, MT), Nortek (Boston, MA) Aquadopp acoustic doppler profilers (ADP), and optode oxygen sensors (MiniDOT, PME, Vista, CA). At the downstream location only, a  $2\pi$  PAR sensor (Biospherical Instruments San Diego, CA) connected to a SeaBird 16Plus CTD (Bellevue, WA) recorded PAR each minute.  $pH_T$  (total scale) and temperature were measured by the SAMIpH instruments (which were factory calibrated and have an accuracy of  $\pm 0.003$  and precision  $< 0.001$ ) hourly at both locations over the 6-d deployment. Three-dimensional water velocity was measured with ADPs in 10-cm bins from 20 cm above the benthos to the water surface at 1-min intervals (accuracy  $\pm 1\%$  of measured value  $\pm 0.5$  cm/s). The oxygen sensors have an accuracy of 10  $\mu$ mol/L and were factory calibrated. Prior to deployment, the  $O_2$  sensors were moored together overnight to provide cross-calibrations. The sensors recorded oxygen each minute over the course of the deployment. On two occasions (Day 4 and 6 of each deployment) water samples for Winkler determination of  $O_2$  were taken adjacent to each of the  $O_2$  sensors using a Niskin (General Oceanic, Miami, FL) bottle. Water samples were fixed immediately after collection (in the boat) and Winkler titrations were performed immediately after return to the lab using a Metrohm Dosimat manual titrator (Riverview, FL). Hourly values of windspeed for each site were obtained from NOAA and AIMS buoys at the study sites.

G was estimated using the alkalinity anomaly method (Smith and Kinsey 1978). Since  $A_T$  was calculated over 6 hours interval, to obtain hourly values, G was also calculated from indirect measures of dissolved inorganic carbon (DIC) (Falter et al. 2012). DIC was calculated from hourly values of pH and  $A_T$  (over 6-hours) using Seacarb (Seawater Carbonate Chemistry) Version 3.2 and then used to calculate G following (Falter et al. 2012). Water samples at each location were analyzed for  $A_T$  using potentiometric titration using standard protocols. For Hawaii,  $A_T$  was measured on the same day of sample collection using a Mettler-Toledo titrator (Table 1). Samples from Lizard Island, Guam, and Palau were preserved by adding 200  $\mu$ L  $HgCl_2$  to inhibit biological activity.  $A_T$  for the water samples were analyzed using potentiometric titrations with a Mettler-Toledo titrator fitted with DG 115-SC pH probe (Mettler Toledo, Switzerland) calibrated every other day with Tris/HCl buffers (Dickson et al., 2007). In each case, titrations were conducted following standard protocols (SOP Dickson....). Accuracy of  $A_T$  measurements was checked by titrating certified reference materials provided by A.G. Dickson that yielded  $A_T$  values within  $\sim 4 \mu\text{mol kg}^{-1}$  of the nominal value.

Primary production was calculated from changes in oxygen concentrations using the following equation:

$$1) P(R) = \frac{(DO_{DN} - DO_{UP})}{L} \frac{(U_{UP}H_{UP} + U_{DN}H_{DN})}{2} - J_{air-sea}$$

where DO is dissolved oxygen concentration, UP is the upstream mooring, DN is the downstream one, H is average water depth, U is the depth-averaged vector-rotated velocity along the axis of the transect, L is the distance between the moorings, and J is the air-sea flux. This assumes that mean depth-integrated Lagrangian transport along the transect path is  $(U_{UP}H_{UP} + U_{DN}H_{DN})/2$ . Community respiration rates (R) were obtained from the same equation using the data collected each night.

Air-sea flux (J) is:

$$2) J_{air-sea} = k_{O_2} (DO_{sat} - O_2^{water})$$

where  $O_2^{water}$  is the concentration of oxygen in the water,  $DO_{sat}$  is the saturation oxygen concentration and  $k_{O_2}$  is the gas transfer coefficient. The saturation of oxygen at the air-water interface,  $DO_{sat}$  is computed from Henry's Law (Benson and Krause, 1984).

Calcification (G) using the  $A_T$  anomaly method (from the discrete water samples) was calculated as:

$$3) G = ((\Delta A_T / 2) * \rho) * (H * U) / D$$

where:

G = net calcification rate (mmol CaCO<sub>3</sub> m<sup>-2</sup> d<sup>-1</sup>), ΔA<sub>T</sub> is the difference between A<sub>T</sub> upstream and A<sub>T</sub> downstream (μmol/kg), ρ is the seawater density (1023 kg/m<sup>3</sup>), H is the average water depth across the transect (m), U is the average hourly velocity between the moorings (m/s) and D is the transect length between locations (m). Net calcification over hourly periods was calculated from changes in DIC (dissolved inorganic carbon [CO<sub>2</sub>/HCO<sub>3</sub>/CO<sub>3</sub>] between the upstream and downstream ends of transect (DIC<sub>up</sub>, DIC<sub>dn</sub>). DIC was calculated from hourly values of pH (SAMIPH), the daily values of A<sub>T</sub> over six hours from water samples. Similarly, aragonite saturation state (Ω) was calculated from pH and A<sub>T</sub> using Seacarb (Seawater Carbonate Chemistry) Version 3.2.

The total change in DIC (DIC<sub>T</sub>) is the sum of the change due to photosynthesis/respiration (ΔDIC<sub>P/R</sub>) and the change due to calcification/ dissolution (ΔDIC<sub>C/D</sub>).

$$4) \Delta DIC_T = \Delta DIC_{P/R} + \Delta DIC_{C/D}$$

To derive G for each hour of the diurnal cycle we used the difference between the total change in DIC and the change due to P/R:

$$5) \Delta DIC_{C/D} = \Delta DIC_T - \Delta DIC_{P/R}$$

## Reference

- Falter JL, Lowe RJ, Atkinson MJ, Cuet P (2012) Seasonal coupling and de-coupling of net calcification rates from coral reef metabolism and carbonate chemistry at Ningaloo Reef, Western Australia. *J Geophys Res Oceans* 117:
- Langdon C, Gattuso J-P, Andersson A (2010) Measurements of calcification and dissolution of benthic organisms and 13 communities.
- Smith SV, Kinsey DW (1978) Calcification and organic carbon metabolism as indicated by carbon dioxide. *Coral Reefs Res Methods* 5:469–484