QCL WATER SCIENCE

University of Copenhagen

Monitoring Dynamic Diurnal Changes in Oxygen, pH and Temperature on Coral Reefs

Climate change is threatening the most diverse marine ecosystems, coral reefs. Rising surface water temperatures as well as ocean acidification are posing a challenge to reefs worldwide. A more overlooked, yet serious stress factor is ocean deoxygenation causing low oxygen (hypoxia) conditions on coral reefs. However, knowledge about the in-situ oxygen dynamics on reefs is limited. Using the new underwater logger AquapHOx from PyroScience we monitored dynamic changes in oxygen, pH and temperature over a diurnal cycle as a result of changing irradiance and tides within a patch of branching Acroporid corals on the reef flat of Heron Island, Great Barrier Reef, Australia.

Set-Up and Study Site

Two AquapHOx loggers from PyroScience were calibrated according to standard procedures and deployed (Fig.1A-D), January 16 – January 21 2020 at low tide on the shallow reef flat of Heron Island, Great Barrier Reef, Queensland, Australia (23° 26.5540 S, 151° 54.7420 E). The underwater loggers were equipped with oxygen and pH sensitive optode sensor spots and were placed in a coral patch, dominated by branching Acroporid corals (Fig. 1B and D). The loggers were held in place with dive weights, with the optical components facing downward into the coral patch, to i) measure within the coral patch and ii) shield the optical sensor spots from high irradiance. During the tidal cycle (Fig.2A and B) the analyte-sensitive part of the loggers remained submerged at all times and data was logged in 5 minute intervals.

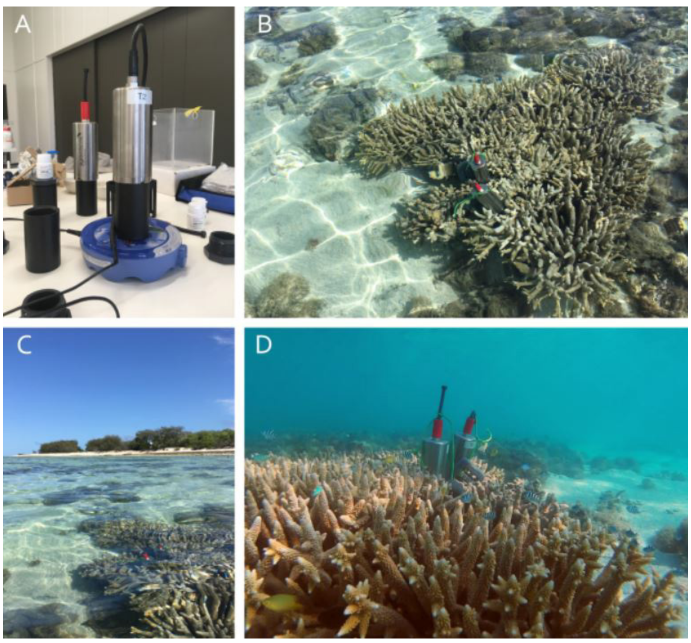

Fig. 1. A) Calibration of the loggers prior to deployment. B-D) Deployed AquapHOx loggers in a coral patch on the reef flat of Heron Island, Australia, as seen from above (B), in relation to the shoreline (C) and under water (D).

Results and Discussion

The water column above the loggers changed quite dramatically (over ~ 1.9 m) with the tides over 24 hours, and the tidal variation appeared to have pronounced consequences for both temperature, pH and oxygen levels in the coral patch (Fig. 2).

The in-situ pH (Fig. 2B) and oxygen concentration (Fig. 2A) were determined in parallel using optical sensor spots (OXSP5 and PHSP5-PK8). The two loggers were placed in close proximity, for comparable results. Temperature was measured (and used for automatic temperature compensation) by the integrated temperature sensor of the loggers and ranged from ~27.5°C (pH logger) and ~27.1 °C (O2 logger) at 6:37 a.m. to ~30.0 °C (pH logger) to ~29.6 °C (O2 logger) at 12:27 p.m. The temperature is plotted with the respectively monitored analyte.

Both pH (Fig. 2B), and oxygen (Fig.2A) followed a similar pattern to the logged temperature with strong increases setting in shortly after sunrise, reaching maxima at ~336 µmol L-1 oxygen at 1:16 p.m. and pH values of ~8.34, which remained relatively constant between 12:57 p.m. and 6:12 p.m. At 6:12 p.m. (25 minutes before sunset) pH, oxygen and temperature showed a small spike followed by a rapid decrease in all three parameters.

Minimum values were observed in darkness (although fluctuating over time, which could be due to water movement caused by tides or animals) with oxygen concentrations reaching as low as ~28 µmol L-1 (thus, a change of 308 µmol L-1), and pH ~7.86 (thus, a change of 0.48 pH units). In the bulk seawater we measured a pH of ~8.3 – 8.4 and an oxygen concentration of ~250 µmol oxygen L-1 (data not shown).

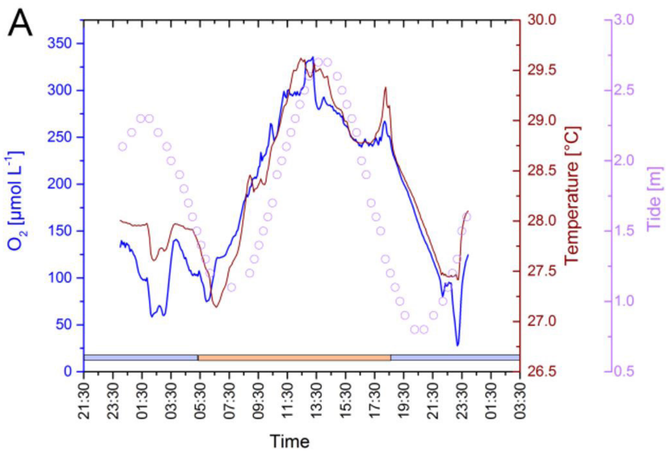

Figure 2A shows O2 (blue) dynamics together with changes in temperature (red) and tide (magenta) monitored for 24 hours. The orange part indicates the time between sunrise and sunset, whereas the blue stripe indicates the time before

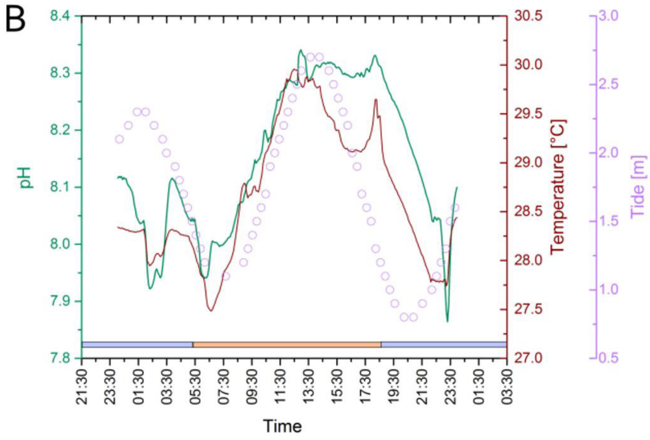

Figure 2 B shows pH (green) dynamics together with changes in temperature (red) and tide (magenta) monitored for 24 hours. The orange part indicates the time between sunrise and sunset, whereas the blue stripe indicates the time before

Conclusion and Outlook

The new AquapHOx underwater loggers were easy to deploy on coral reef patches and generated high quality in-situ data demonstrating pronounced diel variations of important environmental variables (temperature, oxygen and pH) driven by irradiance and tidal changes. This includes demonstration of hypoxic conditions in the investigated coral patch during night-time. Here we present data for one full 24 hour diel cycle starting at midnight. However, the loggers have successfully acquired similar data over several days – and the logger can operate for weeks to months. The AquapHOX underwater loggers are ideal tools to follow chemical dynamics on coral reefs, and would be well suited for detailed long-term monitoring e.g. of the oxygen status and occurrence of hypoxia on coral reefs. Such information is currently highly limited in the scientific literature. We used the heavy-duty deep-sea version of the AquapHOx logger (for underwater operation down to 4000 m water depth). The shallow water version of it will facilitate a larger network of logger deployments, significantly enhancing the knowledge of physico-chemical dynamics on corals reefs under normal, and climate change related stress conditions.

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