# #36 –May 2017 (http://nzoac.nz/)

## News The Pacific Partnership on Ocean Acidification

In June this year, the Pacific islands are amplifying their voice at the United Nations Ocean Conference at the UN Headquarters in New York, focusing on Sustainable Development Goal 14 – Life Below Water. This Pacific Conversation discusses ocean acidification and its impacts on Pacific species, providing you with more information to help make a difference in our region. Did you know that a lower pH, the potential of hydrogen, makes the ocean a louder place? By 2050, under conservative projections of ocean acidification, sounds could travel as much as 70% farther in some ocean areas. This means ocean acidification affects whales and other animals, not just coral reefs and shellfish. The ocean absorbs about 25% of the CO2 that we emit. If we had to pay for it, the value of this ‘ocean service’ to the global economy is USD 60 to 400 billion annually (EPOCA). By taking up our extra CO2, the ocean has acidified by 30% since the start of the Industrial Revolution. The current rate of decrease is 0.02 units per decade, faster than any rate in the past 300 million years. Projections show that by 2060, seawater acidity could have increased by 120%. Ocean acidification affects some species directly, and combines with other stressors. Nutrient pollution also makes nearby acidification worse. We are not powerless in the face of ocean acidification. We can reduce our carbon footprints. We can help our environments and species cope by protecting them and restoring carbon-fixing ecosystems like forests and wetlands. We can reduce other local stressors such as destructive fishing and reducing land-based sources of pollution. Wetlands are our carbon allies, taking up CO2 and storing it in their biomass and soils. But every year, coastal wetland destruction releases 0.15 to 1.02 billion tonnes of CO2 (the same as burning 423 billion litres of petrol, more than the entire commercial airline industry uses in a year!).

When we make the right choices to support our ecosystems, we create positive growth for our ocean, our health, and our industries. When you buy local goods, protect wetlands, and prevent pollution, you are saving the ocean—and saving us too.

Want to know more about ocean acidification in the Pacific? Click [here](https://www.sprep.org/attachments/Publications/FactSheet/Oceans/ocean-acidification-pacific.pdf). SPREP, 24 May 2017. [Article.](https://www.sprep.org/climate-change/ocean-acidification-pacific-conversations-with-sprep)

## The Global Ocean Acidification Observing Network (GOA-ON)

The Global Ocean Acidification Observing Network (GOA-ON), a collaborative international network of 367 members representing 66 nations, is committed to increasing global ocean acidification observing capacity in support of SDG target 14.3: Average marine acidity (pH) measured at agreed suite of representative sampling stations. To achieve this commitment, GOA-ON and its partners are expected to continue to develop and nurture this global network. Importantly, we plan to work to build capacity in regions that currently have limited observation records and little ocean science capacity by conducting targeted training workshops on ocean acidification monitoring and experimentation best practices. We are committed to distributing sensor kits that will allow scientists in resource-poor countries to collect reliable data and so contribute to the global ocean acidification monitoring effort. We also plan to provide stipendiary support to maintain those kits, and create international networking opportunities for early-career and experienced scientists through the GOA-ON Pier2Peer program (<http://goa-on.org/GOA-ON_Pier2Peer.html>). Sensor kits are to be distributed to scientists in Fiji, Mauritius, Mozambique, Seychelles, South Africa, and in several Caribbean nations by 2019.

The Ocean Conference (official website), May 2017. [Statement.](https://oceanconference.un.org/commitments/?id=16542)

**OA-ICC highlights**

The “OA-ICC Highlights” is a quarterly newsletter and all previous editions can be viewed [here](https://www.iaea.org/ocean-acidification/page.php?page=2236).

## Upcoming Events

**Ocean Acidification Day: June 8, 2017**

When it comes to understanding, projecting, and anticipating the impacts of ocean acidification notevery country is on the same page. For example, no studies of ocean acidification impacts have been performed along the African coast despite its biological and socio‐economical vulnerability to future global changes.

**Show your support for the OA‐Africa network by joining the Ocean Acidification Day** **on June 8, 2017.**

You can support this initiative of the OA‐Africa network by:

* Taking a pH measurement on your coast on June 8, 2017
* Taking a picture of the event and share the data on a large scale social media campaign
* Contacting the press to join the event

*Contact: Sam Dupont (*sam.dupont@gu.se)

## New education resource now available

**The Ocean of Tomorrow
*Ocean Acidification Resource for Secondary Schools***This is a new free resource designed to help teachers and educators deliver lessons in the classroom that focus on the impact of ocean acidification on the marine environment.

The resource provides:

* Background information
* Instructions for investigations
* Data forms for students to record their results
* Links to presentations, posters and other materials.

This resource book has been supported by the Lou and Iris Fisher Charitable Trust and the University of Otago Ocean Acidification Research Theme. [**https://goo.gl/rbNsl7**](https://goo.gl/rbNsl7)

Selection of reports, theses and recent papers from the SW Pacific

**Independence of nutrient limitation and carbon dioxide impacts on the Southern Ocean coccolithophore *Emiliania huxleyi*.** Future oceanic conditions induced by anthropogenic greenhouse gas emissions include warming, acidification and reduced nutrient supply due to increased stratification. Some parts of the Southern Ocean are expected to show rapid changes, especially for carbonate mineral saturation. Here we compare the physiological response of the model coccolithophore *Emiliania huxleyi* (strain EHSO 5.14, originating from 50°S, 149°E) with pH/CO2 gradients (mimicking ocean acidification ranging from 1 to 4 × current pCO2 levels) under nutrient-limited (nitrogen and phosphorus) and -replete conditions. Both nutrient limitations decreased per cell photosynthesis (particulate organic carbon (POC) production) and calcification (particulate inorganic carbon (PIC) production) rates for all pCO2 levels, with more than 50% reductions under nitrogen limitation. These impacts, however, became indistinguishable from nutrient-replete conditions when normalized to cell volume. Calcification decreased three-fold and linearly with increasing pCO2 under all nutrient conditions, and was accompanied by a smaller ~30% nonlinear reduction in POC production, manifested mainly above 3 × current pCO2. Our results suggest that normalization to cell volume allows the major impacts of nutrient limitation (changed cell sizes and reduced PIC and POC production rates) to be treated independently of the major impacts of increasing pCO2 and, additionally, stresses the importance of including cell volume measurements to the toolbox of standard physiological analysis of coccolithophores in field and laboratory studies. Müller M. N., Trull T. W. & Hallegraeff G. M., in press.  ISME Multidisciplinary Journal of Microbial Ecology. [Article.](http://dx.doi.org/10.1038/ismej.2017.53)

**Climate change and tropical sponges:. The effect of elevated pCO₂ and temperature on the sponge holobiont** As atmospheric CO₂ concentrations rise, associated ocean warming (OW) and ocean acidification (OA) are predicted to cause declines in reef-building corals globally, shifting reefs from coral-dominated systems to those dominated by less sensitive species. Sponges are important structural and functional components of coral reef ecosystems, but despite increasing field-based evidence that sponges may be ‘winners’ in response to environmental degradation, our understanding of how they respond to the combined effects of OW and OA is limited. This PhD thesis explores the response of four abundant Great Barrier Reef species – the phototrophic *Carteriospongia foliascens* and *Cymbastela coralliophila* and the heterotrophic *Stylissa flabelliformis* and *Rhopaloeides odorabile* to OW and OA levels predicted for 2100, under two CO₂ Representative Concentration Pathways (RCPs). The overall aim of this research is to bridge gaps in our understanding of how these important coral reef organisms will respond to projected climate change, to begin to explore whether a sponge dominated state is a possible future trajectory for coral reefs.

To determine the tolerance of adult sponges to climate change, these four species were exposed to OW and OA in the Australian Institute of Marine Science’s (AIMS) National Sea Simulator (SeaSim) in a 3-month experimental study. The first data chapter explores the physiological responses of these sponges to OW and OA to gain a broad understanding of sponge holobiont survival and functioning under these conditions. In the second and third data chapters I explore the cellular lipid and fatty acid composition of sponges, and how these biochemical constituents vary with OW and OA. Finally, to provide greater insight into the population level impacts of climate change on tropical sponges, in the last data chapter I explore the response of the phototrophic species *Carteriospongia foliascens* to OW/OA throughout its developmental stages.

I found that while sponges can generally tolerate climate change scenarios predicted under the RCP6.0 conditions for 2100 (30ºC/ pH 7.8), environmental projections for the end of this century under the RCP8.5 (31.5ºC/ pH 7.6) will have significant implications for their survival. Temperature effects were much stronger than OA effects for all species; however, phototrophic and heterotrophic species responded differently to OA. Elevated pCO₂ exacerbated temperature stress in heterotrophic sponges but somewhat ameliorated thermal stress in phototrophic species. Furthermore, sponges with siliceous spiculated skeletons resisted the RCP 8.5 conditions for longer than the aspiculate species. Biochemical analysis revealed that spiculated species also have greater cell membrane support features, which is likely to contribute to the observed stress tolerance. I also found that the additional energy available to phototrophic sponges under OA conditions may be used for investment into cell membrane support, providing protection against thermal stress. Finally, larval survival and settlement success of C. foliascens was unaffected by OW and OA treatments, and juvenile sponges exhibited greater tolerance than their adult counterparts, again with evidence that OA reduces OW stress for some of these life stages.

Based on the species studied here, this thesis confirms that sponges are better able to deal with OW and OA levels predicted for 2100 under RCP6.0, compared to many corals for which survival in a high CO₂ world requires OW to remain below 1.5°C. This suggests sponges may be future ‘winners’ on coral reefs under global climate change. However, if CO₂ atm concentrations reach levels predicted under RCP8.5, the prognosis for sponge survival by the end of this century changes as inter-species sponge tolerances to OW and OA differ. Under this projection it is likely we will also start to see a shift in sponge populations to those dominated by phototrophic sponges with siliceous spiculated skeletons. Overall, this thesis gives a holistic view of OW and OA impacts on tropical sponges and provides the basis from which to explore the potential for a sponge-coral regime shift in a high CO₂ world. Bennett H., 2017.  PhD thesis, Victoria University of Wellington, 219 p. [Thesis.](http://hdl.handle.net/10063/6240)

**Estimates of water-column nutrient concentrations and carbonate system parameters in the global ocean: a novel approach based on neural networks.**A neural network-based method (CANYON: CArbonate system and Nutrients concentration from hYdrological properties and Oxygen using a Neural-network) was developed to estimate water-column (i.e., from surface to 8,000 m depth) biogeochemically relevant variables in the Global Ocean. These are the concentrations of three nutrients [nitrate (NO3−), phosphate (PO43−), and silicate (Si(OH)4)] and four carbonate system parameters [total alkalinity (AT), dissolved inorganic carbon (CT), pH (pHT), and partial pressure of CO2 (pCO2)], which are estimated from concurrent in situ measurements of temperature, salinity, hydrostatic pressure, and oxygen (O2) together with sampling latitude, longitude, and date. Seven neural-networks were developed using the GLODAPv2 database, which is largely representative of the diversity of open-ocean conditions, hence making CANYON potentially applicable to most oceanic environments. For each variable, CANYON was trained using 80 % randomly chosen data from the whole database (after eight 10° × 10° zones removed providing an “independent data-set” for additional validation), the remaining 20 % data were used for the neural-network test of validation. Overall, CANYON retrieved the variables with high accuracies (RMSE): 1.04 μmol kg−1 (NO3−), 0.074 μmol kg−1 (PO43−), 3.2 μmol kg−1 (Si(OH)4), 0.020 (pHT), 9 μmol kg−1 (AT), 11 μmol kg−1 (CT) and 7.6 % (pCO2) (30 μatm at 400 μatm). This was confirmed for the eight independent zones not included in the training process. CANYON was also applied to the Hawaiian Time Series site to produce a 22 years long simulated time series for the above seven variables. Comparison of modeled and measured data was also very satisfactory (RMSE in the order of magnitude of RMSE from validation test). CANYON is thus a promising method to derive distributions of key biogeochemical variables. It could be used for a variety of global and regional applications ranging from data quality control to the production of datasets of variables required for initialization and validation of biogeochemical models that are difficult to obtain. In particular, combining the increased coverage of the global Biogeochemical-Argo program, where O2 is one of the core variables now very accurately measured, with the CANYON approach offers the fascinating perspective of obtaining large-scale estimates of key biogeochemical variables with unprecedented spatial and temporal resolutions. The Matlab and R codes of the proposed algorithms are provided as Supplementary Material. Sauzède R., et al.,., 2017. Frontiers in Marine Science 4:128. [Article.](http://dx.doi.org/10.3389/fmars.2017.00128)

**A good Kiwi isn’t acidic: how ocean acidification is affecting the New Zealand economy.** In a country that houses a mere 4 million people, it is no wonder that agriculture has become the main facet of New Zealand’s economy. However, while the sheep and produce have flourished from land protection laws, marine life has struggled in recent years due to an increase in oceanic carbon levels. In an area of the Pacific that is so rich in coral reefs, Great White breeding areas, and a plethora of fish species, any upset of the natural preexisting chemical balance has a tangible impact. New Zealand is dealing with a crisis with huge economic and ecological ramifications. I study the exact adverse effects that ocean acidification has had on the economy of New Zealand. The scientific process of how ocean acidification occurs is a building block of this understanding as well as the Gross Domestic Product (GDP) of the country. The rise of marine pH levels is inextricably linked to the downturn of prosperity in New Zealand’s agricultural sector. My solutions address stricter policies in regards to fishing and emissions regulations to augment the regulation of established New Zealand commercial fishing laws. In this thesis, my goal is to highlight that ocean acidification is a climate problem that affects the entire New Zealand population. By putting these effects into economic terms, I hope to urge change in the “business as usual” way countries conduct themselves, starting with policy makers whose focus is growing their GDP. To illustrate this point effectively, I utilize the disciplines of chemistry, economics, and politics to analyze the trends and consequences of ocean acidification. Hurley L., 2017.  Thesis, Fordham University, 52 p. [Thesis.](http://fordham.bepress.com/environ_2015/38)

**Reef-building corals thrive within hot-acidified and deoxygenated waters.**Coral reefs are deteriorating under climate change as oceans continue to warm and acidify and thermal anomalies grow in frequency and intensity. In vitro experiments are widely used to forecast reef-building coral health into the future, but often fail to account for the complex ecological and biogeochemical interactions that govern reefs. Consequently, observations from coral communities under naturally occurring extremes have become central for improved predictions of future reef form and function. Here, we present a semi-enclosed lagoon system in New Caledonia characterised by diel fluctuations of hot-deoxygenated water coupled with tidally driven persistently low pH, relative to neighbouring reefs. Coral communities within the lagoon system exhibited high richness (number of species = 20) and cover (24–35% across lagoon sites). Calcification rates for key species (*Acropora formosa, Acropora pulchra, Coelastrea aspera* and *Porites lutea*) for populations from the lagoon were equivalent to, or reduced by ca. 30–40% compared to those from the reef. Enhanced coral respiration, alongside high particulate organic content of the lagoon sediment, suggests acclimatisation to this trio of temperature, oxygen and pH changes through heterotrophic plasticity. This semi-enclosed lagoon therefore provides a novel system to understand coral acclimatisation to complex climatic scenarios and may serve as a reservoir of coral populations already resistant to extreme environmental conditions. Camp E. F et al., 2017.  Scientific Reports 7:2434. [Article.](http://dx.doi.org/10.1038/s41598-017-02383-y)

**Inorganic carbon physiology underpins macroalgal responses to elevated CO2.** Beneficial effects of CO2 on photosynthetic organisms will be a key driver of ecosystem change under ocean acidification. Predicting the responses of macroalgal species to ocean acidification is complex, but we demonstrate that the response of assemblages to elevated CO2 are correlated with inorganic carbon physiology. We assessed abundance patterns and a proxy for CO2:HCO3− use (δ13C values) of macroalgae along a gradient of CO2 at a volcanic seep, and examined how shifts in species abundance at other Mediterranean seeps are related to macroalgal inorganic carbon physiology. Five macroalgal species capable of using both HCO3− and CO2 had greater CO2 use as concentrations increased. These species (and one unable to use HCO3−) increased in abundance with elevated CO2 whereas obligate calcifying species, and non-calcareous macroalgae whose CO2 use did not increase consistently with concentration, declined in abundance. Physiological groupings provide a mechanistic understanding that will aid us in determining which species will benefit from ocean acidification and why. Cornwall, C.E., et al., 2017. Scientific Reports, 7:46297, DOI: 10.1038/srep46297.