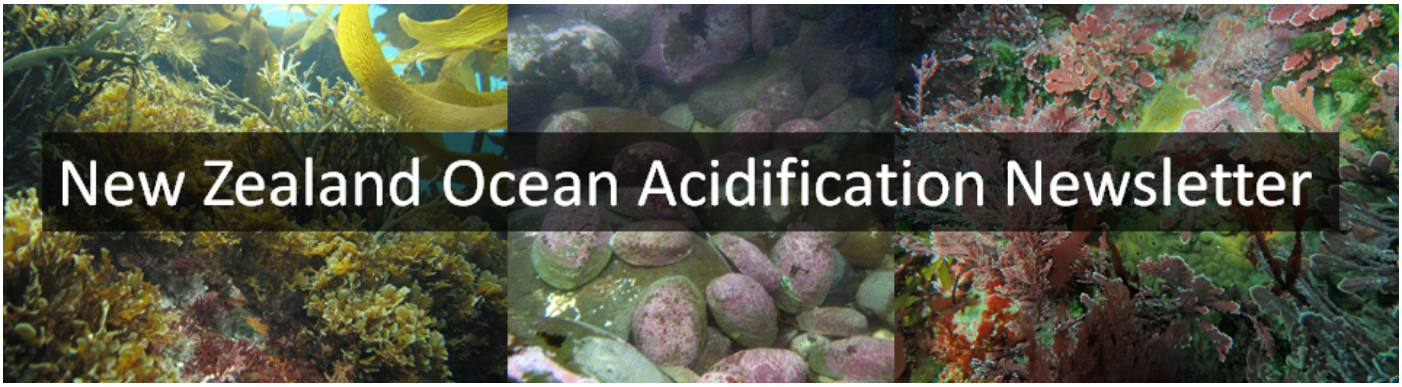
#62 – January 2020 (http://nzoac.nz/)



Local News

CARIM workshop 19th Feb

A summary workshop for the MBIE programme Coastal Acidification – Rates, Impacts and Management (CARIM) will be held on Feb 19th, from 8.45 am to 3.15 pm, in room TTR LT101. All are welcome. If you are interested in attending, please register via email with Victoria Metcalf (Victoria.metcalf@gamil.com).

Reminder – 31st Jan is the last day to register for the 2020 New Zealand Ocean Acidification Community Conference

The 2020 New Zealand Ocean Acidification Conference will be held in Wellington on the 17th to 18th of February at Victoria University. **Registration to attend will close on the 31st of Jan**. Please see previous version of the newsletter for details on registration or contact Christopher.cornwall@vuw.ac.nz

Selection of recent papers

A framework for experimental scenarios of global change in marine systems using coral reefs as a case study Understanding the consequences of rising CO2 and warming on marine ecosystems is a pressing issue in ecology. Manipulative experiments that assess responses of biota to future ocean warming and acidification conditions form a necessary basis for expectations on how marine taxa may respond. Although designing experiments in the context of local variability is most appropriate, local temperature and CO2 characteristics are often unknown as such measures necessitate significant resources, and even less is known about local future scenarios. To help address these issues, we summarize current uncertainties in CO2 emission trajectories and climate sensitivity, examine region-specific changes in the ocean, and present a straightforward global framework to guide experimental designs. We advocate for the inclusion of multiple plausible future scenarios of predicted levels of ocean warming and acidification in forthcoming experimental research. Growing a robust experimental base is crucial to understanding the prospect form and function of marine ecosystems in the Anthropocene.

Geraldi N. R., Klein S. G., Anton A. & Duarte C. M., 2020. A framework for experimental scenarios of global change in marine systems using coral reefs as a case study. *Royal Society Open Science* 7: 191118. doi: 10.1098/rsos.191118. Article.

Climate shapes population variation in dogwhelk predation on foundational mussels Trait variation among populations is important for shaping ecological dynamics. In marine intertidal systems, seawater temperature, low tide emersion temperature, and pH can drive variation in traits and affect species interactions. In western North America, Nucella dogwhelks are intertidal drilling predators of the habitat-forming mussel Mytilus californianus. Nucella exhibit local adaptation, but it is not known to what extent environmental factors and genetic structure

contribute to variation in prey selectivity among populations. We surveyed drilled mussels at sites across Oregon and California, USA, and used multiple regression and Mantel tests to test the effects of abiotic factors and Nucella neutral genetic relatedness on the size of mussels drilled across sites. Our results show that Nucella at sites characterized by higher and less variable temperature and pH drilled larger mussels. Warmer temperatures appear to induce faster handling time, and more stable pH conditions may prolong opportunities for active foraging by reducing exposure to repeated stressful conditions. In contrast, there was no significant effect of genetic relatedness on prey size selectivity. Our results emphasize the role of climate in shaping marine predator selectivity on a foundation species. As coastal climates change, predator traits will respond to localized environmental conditions, changing ecological interactions.

Contolini G. M., Reid K. & Palkovacs E. P., in press. Climate shapes population variation in dogwhelk predation on foundational mussels. *Oecologia*. Article (subscription required).

Combined effects of CO2 level, light intensity, and nutrient availability on the coccolithophore Emiliania huxleyi Continuous accumulation of fossil CO2 in the atmosphere and increasingly dissolved CO2 in seawater leads to ocean acidification (OA), which is known to affect phytoplankton physiology directly and/or indirectly. Since increasing attention has been paid to the effects of OA under the influences of multiple drivers, in this study, we investigated effects of elevated CO2 concentration under different levels of light and nutrients on growth rate, particulate organic (POC) and inorganic (PIC) carbon quotas of the coccolithophorid Emiliania huxleyi. We found that OA treatment (pH 7.84, CO2 = 920 μatm) reduced the maximum growth rate at all levels of the nutrients tested, and exacerbated photo-inhibition of growth rate under reduced availability of phosphate (from 10.5 to 0.4 μmol l−1). Low nutrient levels, especially lower nitrate concentration (8.8 μmol l−1 compared with 101 μmol l−1), decreased maximum growth rates. Nevertheless, the reduced levels of nutrients increased the maximum PIC production rate. Decreased availability of nutrients influenced growth, POC and PIC quotas more than changes in CO2 concentrations. Our results suggest that reduced nutrient availability due to reduced upward advective supply because of ocean warming may partially counteract the negative effects of OA on calcification of the coccolithophorid.

Zhang Y., Fu F., Hutchins D. A. & Gao K., 2019. Combined effects of CO2 level, light intensity, and nutrient availability on the coccolithophore Emiliania huxleyi. *Hydrobiologia* 842 (1): 127–141. Article (subscription required).

Clam feeding plasticity reduces herbivore vulnerability to ocean warming and acidification Ocean warming and acidification affect species populations, but how interactions within communities are affected and how this translates into ecosystem functioning and resilience remain poorly understood. Here we demonstrate that experimental ocean warming and acidification significantly alters the interaction network among porewater nutrients, primary producers, herbivores and burrowing invertebrates in a seafloor sediment community, and is linked to behavioural plasticity in the clam Scrobicularia plana. Warming and acidification induced a shift in the clam's feeding mode from predominantly suspension feeding under ambient conditions to deposit feeding with cascading effects on nutrient supply to primary producers. Surface-dwelling invertebrates were more tolerant to warming and acidification in the presence of S. plana, most probably due to the stimulatory effect of the clam on their microalgal food resources. This study demonstrates that predictions of population resilience to climate change require consideration of non-lethal effects such as behavioural changes of key species.

Colen C. V., Ong E. Z., Briffa M., Wethey D. S., Abatih E., Moens T. & Woodin S. A., in press. Clam feeding plasticity reduces herbivore vulnerability to ocean warming and acidification. *Nature Climate Change*. Article (subscription required).

A coralline alga gains tolerance to ocean acidification over multiple generations of exposure Crustose coralline algae play a crucial role in the building of reefs in the photic zones of nearshore ecosystems globally, and are highly susceptible to ocean acidification. Nevertheless, the extent to which ecologically important crustose coralline algae can gain tolerance to ocean acidification over multiple generations of exposure is unknown. We show that, while calcification of juvenile crustose coralline algae is initially highly sensitive to ocean acidification, after six generations of exposure the effects of ocean acidification disappear. A reciprocal transplant experiment conducted on the seventh generation, where half of all replicates were interchanged across treatments, confirmed that they had acquired tolerance to low pH and not simply to laboratory conditions. Neither exposure to greater pH variability, nor chemical conditions within the micro-scale calcifying fluid internally, appeared to play a role in fostering this capacity. Our results demonstrate that reef-accreting taxa can gain tolerance to ocean acidification over multiple generations of exposure, suggesting that some of these cosmopolitan species could maintain their critical ecological role in reef formation.

Cornwall C. E., Comeau S., DeCarlo T. M., Larcombe E., Moore B., Giltrow K., Puerzer F., D'Alexis Q. & McCulloch M. T., in press. A coralline alga gains tolerance to ocean acidification over multiple generations of exposure. *Nature Climate Change*. Article (subscription required).

Impact of ocean acidification on the metabolome of the brown macroalgae Lobophora rosacea from New Caledonia Macroalgae are critical components of coral reef ecosystems. Yet, they compete for space with corals, and in case of environmental disturbances, they are increasingly involved in phase-shifts from coral-dominated to macroalgae-dominated reefs. As regard to climate change, ocean acidification (OA) has been shown to be detrimental to corals and could favor macroalgal proliferations. However, little is known about the effects of OA on macroalgal phenotypes. Comparative metabolomic studies are particularly relevant to assess phenotypic responses of macroalgae to stress as some seaweed are known to produce a large diversity of specialized metabolites involved in various ecological functions. The main aim of our study was to explore the impact of OA on the metabolome of brown macroalgae using Lobophora rosacea as a model species. This species is widespread in New Caledonian lagoons where it is a key component of coral-algal interactions. Metabolomic changes were analyzed using Liquid Chromatography-Mass Spectrometry (UPLC-HRMS) applied to three different OA scenarii: low and variable pH over a long-term timescale (in situ at Bouraké), low and constant pH over a short-term timescale (ex situ experiment), and current pH (control). Different metabotypes were defined in diverse pH conditions, and a significant decrease in some specialized metabolites concentrations was noticed at low pH including lobophorenols B and C as well as other oxylipin derivatives. We suggest a down-regulation of metabolic pathways involving lobophorenols, in low pH conditions, or their transformation, which is in accordance with the optimal defense theory. In addition, we used Microtox® bioassays as a proxy for macroalgal toxicity and found no significant differences between low pH and control samples. This study details the first metabolomic-based study on a fleshy macroalgae in response to OA and provides new insights for this important functional group producing a large number of metabolites in response to their close environment.

Gaubert J., Rodolfo-Metalpa R., Greff S., Thomas O. P. & Payri C. E., 2020. Impact of ocean acidification on the metabolome of the brown macroalgae Lobophora rosacea from New Caledonia. *Algal Research* 46: 101783. doi: 10.1016/j.algal.2019.101783. Article (subscription required)

Effects of low pH and feeding on calcification rates of the cold-water coral Desmophyllum dianthus Cold-Water Corals (CWCs), and most marine calcifiers, are especially threatened by ocean acidification (OA) and the decrease in the carbonate saturation state of seawater. The vulnerability of these organisms, however, also involves other global stressors like warming, deoxygenation or changes in sea surface productivity and, hence, food supply via the downward transport of organic matter to the deep ocean. This study examined the response of the CWC Desmophyllum dianthus to low pH under different feeding regimes through a long-term incubation experiment. For this experiment, 152 polyps were incubated at pH 8.1, 7.8, 7.5 and 7.2 and two feeding regimes for 14 months. Mean calcification rates over the entire duration of the experiment ranged between −0.3 and 0.3 mg CaCO3 g−1d−1. Polyps incubated at pH 7.2 were the most affected and 30% mortality was observed in this treatment. In addition, many of the surviving polyps at pH 7.2 showed negative calcification rates indicating that, in the long term, CWCs may have difficulty thriving in such aragonite undersaturated waters. The feeding regime had a significant effect on skeletal growth of corals, with high feeding frequency resulting in more positive and variable calcification rates. This was especially evident in corals reared at pH 7.5 (ΩA = 0.8) compared to the low frequency feeding treatment. Early life-stages, which are essential for the recruitment and maintenance of coral communities and their associated biodiversity, were revealed to be at highest risk. Overall, this study demonstrates the vulnerability of D. dianthus corals to low pH and low food availability. Future projected pH decreases and related changes in zooplankton communities may potentially compromise the viability of CWC populations.

Martínez-Dios A., Pelejero C., López-Sanz A., Sherrell R. M., Ko S., Häussermann V., Försterra G. & Calvo E., 2020. Effects of low pH and feeding on calcification rates of the cold-water coral Desmophyllum dianthus. *Peer J* 8: e8236. doi: 10.7717/peerj.8236. Article.

The effects of aragonite saturation state on hatchery-reared larvae of the greenshell mussel Perna canaliculus The major cultured mussel species Perna canaliculus is now supported by hatchery production, providing the opportunity to explore and optimize environmental parameters to enhance production. Other cultured bivalve larvae have demonstrated performance that is directly correlated to the aragonite saturation state (Ωar) of their tank water, with low or undersaturated water being detrimental and artificially elevated Ωar enhancing productivity. Trials were, therefore, designed to specifically explore Ωar sensitivity in preveliger (0–2 days old, prodissoconch I = "PD1") and veliger (2–21 days old, prodissoconch II = "PD2") stages of P. canaliculus separately. For the PD1 experiment, commercial incubation tanks (control Ωar 1.9) were modified to target Ωar 0.5 or 0.8 by elevating pCO2, or 2.9, 4.5, and ~7 by the addition of sodium carbonate. In the control environment, 72.8% ± 2.9% of fertilized eggs formed viable "D" veligers within two days; an increased yield of 82.6% ± 3.8% in Ωar 4.5 was found to be nonsignificant. In comparison, only 12.7% of the Ωar ~7 and <1% of the Ωar 0.5 and 0.8 eggs attained the veliger stage, with the remaining underdeveloped or malformed. By 2 days postfertilization, reactive oxygen species were significantly elevated in the undersaturated treatments, whereas DNA damage, lipid hydroperoxides, and protein carbonyls were significantly higher in the Ωar 0.5 and ~7 treatments. Antioxidant enzyme levels were significantly lower in these extreme treatments, whereas Ωar 4.5 larvae showed elevated superoxide dismutase, glutathione reductase, and peroxidase levels. Carry-over effects persisted when veligers were transferred to control conditions, with no net recruitment from undersaturated Ωar, 29.4% of eggs surviving to pediveliger under control conditions, compared with 33.2% following Ωar 4.5 exposure or 1.9% from Ωar ~7. In the PD2 veliger trial, linear

shell growth halved in undersaturated water, but was unaffected by elevation of Ωar. Mortality rate was consistent across all treatments, suggesting relative resilience to different Ωar. It is recommended that hatcheries trial Ωar 4–4.5 enrichment in preveliger incubation water to improve yield and minimize oxidative stress. Preveliger stages present a potential survival bottleneck, and focused research exploring sensitivity to near-future ocean acidification is, therefore, needed.

Ragg N. L. C., Gale S. L., Le D. V., Hawes N. A., Burritt D. J., Young T., Ericson J. A., Hilton Z., Watts E., Berry J. & King N., 2019. The effects of aragonite saturation state on hatchery-reared larvae of the greenshell mussel Perna canaliculus. *Journal of Shellfish Research* 38 (3): 779-793. Article (subscription required).