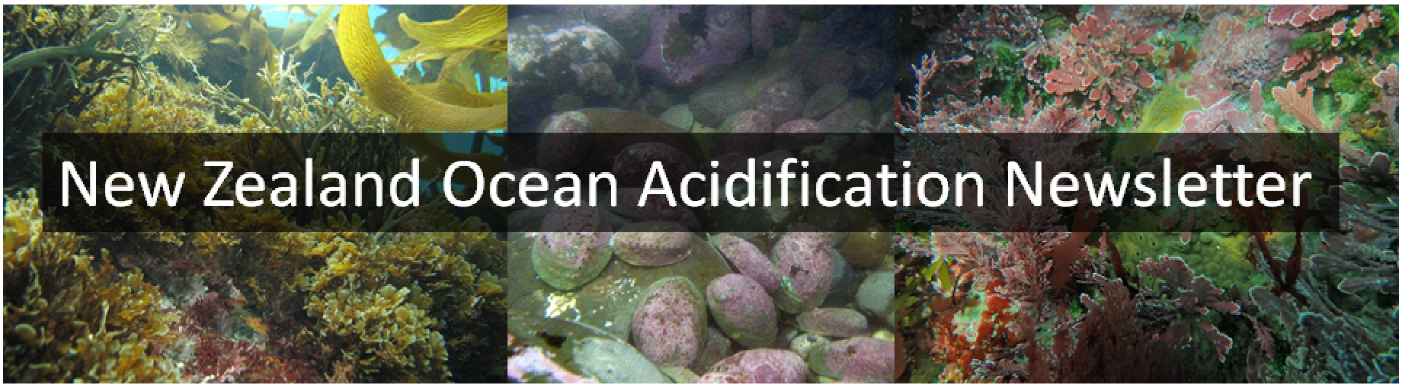
**#58 – June-July 2019 (http://nzoac.nz/)**




## Local News

### 2020 New Zealand Ocean Acidification Conference

**17 – 18th February, 2020**
**Victoria University of Wellington**

The 2020 New Zealand Ocean Acidification Conference will be held in Wellington on the 17th to 18th of February at Victoria University. The organising committee will be in touch soon regarding abstract submissions and plenary speakers.

There will be an associated workshop for students and early career researchers on multiple drivers, and also the annual CARIM workshop both held at Victoria University of the 19th of February the day after the NZ OA conference.

### NZOAC post-conference workshop:

**19 February, 2020**
**9:30 – 4:00**
**Victoria University of Wellington**

### How will biota respond to a changing ocean?
### A best practice guide for multiple drivers research

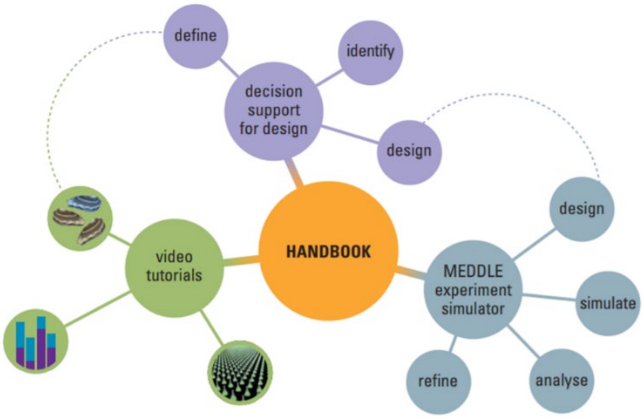
Christina M. McGraw (University of Otago, Department of Chemistry) and Christopher Cornwall (Victoria University, School of Biological Sciences)

Marine species and ecosystems are exposed to a wide range of environmental changes due to human activities. These anthropogenic pressures are referred to as *drivers* or *stressors* and include temperature, $CO_2$, pH, oxygen, salinity, density, irradiance and nutrients, eutrophication, UV exposure, and point source pollution. These drivers will change concurrently and will vary on both local and global scales. To predict the response of biota to these complex and highly-localised changes, new experimental approaches are needed. For example, a full factorial experimental design with 3 drivers, 5 levels per driver and 3 replicates requires 375 experimental units across 125 treatments.

To help researchers design tractable multiple driver experiments and achieve better alignment and integration of research efforts, Scientific Committee on Oceanic Research (SCOR) Working Group 149 has developed a range of resources:

- A *Decision support tool* to help researchers refine their research question, identify local drivers, and develop an appropriate experimental design.
- *MEDDLE web-based software* allows researchers to design, simulate, download and analyse data from a multiple driver experiment. This allows users to test their experimental design and data analysis plan before carrying out the experiment.
- *Video tutorials* cover fundamentals of multiple driver experiments (e.g. *Experimental Design*) and specialised topics (e.g. *Environmental Realism*).

This hands-on, 1-day workshop will introduce these resources (available at https://meddle-scor149.org/) and guide participants through their use.




The Best Practice Guide for Multiple Driver Research includes a handbook, web-based decision support tool, MEDDLE simulation software and a library of video tutorials.

Spaces are limited in this free workshop.

To register, e-mail christina.mcgraw@otago.ac.nz by January 31st.

## International News and jobs

### 5th International Symposium on the Ocean in a High $CO_2$ World 7 - 10 September 2020

Dates and location for the 5th International Symposium on the Oceans in a High CO2 World have been announced. This is the world's premier ocean acidification conference, and it will be held in Lima, Peru on the 7th till the 10th of September 2020.

## Selection of recent papers

**Long-term acclimation to near-future ocean acidification has negligible effects on energetic attributes in a juvenile coral reef fish.** Increased levels of dissolved carbon dioxide (CO2) drive ocean acidification and have been predicted to increase the energy use of marine fishes via physiological and behavioural mechanisms. This notion is based on a theoretical framework suggesting that detrimental effects on energy use are caused by plasma acid–base disruption in response to hypercapnic acidosis, potentially in combination with a malfunction of the gamma aminobutyric acid type A (GABAA) receptors in the brain. However, the existing empirical evidence testing these effects primarily stems from studies that exposed fish to elevated CO2 for a few days and measured a small number of traits. We investigated a range of energetic traits in juvenile spiny chromis damselfish (Acanthochromis polyacanthus) over 3 months of acclimation to projected end-of-century CO2 levels (~ 1000 µatm). Somatic growth and otolith size and shape were unaffected by the CO2 treatment across 3 months of development in comparison with control fish (~ 420 µatm). Swimming activity during behavioural assays was initially higher in the elevated CO2 group, but this effect dissipated within ~ 25 min following handling. The transient higher activity of fish under elevated CO2 was not associated with a detectable difference in the rate of oxygen uptake nor was it mediated by

GABAA neurotransmitter interference because treatment with a GABAA antagonist (gabazine) did not abolish the $CO_2$ treatment effect. These findings contrast with several short-term studies by suggesting that end-of-century levels of $CO_2$ may have negligible direct effects on the energetics of at least some species of fish.

Sundin J., Amcoff M., Mateos-González F., Raby G. D. & Clark T. D., in press. Long-term acclimation to near-future ocean acidification has negligible effects on energetic attributes in a juvenile coral reef fish. *Oecologia*. Article (subscription required).

**Effects of ocean acidification on marine photosynthetic organisms under the concurrent influences of warming, UV radiation, and deoxygenation.** The oceans take up over 1 million tons of anthropogenic $CO_2$ per hour, increasing dissolved $pCO_2$ and decreasing seawater pH in a process called ocean acidification (OA). At the same time greenhouse warming of the surface ocean results in enhanced stratification and shoaling of upper mixed layers, exposing photosynthetic organisms dwelling there to increased visible and UV radiation as well as to a decreased nutrient supply. In addition, ocean warming and anthropogenic eutrophication reduce the concentration of dissolved $O_2$ in seawater, contributing to the spread of hypoxic zones. All of these global changes interact to affect marine primary producers. Such interactions have been documented, but to a much smaller extent compared to the responses to each single driver. The combined effects could be synergistic, neutral, or antagonistic depending on species or the physiological processes involved as well as experimental setups. For most calcifying algae, the combined impacts of acidification, solar UV, and/or elevated temperature clearly reduce their calcification; for diatoms, elevated $CO_2$ and light levels interact to enhance their growth at low levels of sunlight but inhibit it at high levels. For most photosynthetic nitrogen fixers (diazotrophs), acidification associated with elevated $CO_2$ may enhance their $N_2$ fixation activity, but interactions with other environmental variables such as trace metal availability may neutralize or even reverse these effects. Macroalgae, on the other hand, either as juveniles or adults, appear to benefit from elevated $CO_2$ with enhanced growth rates and tolerance to lowered pH. There has been little documentation of deoxygenation effects on primary producers, although theoretically elevated $CO_2$ and decreased $O_2$ concentrations could selectively enhance carboxylation over oxygenation catalyzed by ribulose-1,5-bisphosphate carboxylase/oxygenase and thereby benefit autotrophs. Overall, most ocean-based global change biology studies have used single and/or double stressors in laboratory tests. This overview examines the combined effects of OA with other features such as warming, solar UV radiation, and deoxygenation, focusing on primary producers.

Gao K., Beardall J., Häder D.-P., Hall-Spencer J. M., Gao G. & Hutchins D. A., 2019. Effects of ocean acidification on marine photosynthetic organisms under the concurrent influences of warming, UV radiation, and deoxygenation. *Frontiers in Marine Science* 6: 322. doi: 10.3389/fmars.2019.00322. Article.

**Wasting away in the intertidal: the fate of chiton valves in an acidifying ocean.** Chitons are locally common in New Zealand, and several studies have suggested that their valves are resistant to dissolution, so it seems contradictory that they are under-represented in the sediment and fossil records of New Zealand. Indeed, special resistance to dissolution seems counterintuitive since the valves are primarily made of aragonite. Here we examine the resistance of chiton skeletal material to dissolution in order to expand our understanding of how taphonomic forces affect chitons and to provide insight into the preservation potential of chiton valves. Live individuals of eight species of chitons were collected from Otago Peninsula, South Island, New Zealand. The valves were subjected to one of two pH treatments: ambient pH of 8.10 and reduced pH of 7.70. Notoplax violacea, Sypharochiton pelliserpentis, and S. sinclairi were the most resistant to dissolution while Acanthochitona zelandica, Chiton glaucus, Onithochiton neglectus, and Ischnochiton maorianus were more vulnerable to dissolution. Leptochiton inquinatus lost the most mass in both treatments, but did not show a significant difference between them. SEM images of the dorsal and ventral surfaces on each valve revealed low-pH damage to crystal structures in the articulamentum, while the tegmentum showed no significant damage. Chiton skeletal material in general does not appear to resist dissolution any better than other examined mollusks, but the resistant tegmentum confers considerable resilience to lowered pH. Chiton valves can last up to an estimated 45 years before becoming unrecognizable, which is much shorter than the normal temperate shallow-water exposure time of hundreds to thousands of years.

Peebles B. A. & Smith A. M., 2019. Wasting away in the intertidal: the fate of chiton valves in an acidifying ocean. *Palaios* 34 (6): 281-290. Article (subscription required).

**Sea urchin reproductive performance in a changing ocean: poor males improve while good males worsen in response to ocean acidification.** Ocean acidification (OA) is predicted to be a major driver of ocean biodiversity change. At projected rates of change, sensitive marine taxa may not have time to adapt. Their persistence may depend on pre-existing inter-individual variability. We investigated individual male reproductive performance under present-day and OA conditions using two representative broadcast spawners, the sea urchins Lytechinus pictus and Heliocidaris erythrogramma. Under the non-competitive individual ejaculate scenario, we examined sperm functional parameters (e.g. swimming speed, motility) and their relationship with fertilization success under current and near-future OA conditions. Significant inter-individual differences in almost every parameter measured were identified. Importantly, we observed strong inverse relationships between individual fertilization success rate under current conditions and change in fertilization success under OA. Individuals with a high fertilization success under current conditions had reduced fertilization under OA, while individuals with a low fertilization success under current conditions improved. Change in fertilization success ranged from −67% to +114% across individuals. Our results demonstrate that while average population fertilization rates remain similar under OA and present-day conditions, the contribution by different males to the population significantly shifts, with implications for how selection will operate in a future ocean.

Smith K. E., Byrne M., Deaker D., Hird C. M., Nielson C., Wilson-McNeal A. & Lewis C., 2019. Sea urchin reproductive performance in a changing ocean: poor males improve while good males worsen in response to ocean acidification. *Proceedings of the Royal Society B: Biological Sciences* 286 (1907). doi: 10.1098/rspb.2019.0785. Article.

**Future ocean climate homogenizes communities across habitats through diversity loss and rise of generalist species**. Predictions of the effects of global change on ecological communities are largely based on single habitats. Yet in nature, habitats are interconnected through the exchange of energy and organisms, and the responses of local communities may not extend to emerging community networks (i.e. metacommunities). Using large mesocosms and meiofauna communities as a model system, we investigated the interactive effects of ocean warming and acidification on the structure of marine metacommunities from three shallow-water habitats: sandy soft-bottoms, marine vegetation and rocky reef substrates. Primary producers and detritus – key food sources for meiofauna – increased in biomass under the combined effect of temperature and acidification. The enhanced bottom-up forcing boosted nematode densities but impoverished the functional and trophic diversity of nematode metacommunities. The combined climate stressors further homogenized meiofauna communities across habitats. Under present-day conditions metacommunities were structured by habitat type, but under future conditions they showed an unstructured random pattern with fast-growing generalist species dominating the communities of all habitats. Homogenization was likely driven by local species extinctions, reducing interspecific competition that otherwise could have prevented single species from dominating multiple niches. Our findings reveal that climate change may simplify metacommunity structure and prompt biodiversity loss, which may affect the biological organization and resilience of marine communities.

Brustolin M. C., Nagelkerken I., Ferreira C. M., Goldenberg S. U. & Fonseca H. U. G., in press. Future ocean climate homogenizes communities across habitats through diversity loss and rise of generalist species. *Global Change Biology*. Article (subscription required).

**Meta-analysis reveals enhanced growth of marine harmful algae from temperate regions with warming and elevated CO2 levels.** Elevated pCO2 and warming may promote algal growth and toxin production, and thereby possibly support the proliferation and toxicity of harmful algal blooms (HABs). Here, we tested whether empirical data support this hypothesis using a meta-analytic approach and investigated the responses of growth rate and toxin content or toxicity of numerous marine and estuarine HAB species to elevated pCO2 and warming. Most of the available data on HAB responses towards the two tested climate change variables concern dinoflagellates, as many members of this phytoplankton group are known to cause HAB outbreaks. Toxin content and toxicity did not reveal a consistent response towards both tested climate change variables, while growth rate increased consistently with elevated pCO2. Warming also led to higher growth rates, but only for species isolated at higher latitudes. The observed gradient in temperature growth responses shows the potential for enhanced development of HABs at higher latitudes. Increases in growth rates with more CO2 may present an additional competitive advantage for HAB species, particularly as CO2 was not shown to enhance growth rate of other non-HAB phytoplankton species. However, this may also be related to the difference in representation of dinoflagellate and diatom species in the respective HAB and non-HAB phytoplankton groups. Since the proliferation of HAB species may strongly depend on their growth rates, our results warn for a greater potential of dinoflagellate HAB development in future coastal waters, particularly in temperate regions.

Brandenburg K. M., Velthuis M. & Van de Waal D. B., 2019. Meta-analysis reveals enhanced growth of marine harmful algae from temperate regions with warming and elevated CO2 levels. *Global Change Biology* 25 (8): 2607-2618. Article.

**How calorie-rich food could help marine calcifiers in a CO2-rich future.** Increasing carbon emissions not only enrich oceans with CO2 but also make them more acidic. This acidifying process has caused considerable concern because laboratory studies show that ocean acidification impairs calcification (or shell building) and survival of calcifiers by the end of this century. Whether this impairment in shell building also occurs in natural communities remains largely unexplored, but requires re-examination because of the recent counterintuitive finding that populations of calcifiers can be boosted by CO2 enrichment. Using natural CO2 vents, we found that ocean acidification resulted in the production of thicker, more crystalline and more mechanically resilient shells of a herbivorous gastropod, which was associated with the consumption of energy-enriched food (i.e. algae). This discovery suggests that boosted energy transfer may not only compensate for the energetic burden of ocean acidification but also enable calcifiers to build energetically costly shells that are robust to acidified conditions. We unlock a possible mechanism underlying the persistence of calcifiers in acidifying oceans.

Leung J. Y. S., Doubleday Z. A., Nagelkerken I., Chen Y., Xie Z. & Connell S. D., 2019. How calorie-rich food could help marine calcifiers in a CO2-rich future. *Proceedings of the Royal Society B: Biological Sciences* 286 (1906). doi: 10.1098/rspb.2019.0757. Article (subscription required).