2020 Prime Minister's MacDiarmid Emerging Scientist Prize

Marine scientist who studies impact of climate change and ocean acidification wins Prime Minister's MacDiarmid Emerging Scientist Prize

Dr Christopher Cornwall has won the Prime Minister's MacDiarmid Emerging Scientist Prize for his cutting-edge research on how marine organisms will fare under climate change. He is a Rutherford Discovery Fellow at Te Herenga Waka – Victoria University of Wellington in the School of Biological Sciences.

"My research seeks to understand how climate change will impact the ability of what we call calcifying species to grow," Chris says.

These calcifying species include iconic species such as pāua and kina, but lately most of his research has been on organisms called coralline algae, a calcifying seaweed, which creates the foundation of reefs in temperate environments, such as New Zealand, as well as forming the backbone of coral reefs in tropical waters. These coralline algae not only create a home for a wide range of organisms but they also use chemical signals to advertise it as a good home for many species.

"Coralline algae is the pink stuff you see on the rocks and they are really ecologically important. They are what we call the foundation species in these reefs. They cement the reefs together in the temperate zones and in the tropics, but they also act as a required settlement substrate for marine invertebrate larvae. They emit a chemical cue into the water that tells the larvae it's good to come back to that reef, that it's a good place to live."

"Without these coralline algae we wouldn't have tropical reefs but also, here in New Zealand, the species we love so much – pāua and kina – their invertebrate larvae also rely on this settlement substrate for their existence," Chris explains.

As climate change heats the planet, the oceans are becoming warmer and more acidic.

"Ocean acidification is a process of decreasing seawater pH and this is caused by the increases in carbon-dioxide in the atmosphere, and this carbon-dioxide is absorbed into the surface waters of the world's oceans. It decreases what we call seawater pH – so making it less alkaline, moving towards increased acidity. What it also does is change the types of carbon that are available in seawater. Together these two processes impact the ability of calcifying species to grow and make their skeleton."

Through his research, Chris sought to understand the underlying physiology of how these organisms lay down calcium carbonate in their skeletons and how climate change and more acidic oceans can disrupt this process.

When Chris started his research, scientists understood that ocean acidification would badly impact the growth of these calcifying species, but they didn't really have a good handle on why.

"For the first time ever, we used boron isotopes to determine the pH levels inside the organisms where they lay down this calcium carbonate."

"What we found was, those species that are more resilient to the effect of ocean acidification had a greater ability to keep that internal pH constant under ocean acidification, whereas those species that were more greatly impacted by ocean acidification were those whose pH internally declined as the external seawater pH declined."

His research showed there was a range of specific traits in corals and coralline algae, and, while some were able to resist ocean acidification, most of them were not.

"So unfortunately, for the majority of species, they were quite sensitive to its impacts and what would occur here is they would reduce their growth rates and their settlement rates. Essentially in the future, they are most likely to be out-competed or completely cease to exist."

Chris said the timing of this loss was difficult to predict, but probably over the next 20 to 30 years there would be large changes in the species we have here in New Zealand, with some outcompeting others. "We have probably already lost some species already," Chris says.

The next chapter of his research was to see if species could gain the ability to tolerate ocean acidification over one lifetime or multiple generations.

"Unfortunately we found that over one lifetime they cannot gain these traits, but the next step was looking to see if they could gain these traits over multiple generations. We ran an eight-generation experiment and found that after six generations of exposure to ocean acidification, this one specific species of coralline algae gained the ability to resist the effects of ocean acidification.

"This research has taught me a lot about the processes involved in potentially safeguarding some of these species in the future. Some species may be able to adapt naturally, and we could use what's called 'assistive evolution' to help with some of that, to speed this process up by growing them in the lab and then out-planting them in real reefs.

"But I think, unfortunately, the real reality of the situation is that climate change is happening on such a vast scale that our ability as humans to mitigate this locally is a drop in the ocean, so to speak, compared to the amount of reef space that's out there, so I don't think we'd be able to feasibly save species from ocean acidification and ocean warming using assisted evolution."

After determining the mechanisms that enabled resistance or sensitivity to the effects of ocean acidification, the next question Chris sought to answer was 'how will this scale up?'

He has been leading research with a team of 21 coral reef scientists who have been modelling how coral reef growth will function in the future at different carbon-dioxide emission levels, assessing more than 200 highly biodiverse reefs.

"We took real reef growth and the cover of corals and coralline algae, put that together with our projections, to understand how each of these 233 reefs will function in the future in terms of their growth rates.

"Importantly, what we found was that these reefs will be badly impacted by both ocean acidification and warming. Our ability to keep CO_2 emissions down is really the best way we can protect these reefs for the future"

The urgency of the situation is one of the reasons that Chris is keen to share his research with schools.

"One of the really important things about marine climate change is that it's really urgent that people understand the message, because this generation of kids who are coming through school for example, they're the ones that are really going to have to deal with this problem, so understanding that it is a problem and how can we do things to change this problem, is a message that really need to get out there."

Chris is a first-in-family scientist who gained a love of biology "fossicking around rock pools while my dad was off fishing". He was inspired by the passion of his lecturers at Victoria University of Wellington and thinks New Zealand is a great place to be a marine biologist.

"We have these wonderful reefs right on our backdoor steps, these huge kelp forests or temperate reefs, right outside our place of work, for example, and we are so close to these tropical reefs in the Pacific and Australia so New Zealand is a great place for budding marine biologists to learn their trade."

Two-and-a-half years ago, Chris was awarded a Rutherford Discovery Fellowship – a scheme administered by Royal Society Te Apārangi on behalf of government to build New Zealand's future research leaders. "This scheme enabled me to come back to New Zealand, it enabled me to start my own research group and fund that group's research and my own research. Without it, I would most likely still be in Australia working there."

Chris has published articles in many of the highest-impact journals, including *Nature*, *Nature Climate Change*, *Global Change Biology* and *Proceedings B*. Between having 2400 citations and his publication record at his early stage in his career, it is clear that he has already had a significant impact in his field of research. He recently organised a national ocean acidification conference and is committed to his role as a science communicator.

The Prime Minister's MacDiarmid Emerging Scientist Prize comes with $200,000 that will enable Chris and his team to continue their research. Chris says there is much that is unmonitored and unknown about New Zealand's marine environment and how it is changing with climate change.

For Chris, uncovering new knowledge is his inspiration.

"After I started doing research I realised that for some of this work that we are doing, we might be the first people ever to uncover that knowledge, and that really inspired me to keep going, it was sort of like putting the pieces of a giant puzzle together and that's really what I love the most about my work."

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