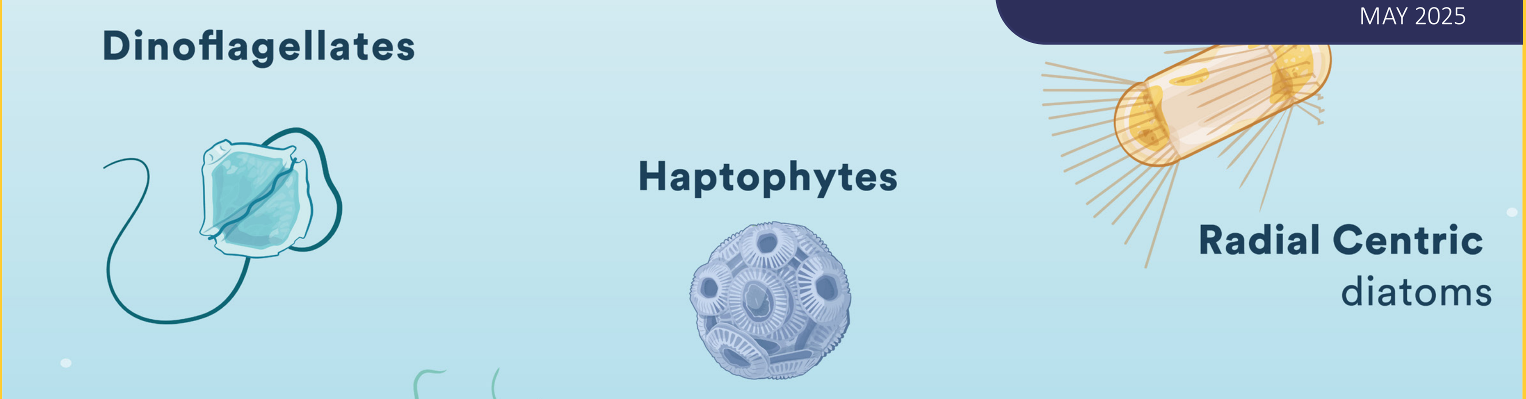


MARINE BIOLOGIST, ECOLOGIST AND ARTIST

JACQUI STUART

Marine biologist and ecologist Jacqui Stuart of the Antarctic Research Centre studies microalgae in Antarctica. From graphic designer to research scientist, she shares how and why she investigates these tiny organisms both in the lab and the field. Science communicator Heather Goodey finds out more.

BACKGROUND

Jacqui was born in Kirikiriroa/Hamilton in 1992 into an outdoorsy family. Initially they were based in Aria, then Wellington briefly, before moving to Hawke's Bay when she was seven. There, she spent her days exploring the hills and the coastline—the ocean would become a constant companion in her life.

INTRODUCTION TO SCIENCE

Jacqui attended Woodford House in Havelock North but wasn't interested in science and dropped the subject as soon as she was able after Y11—focusing instead on art and design. Unhappy at school, she left before completing Y13. Still, having already achieved university entrance in Y12, she followed her creative interests with a graphic design degree at the Whanganui School of Design through the University of Waikato.

Top graphic credit: Jacqui Stuart

HOW SHE GOT INTO SCIENCE

She did not connect her love of nature with science until much later, after noticing gradual changes at her favourite non-protected diving spots: increased rubbish and dwindling sea life. Yet, elsewhere, she observed the positive environmental impacts of marine reserves. This prompted her to change direction and work in an area better aligned with her interests and values, returning to university and retraining as a marine biologist.

TRAINING AND ROLES

Above: Jacqui Stuart

Jacqui received a Master of Marine Biology from James Cook University in Townsville, Australia, in 2019—with the Great Barrier Reef on her doorstep. In the same year, she returned to New Zealand to work as a research assistant at the Cawthorn Institute, researching the impact of marine microalgae on seafood, particularly the potential impact of adverse toxic algae on humans.

She recently completed her PhD (Doctorate of Philosophy) in 2024 in a partnership between Cawthorn Institute and the Victoria University of Wellington.

Jacqui admits that every decision in her career was never part of an overarching plan, saying: "If you had told me that I would be studying microalgae and be passionate about it, I would have laughed at you!"

Jacqui is now based in Wellington, working for the Antarctic Research Centre investigating microalgae in Antarctica.

RESEARCH FIELD

Jacqui specialises in marine biology and ecology and is currently studying what different microalgae are found in different marine habitats and exploring what macronutrients these populations provide to the marine food web. She is interested in how changes to climate and other stressors might change how much microalgae there is, which different microalgae grow best and change the

MICROALGAE

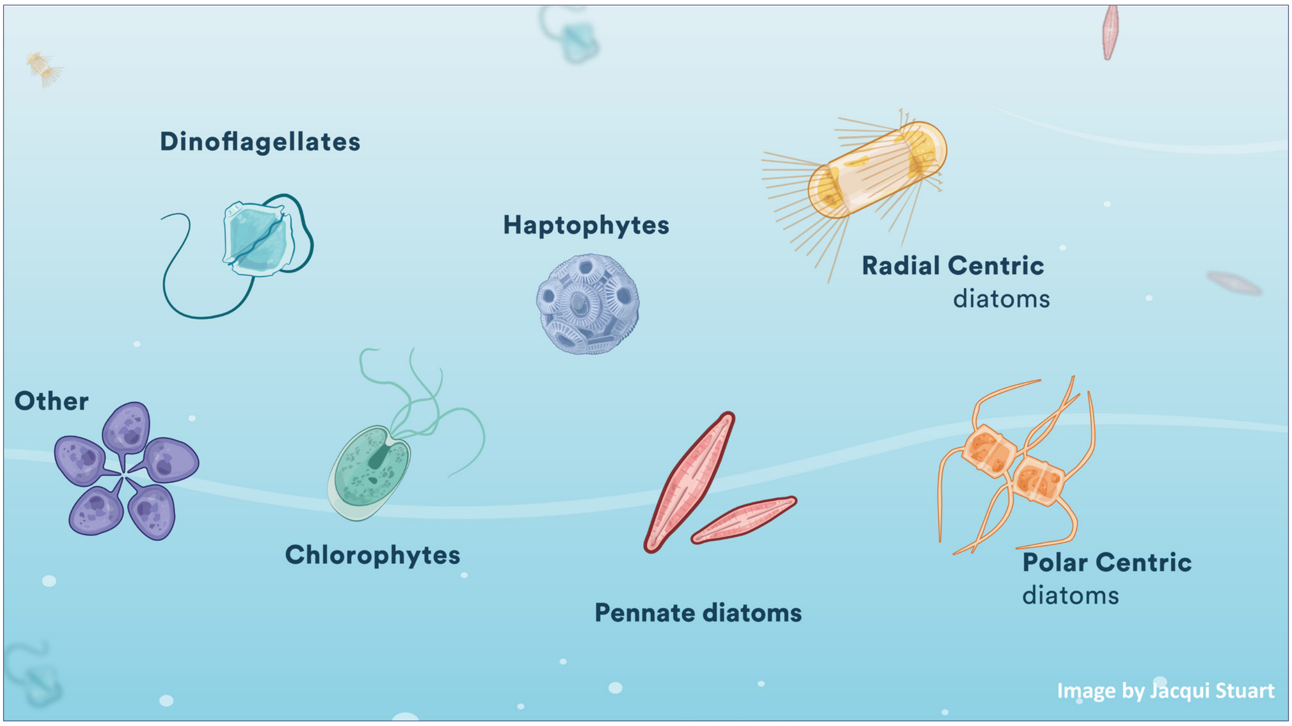
Microalgae are tiny plant-like organisms that use sunlight to create energy. Like plants, microalgae are **producers** but do not have leaves or roots. Microalgae contain **chlorophyll** and can **photosynthesise**, using the energy from sunlight to turn **carbon dioxide** and water into **oxygen** and **sugars.**

Although they are too small to observe without a microscope, microalgae are incredibly important.

They are found in huge numbers throughout the oceans. Microalgae are responsible for much of the ocean's **primary production**—the process of capturing energy from sunlight and turning it into food that supports nearly all marine life.

They form the foundation of the marine food web, generate around 50% of the Earth's oxygen and help remove carbon dioxide from the atmosphere.

Figure 1: Microalgal groups that make up the communities found in Antarctica and oceans world wide.
Graphic credit: Jacqui Stuart



macronutrients the microalgae produce. This is key to understanding how climate change can impact the Antarctic food web.

EXPLORATION METHODS

COLLECTING SAMPLES

Jacqui and an amazing team of scientists have collected microalgae samples from the same sites in Antarctica in 2022 and 2024 using a SIPRE sea ice drill (Figure 3c) and a specially designed drill called a sympagic sampler (Figure 3d). To understand what the microalgal communities were like in and under the ice they collected a series of sea ice and sub-ice platelet layer core samples. These were collected within a close timeframe at the same sites so there is replication. This means you can be more confident in your results, as you can compare multiple samples.

At the study sites, sea ice measured 2.5 metres and 1.5 metres thick. Beneath that, the platelet ice layer varied—2.5 metres under the thicker ice and around 1 metre beneath the thinner site.

"The challenge is to push the drill through the sea ice without disturbing the platelet ice or the surrounding water and then collect a specific layer. You remove the ice plug first, which is always fun, then we use a vacuum to suck the platelet ice core up into a sample container; we usually do about 25 centimetre segments." Learn more about the drill here.

Above: Microalgae. Credit Jacqui Stuart

UNDERSTANDING THE ANTARCTIC FOOD WEB AND THE IMPORTANCE OF MACRONUTRIENTS

Connections within the Antarctic food web—from producers to top predators—are much shorter and more direct since there is less diversity in primary producers like seaweed or sea grass. Microalgae are more dominant in this environment and as a result changes to the microalgae community can have far greater impacts compared to other more complex food webs elsewhere.

Microalgae are the source of **macronutrients**, such as **carbohydrates**, **lipids** and **proteins**, for the zooplankton that feed on them. Different microalgae provide different macronutrients, and different zooplankton need different nutrients.

Other larger animals then feed on the zooplankton; some whale species depend directly on krill, and some penguins' diet is predominantly silverfish. Microalgae are essential to the survival of most life in the Antarctic food web. Without them, the entire ecosystem would be severely disrupted. Changes to the nutrients available can affect microalgae growth and lead to major changes throughout the food web.

ANALYSING SAMPLES

Jacqui measures chlorophyll and uses gas chromatography and species identification with environmental DNA (eDNA) and microscopy to identify which microalgae are present.

"Once we have our samples, we melt them. We filter the sample and measure the amount of chlorophyll-a, this is an estimate of the total amount of microalgae. We then use eDNA to estimate the proportion of the population represented by each microalgae group.

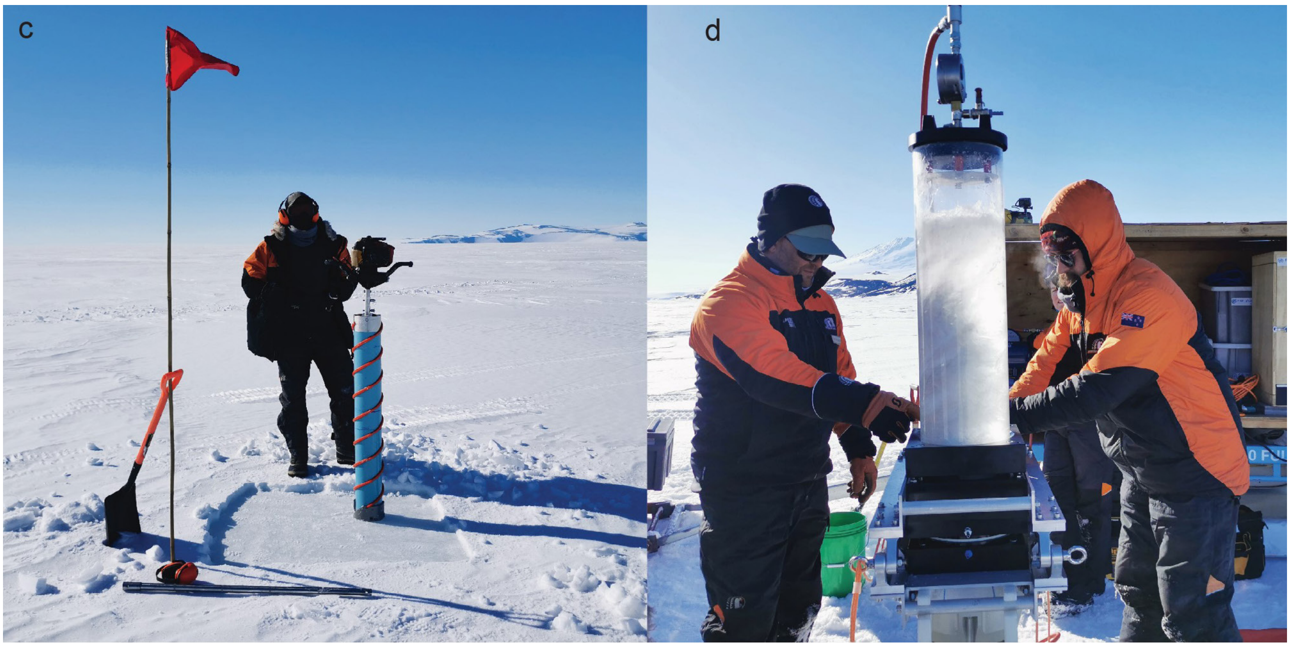
“A sub-sample of each core section are also preserved in sample containers to be observed under a microscope.”

Identifying microalgal groups with a microscope complements the eDNA samples and ensures that the results from one technique are confirmed by the other. Gas chromatography is used to identify the macronutrients in the sample. All this data is integrated to get an understanding of the populations in the sea ice. Using multiple sources and multiple sample replicates increases reliability of data.

CHALLENGES

“In eDNA samples from the environment, we can capture whole microalgal cells as well as free and fragmented DNA. However, when we use metabarcoding to study these communities, we only sequence a small region

Figure 3: Sampling in 2022 with (c) a SIPRE coring drill used to sample the sea ice and (d) sympagic sampler in action, pulling up a platelet core section. Credit Jacqui Stuart.



of a single gene. Metabarcoding is like scanning the DNA 'barcodes' of lots of organisms at once to find out what species are in a sample. Some microalgae have multiple copies of that gene, while others have only one, so the number of DNA sequences we detect does not directly reflect the number of individual cells. This is why microscopy is important — by directly observing and counting cells, we can complement the DNA data and get a clearer picture of the microalgal community."

DESIGNING INVESTIGATIONS

Ice thickness and snow cover changes affect how much light reaches microalgae, so Jacqui designed a range of experiments to study their response to varying light levels. In the laboratory, she studied how specific microalgae species change how fast they grow, and the macronutrients produced.

At her study site in Antarctica in 2024, Jacqui continued this experiment at the whole microalgal community level. She removed all ($10m^3$) the snow from an area of sea ice, and piled up 10 centimetre of snow on another 10 x 10 m^2 area, while leaving a 'control' or

Figure 2. Beautiful sub-ice platelet layers: (left) a single platelet crystal about the size of a hand - image Jacqui Stuart. (middle) platelet crystal collection on the underside of a sea ice chunk - image Jacqui Stuart). (right) undulating sub-ice platelet layer photographed from under the ice green with microalgae. Image: Leigh Tate NIWA

ICE IN ANTARCTICA

Microalgae can live in ice and oceans. There are different types of ice; generally, there are more algae in the lower layers (platelet ice), which have delicate ice structures like an upside down reef under the sea ice made out of ice crystals. This type of ice, platelet ice, doesn't form everywhere in Antarctica, usually only in areas where there is an ice shelf close by. More porous than sea ice, microalgae can live on the platelets and in the water between the platelets.

"More space means there's more room for the algae to grow, and more flow of nutrients than in the sea ice," says Jacqui. "Making it a very important habitat within the ice column. There is a field of algae that species like krill can come and graze on."

To sample the microalgae growing in the platelet ice it is necessary to drill through the solid sea ice and then collect a core sample of the fragile platelet ice along with the water that is between and around the ice crystals . "Until recently, the platelet layer couldn't be sampled because we didn't have the technology to collect and isolate samples."

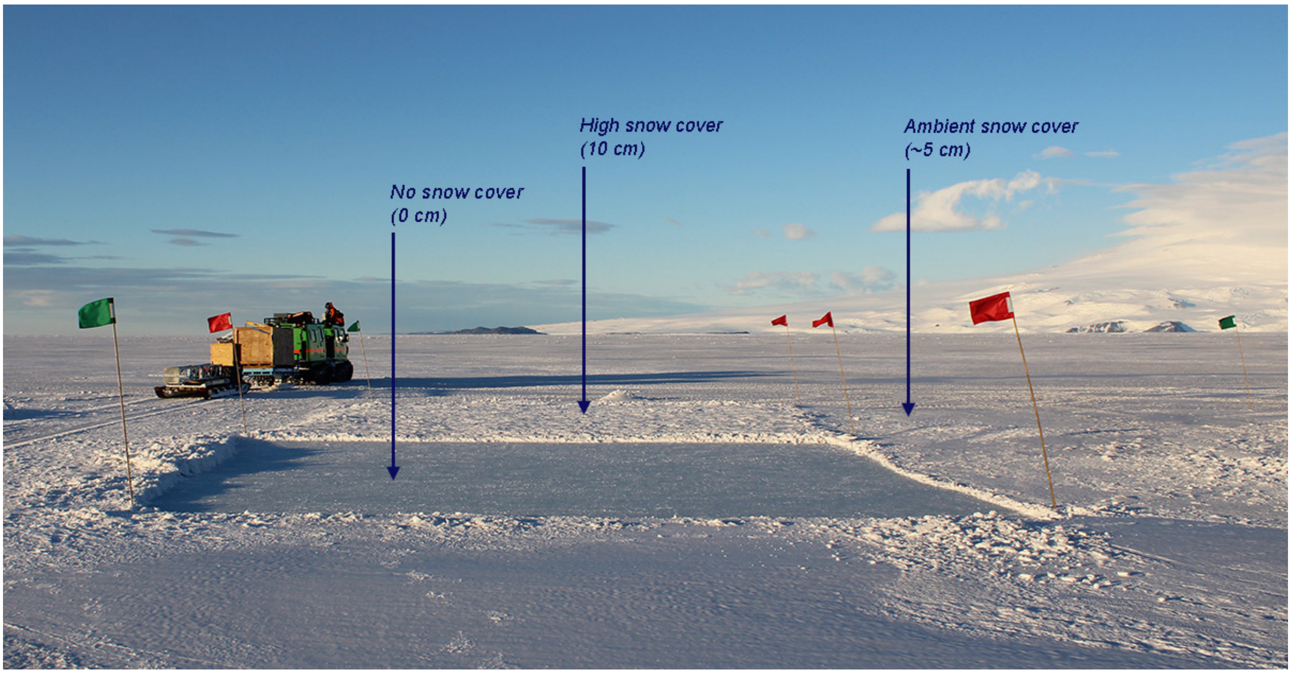


Figure 4. Snow load experiment set up in McMurdo Sound, Antarctica (2024). Credit Jacqui Stuart

unaltered area as well. This experiment set up took four people all day to complete. Moving all this snow created different light conditions for the microalgae, much like the lab experiment— where more snow means less light. She collected samples from each snow 'treatment' (0cm, 10cm and control) at 5 day intervals to observe how the microalgae were affected, which species thrived, struggled and did it change what nutrients they produced?

VALUABLE RESULTS

Jacqui says the findings from 2022 are valuable—her team now knows the composition of algae growing in the platelet layer, while the samples collected in 2024 (still being worked on) will help calculate how the macronutrients are connected to the community composition in the platelet layer, and show what they can provide to the food web.

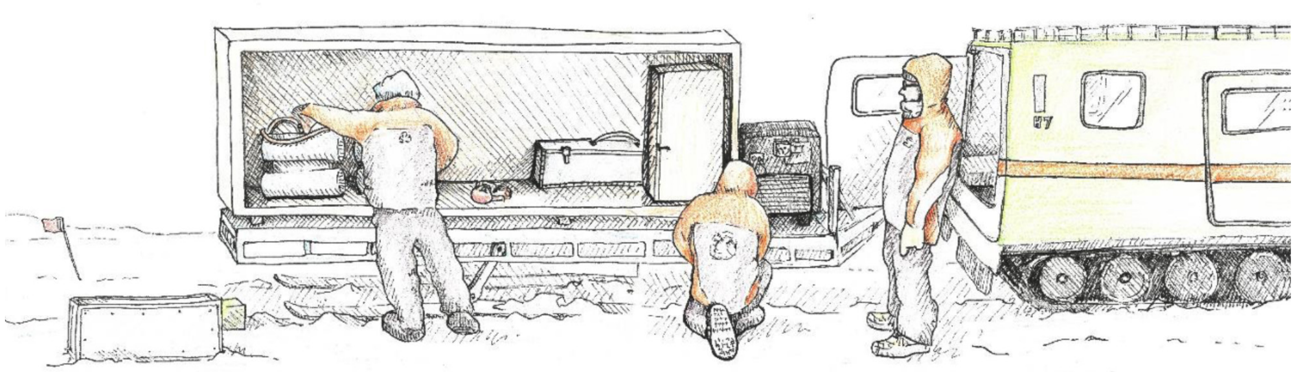
"This helps us understand the current state of the ecosystem and allows us to investigate how the ecosystem might change and what impact that would have on all the other species that rely on microalgae directly or indirectly.

"One finding that was surprising was how different microalgae species respond differently to changes in light. Quite unexpectedly in the laboratory based experiments, one microalgae, a dinoflagellate which is not considered toxic, made more of a compound (fatty acid) thought to be toxic to fish under conditions that are becoming more prevalent in Antarctica. This particular fatty acid has been associated with fish deaths in other microalgae species that produce it.

This was all carried out in a laboratory, so we do not yet know if this will happen in the ecosystem. Equally, there could be beneficial effects from changing ice thickness and light intensity. We do know the sea ice is changing we just do not know yet what the impact on that is. That is what makes this research so important."

MĀTAURANGA `MĀORI

"The well-being of Antarctica influences the health of the planet. The idea that all life is interconnected and no one community survives in isolation—Antarctica personifies this interconnection."



WHAT SHE LIKES ABOUT SCIENCE

Jacqui describes herself as a nature-centric person—curious by nature and driven by big questions. She finds science both humbling and exhilarating: a reminder of how tiny humans are on the broader ecosystem and a way to keep discovering the unknown.

“I like asking why,” she says. “I love nature.”

What happens to microalgae over winter? “We do know some form cysts, (like going into hibernation) and some algae do not just rely on photosynthesis for energy. But essentially, we do not really know. Other scientists are now looking at how to get equipment that can sample during winter.”

Jacqui recommends keeping an open mind for budding scientists because you never know where your interests will take you.

“No skill goes wasted; I now incorporate my art (above image) into academic research articles to help communicate science ideas.”

GLOSSARY

SIPRE sea ice drill, Sympagic sampler: specialised equipment for collecting samples in ice.

Chlorophyll: The pigments found in most plants that is needed for photosynthesis.

Chlorophyll-a: A specific form of chlorophyll, measuring chlorophyll-a is a way to measure how much microalgae are present.

DNA: Deoxyribonucleic acid (DNA) is a molecule that contains the instructions needed for an organism to develop and function.

eDNA: The genetic material left by organisms in the environment (water, air, sediment). It can be used to detect the presence of species in the environment.

DNA barcode: A short DNA sequence that is unique to an organism. DNA barcodes can be used to distinguish closely related species.

Metabarcoding: A procedure used to determine the different species in a sample using the DNA barcode.

Chromatography: A chemical technique to separate different molecules in a mixture.

Gas chromatography: A laboratory instrument used to separate and analyse chemicals in a sample.

Microscopy: Using a microscope to observe objects too small to be seen with the naked eye.

Dinoflagellate: Microscopic single-celled organism that lives in freshwater and seawater. Under warm conditions, marine species can grow and spread to cause a red ‘bloom’ visible in the sea.

Macronutrient: a nutrient that is required in large amounts.

CLASSROOM ACTIVITIES

Communicating and investigating science

Microalgae and UV light: Ideas for educators

RELEVANT LINKS

Jacqui’s microalgae song

More information on climate change and marine food webs and the consequences for NZ fisheries and sea life.

Snow load experiment timelapse video