ABIGAIL M SMITH

Addicted to Bryozoans

I have been enchanted by the small animals of the seashore since I was a child growing up on the coast of Maine. I love how they co-exist in their tiny micro-world, and how the colours and textures swirl and interact in the tidal rock pools. I studied nearly everything as an undergraduate (comparative religion, music, economics, biology, English), but finally emerged with a degree in geology and biology. It was while I was on a field semester at the Bermuda Biological Station that I became interested in calcification – how marine plants and animals make shells, and what those shells can tell us about the marine world.

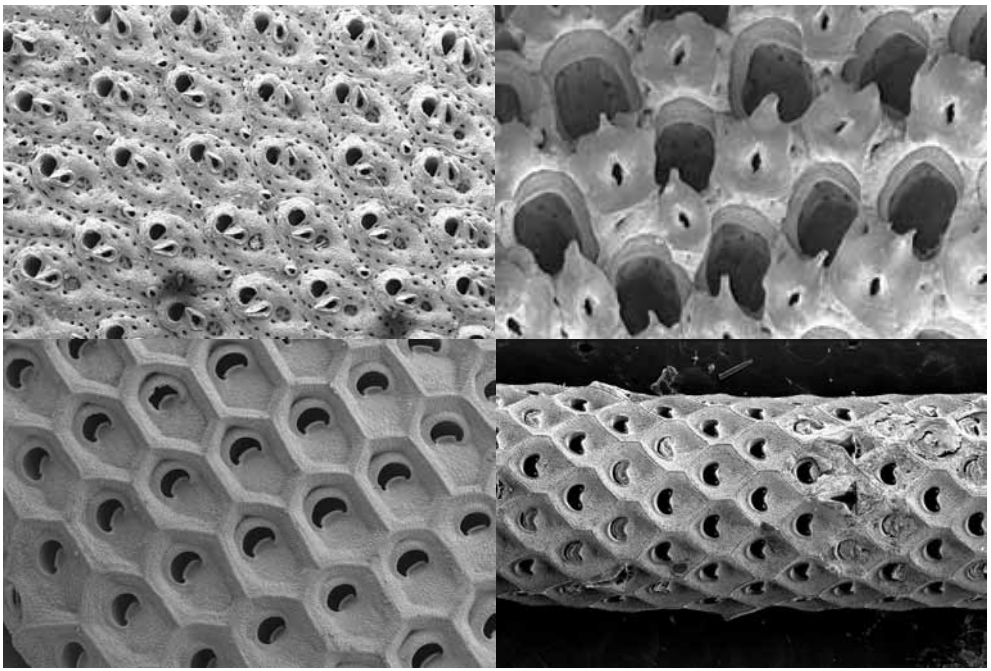

Figure 1. Bryozoan colonies are made from very small repeating box-like units called zooids. They can be as big as 1mm across, but usually they are smaller. The various pores and spines ornamenting the boxes are special to each species. Tiny individuals like these (the red scale bar is 0.5mm) can build up to make colonies several centimetres across. Photographs: AM Smith.

Most people are familiar with the shells of large molluscs: clams, scallops, mussels, oysters, snails, pāua. It may seem surprising that almost every group of marine creatures produces at least some kind of skeletal structure – biomineralisation is everywhere in the sea. Vertebrates like us make our skeletons from what we eat, but invertebrates like urchins, barnacles, worms and corals make their skeletons straight out of seawater. Despite that common origin, there is huge variation in their shapes and sizes and textures. When they die, shells break up into fragments, littering the seafloor with evidence of the past.

I became fascinated by calcareous algae. Why would a plant that needs the sun make itself a coat of armour? I decided to come to New Zealand to work with Prof Cam Nelson, a world authority on temperate-latitude shells and the sediments that come from them,[1] to try to understand more about calcareous algae. But when I finally arrived at the University of Waikato, dazed with distance, Cam suggested that I study bryozoans. At that point, I did not know what they even were. I soon found out: bryozoans are tiny, inedible, hard to identify, under-studied, and absolutely beautiful. I was hooked.

Figure 2. Bryozoan colonies are constructed in various ways, including flat and encrusting, branched in many ways, spherical, feather-like, leafy or lacy, and thick heavy crusts. Scales are in millimetres, scale bars = 1mm. Photographs: AM Smith.

Bryozoans are tiny marine animals[2] that live in colonies. Each animal, the size of a pinhead, makes itself a small box to live in, and then colonies are formed by stacking the boxes in different ways. Bryozoan boxes are often rather similar, but they can be put together in many different shapes – the same way that Lego building blocks can be.[3] Bryozoan colonies can be arranged like tiny flowers, like trees, like folded sheets, like crusts, like nets, and like beads on a necklace. All this variety mainly serves to lift their tiny tentacles up into the water in order to catch the particles that they eat. While we can't see the ornamented boxes of individual bryozoans without a microscope, we can see the variety and beauty in how they arrange themselves in colonies that can be up to 20 centimetres across or tall.

There are many ways in which bryozoans contribute to the world: they are some of the most resilient and persistent bio-foulers in the ocean and many species have colonised the world's oceans;[4] some naturally produce anti-cancer compounds[5] and remarkably strong adhesives; and many provide insight into the oceans of the past, as they are almost unchanged from their origins 470 million years ago. New Zealand has an unusually diverse and abundant bryozoan fauna[6] with especially complex and interesting skeletal compositions.[7]

About 40km off the Otago Peninsula, bryozoan colonies grow big enough to form spaces for other animals, including juvenile fish. A wide range of bryozoan species (maybe as many as 100 different kinds) live together to form deep-water thickets.[8] A whole cool-water ecosystem relies on these calcareous structures built by tiny animals, much like coral reefs in the tropics – though the Otago reefs are 80m deep and wholly in the dark. Bryozoan colonies can take decades to grow,[9] and they are easily damaged by bottom trawling and dredging. There are perilously few shelf-depth bottom habitats that are protected in New Zealand from such disturbance – whole bryozoan colonies are becoming rarer and rarer. Even though we don't eat bryozoans, our food-gathering practices exert collateral damage.

Figure 3. As many as 100 different species of bryozoans live in the thickets off Otago, in water depths of 60-100m. They provide habitat for other creatures (such as worms and brittle stars), and when they die they form thick sediment deposits. To study them we collect a small dredge, then separate them out into different species. Photographs: AM Smith.

In the twenty-first century, the ocean on planet Earth is a place of rapid change. People are producing more CO_2 than ever before, with the amounts going up daily. The ocean absorbs 30-50 percent of this gas, which is good for terrestrial life but makes things harder for those that live in the sea. Just like in a bottle of selzer, dissolved CO_2 makes the fluid more acidic. An acidifying ocean is no place to be a creature that makes its own shell – and tiny ones are the most vulnerable. Scientists are finding small sea creatures, like bryozoans, making increasingly ragged and incomplete shells, showing the tangible effects of acidification on marine life.[10]

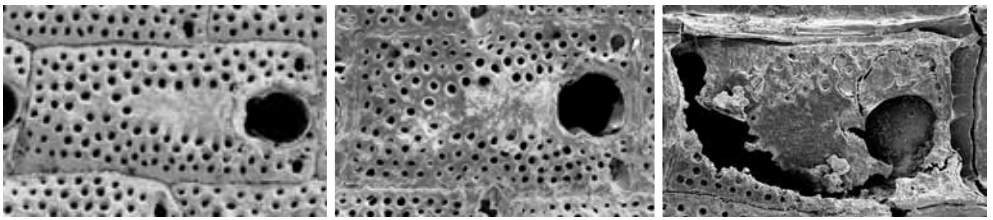

Figure 4. These photographs show the skeletal changes during a laboratory acidification experiment on Otago shelf bryozoan *Hippomenella vellicata*. Scale bar is 0.2mm. Photographs: AM Smith.

As part of the Art + Oceans project, I showed several artists the wide variety of shapes and architectures that bryozoans can make. I enthused about their beauty, I handed over examples of local bryozoans, and I tried to show them why I, like most people who work with bryozoans, just love them and think they are important. I shared my sorrow over the threats that face the marine environment, and these lacy animals.

I thought it was fascinating how each artist took a different tack, and headed off to make their art inspired by these tiny creatures of the seashore.

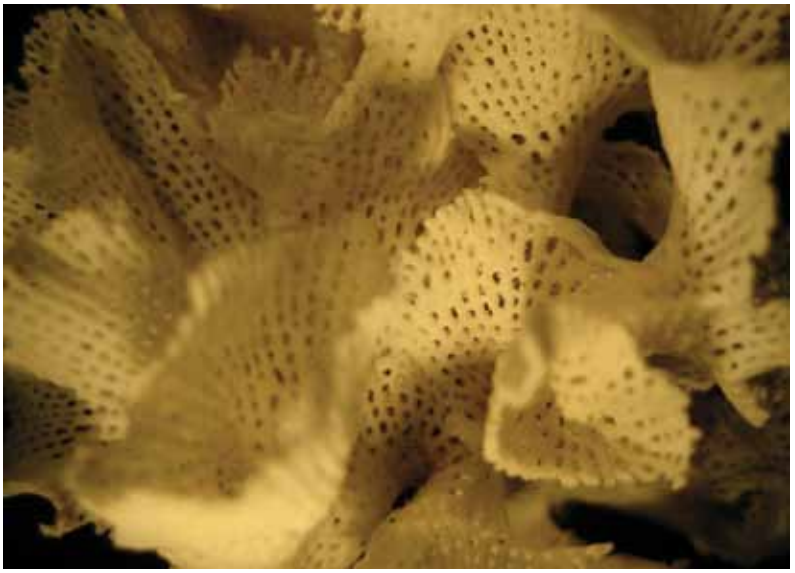

Figure 5. The fronds of bryozoan *Hornera foliacea* show why bryozoans are sometimes called "lace corals." Photograph: AM Smith.

Abigail Smith came to New Zealand in 1988 to carry out her PhD research on bryozoans at the University of Waikato. She has been lecturing and supervising research students in marine science at Otago University since 1992, during which time she has also published over 70 scientific articles and given more than 100 talks, most of them on bryozoans. She has been active in the International Bryozoology Association, the New Zealand Marine Sciences Society and the New Zealand Ocean Acidification Community. While she loves her work, she never lets it get in the way of her hobbies: cricket, knitting and making jam.

Art works from the three artists inspired by Abby Smith Bryozoan research, ranged from the soft sculptures and manipulable bryozoan magnetic 'units' (Susan Nunn), expressive wall hanging (Vivien Dwyer) to the painstaking CAD drawing and 3-D printed sculptures of microscopic bryozoans by Brittany Sue Mason.

1. One of Prof Nelson's much-cited and important papers is CS Nelson, SL Keane and PS Head, "Non-tropical Carbonate Deposits on the Modern New Zealand Shelf," *Sedimentary Geology*, 60 (1988), 71-94.
2. There are some freshwater bryozoans, but they don't make skeletons.
3. AM Smith, CS Nelson and HG Spencer, "Skeletal Carbonate Mineralogy of New Zealand Bryozoans," *Marine Geology*, 151 (1998), 27-46.
4. DP Gordon and SF Mawatari, "Atlas of Marine-fouling Bryozoa of New Zealand Ports and Harbours," *Miscellaneous Publication. New Zealand Oceanographic Institute*, 107 (1992), 1-52.
5. AE Trinidad-Silva, GE Lim-Fong, KH Sharp and MG Haygood, "Bryostatins: Biological Context and Biotechnological Prospects," *Current Opinion in Biotechnology*, 21 (2010), 834-42.
6. DP Gordon, J Beaumont, A MacDiarmid, D Robertson and S Ahyong, "Marine Biodiversity of Aotearoa New Zealand," *PLoS ONE*, 5:8 (2010), 1-17: e10905.
7. AM Smith, MM Key Jr. and DP Gordon, "Skeletal Mineralogy of Bryozoans: Taxonomic and Temporal Patterns," *Earth-Science Reviews*, 78 (2006), 287-306.
8. ACL Wood, PK Probert, AA Rowden and AM Smith, "Complex Habitat Generated by Marine Bryozoans: A Review of its Distribution, Structure, Diversity, Threats and Conservation," *Aquatic Conservation*, 22 (2012), 547-563. doi: 10.1002/aqc.2236.
9. AM Smith, "Growth and Calcification of Marine Bryozoans in a Changing Ocean," *Biological Bulletin*, 226 (2014), 203-10.
10. AM Smith, "Bryozoans as Southern Sentinels for Ocean Acidification: A Major Role for a Minor Phylum," *Marine and Freshwater Research*, 60 (2009), 475-82.

BRITTANY SUE MASON

Bryozoans

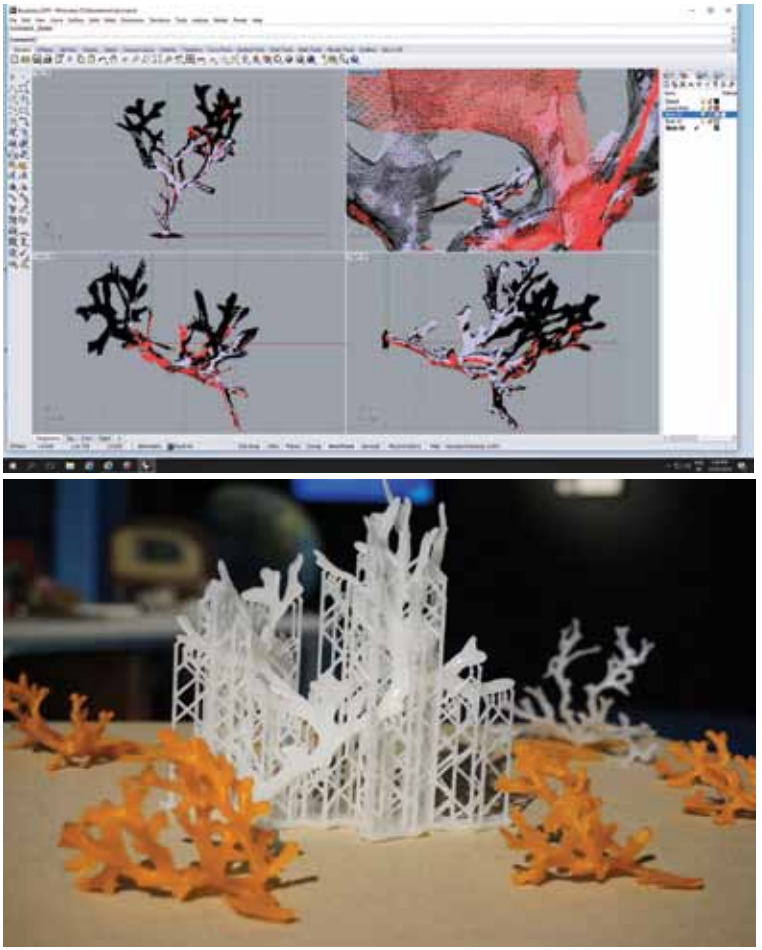

Figure 1 and 2. Brittany Sue Mason.

Brittany Sue Mason immigrated to New Zealand in 2011, and completed her BFA at the Dunedin School of Art with a concentration on jewellery design and metalsmithing in 2013. Her artwork is deeply influenced by the tiny textures and patterns of the natural world.

VIVIEN DWYER

Disintegrating Colonies

This work is intended to show the effects of CO_2 build-up in the waters of the ocean. Colonies of coral-like creatures called bryozoans are losing their shells to acidification, which limits their ability to produce the individual structures within which they live.

I love little crittters and the fact that these bryozoans are becoming homeless because of too much acid eating away at their homes is distressing – especially as I can see them becoming extinct if we don't do something about our emissions. This work represents my reaction to their plight and uses acidic pink colouration drifting in the mostly blue ocean, like rust attacking iron and rendering it useless. Eventually it will destroy what lies beneath.

I think we humans are too inclined to see the ocean as so vast that it can absorb anything without much harm. We have used it as a dustbin for much of our existence, but now it has reached the stage where it cannot sustain any more damage without, in turn, damaging us. We are the chicks who fouled their nest – but in reality we must grow up and tidy our home or much of what now exists will be swept away, including all that we have achieved. We only have one home, so we must take care of it. There is no other place to go if this one becomes uninhabitable.

To create this piece, I have used deconstructed printmaking processes and hand-printing in combination with thickened dyes, print paste and the judicious use of scissors and thread. My aim is to illustrate the processes of disintegration and death through acidification and to raise awareness about this, as it is our production of pollution that has endangered these creatures. In doing this, I have taken advantage of the fact that some of these creatures have what look to us like smiley faces. I have made them into the very unhappy, disintegrating faces you see on the work. They can't tell us about what they see, so I am doing that for them.

In evolutionary terms, we are just a miniscule part of the life of this planet. I would like us as a species to be around a little longer, along with all the living things that reside here with us. Life will not end because of us and what we have done, but it will be changed and impoverished for a very long time if we don't take more care. The diversity of this, our place in the universe, is what we should be aiming to preserve at all costs.

It is what keeps us alive.

Vivien Dwyer is a recent graduate with an Master of Visual Arts. She has been an artist for some years and returned to Art School after her children grew up and became independent. She works in textile art with a special focus on printmaking and felting.
Photographs: Pam McKinlay.

SUSAN NUNN

What is Abundant, Diverse, Widespread, Beautiful, Fascinating, Little Known and Totally Inedible? Bryozoans of the Otago Shelf

I collaborated with Professor Abigail Smith, a marine geologist who works on skeletal carbonate biogeochemistry (what shells are made of) and ocean acidification (how shells dissolve). She has an interest in the bryozoans of the Otago Shelf, off the coast of Dunedin, New Zealand.

In her book *Bryozoans of Southern New Zealand: A Field Identification Guide*, Abby has reproduced many colourful photographs that I have used in an attempt to recreate some of the locally collected samples. I was intrigued with the shapes, sizes, colours and textures of the featured bryozoa and have tried to capture them using a variety of fabrics, felts, netting, beads, trims and threads.

Figure 1: Beania bilaminata, original on left, recreation on right. Photographs: Abby Smith, left. Susan Nunn, right.

Some of these reproductions have been set out, neatly identified, in a specimen box. Others have been set out in an 'aquarium' in an attempt to capture the look of the Otago Shelf where these specimens have come from. All are set out on a scientist's desk complete with a toy microscope and magnifying glass.

Figure 2: Completed installation (detail). Photographs: Pam McKinlay.

In my face-to-face meeting with Abby, she commented that the recreated bryozoans were interesting, but she was more interested in how they replicate themselves.

When looked at microscopically, the bryozoans are simple repeating modules, starting with a single dot that is then repeated in an amazing variety of combinations to create the very complex individual bryozoa. This can be visualised by looking at tessellations such as Escher's or the modular constructions created with Lego bricks in an infinite range of possibilities.

Abby produced a couple of simple drawings that demonstrated their modular construction. This got us thinking about how this could be interpreted in art terms, to be made interactive and have viewers participate.

I conducted several trial-and-error experiments using a variety of attachment methods in an attempt to keep the elements together in credible bryozoan forms. Finally, I developed the blue- and red-covered magnets. The long covered dowels with magnets glued to each end, the covered non-magnetic metal discs, and the added ball bearings have achieved a working interactive piece.

A number of viewers have stopped to 'play' with the pieces, creating an ever-changing display of random bryozoa.

Collaborating with Professor Abigail Smith has been a wonderful experience and an opportunity to learn a great deal about a subject with which I have previously had very little personal experience.
We hope the viewer can take away an appreciation of the way in which nature has put together these very small but fascinating marine creatures.

Susan Nunn completed her Bachelor of Visual Art (Hons) at the Dunedin School of Art in 2016. She works predominately in textiles and has previously taken part in similar collaborations in art and science.

Figure 3: Created Bryozoa.
Photograph: Pam McKinlay.

Figure 4. Opening night guest 'creating' Bryozoa.
Photograph: Jesse-James Pickery

Figure 5: Completed Installation.
Photograph: Pam McKinlay.