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Coccolithophore Relief: An Art and Science Interrogation of Ocean Acidification

Organisms that remove carbon from the world's carbon cycle are becoming ever more important as we try to constrain our carbon emissions to slow climate change. Marine phytoplankton, like coccolithophores, are responsible for 50 percent of global carbon fixation.[1] Through photosynthesis, which also produces oxygen as a by-product, they fix carbon dioxide throughout their lives in the surface waters of the ocean. Even in their death, they help remove carbon from the system. Coccolithophores make armoured plates (coccoliths, hereafter referred to as 'liths') from calcium carbonate, which together form a sort of external skeleton for each organism (Figure 1). When they die, they sink and join bottom sediments, in effect exporting and burying carbon in deep-sea sediments.[2]

Ocean acidification (OA), which increases with anthropogenic CO_2 production, is compromising the health of coccolithophores.[3] As oceans become more acidic there is less available carbonate, which the coccolithophores need to make their plates strong and well-formed. In future, coccolithophores will struggle to grow properly, and will have to invest more energy in the process. This means they will be out-competed by other more tolerant organisms like green algae and cyanobacteria.[4] A reduction in the abundance of coccolithophores could dramatically decrease the amount of carbon being removed from the global carbon cycle, and reduce the ability of the oceans to export and store carbon in deep-sea sediments. This means that the rate of carbon dioxide accumulation in the atmosphere will increase even more.

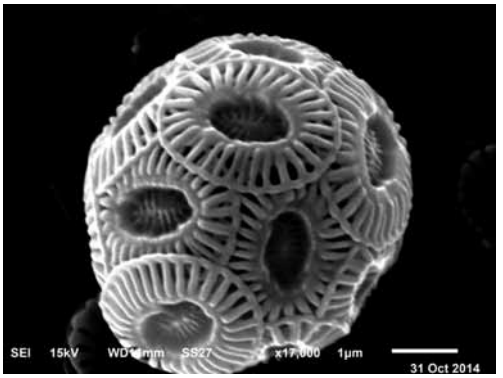

Figure 1. Coccolithophore *Emiliana huxleyi*. Photograph: Ro Allen.

BUILDING SOCIAL REFLECTION ON COCCOLITHOPHORE HEALTH

We decided to share the story of coccolithophores, including their important environmental role and their sensitivity to ocean acidification, with the public. We intentionally developed a project involving social arts practice to help people reflect on the importance of these small things. This included the beauty of the tiny liths that make up the coccolithophore's amour, the importance of each little lith to collectively make a healthy organism (that in turn has an important global role), and the effect of our individual small actions contributing to climate change. Engaging communities in social arts practice, by involving hands-on making with cognitive activity, gives time and space for such critical reflection.[5] Joining key features of the scientific narrative with congruent aspects of the art-making can serve to reinforce understanding and potential behaviour change.

The structural integrity of a healthy lith can be clearly seen, and so too the negative impact of acidification (and increased temperature) in a poorly formed lith of an unhealthy coccolithophore.[6] We knew our project would focus on this clear visual comparison between healthy and unhealthy, but were uncertain how to provide the best arts-based activity to involve the public in making art that explored the difference in structural integrity of healthy and unhealthy liths. We also wanted to communicate the idea that many liths make a whole organism, healthy or unhealthy. This idea of many components making the whole needed to be reflected in the arts practice as well. Iterative conversations attended to what information needed to be communicated, the practicalities of the social art venue and exhibition schedule, as well as what was engaging yet possible for people to do quickly. Meetings, individual thinking, emails, practical experimentation and visualising of what might happen evolved over several months.

Because we are working with environmental issues, we also had to consider the art materials we were working with. We tried to source what would otherwise be industry offcuts or waste; for example, the paper we wound up using was offcuts from a local printer business associated with the University of Otago. Intentional recovery and recycling at-the-end-of-product life meant forming relationships with industries and keeping an eye out at the secondhand shops. All of this became part of the slower burn of foreseeing, problem-solving and designing an interactive event with targeted outcomes.

EXPLORING COCCOLITHOPHORES IN 3D

We wanted people to be able to hold a model of a coccolithophore in their hands, to see the beauty of these otherwise microscopic beings and elicit feelings of care through the act of holding something precious and fragile. On his website, another artist exploring the long-term carbon cycle of the planet, Jamie Perrelet, provides access to stereolithography files that allow users to 3D print an *Emiliana huxleyi* coccolithophore. Perrelet explains: "Among the growing applications of 3D printing is the capability to use physically printed models as innovative and transformative learning tools, which can help bring our understanding of the world to life."[7]

William Early from the EPICentre at Otago Polytechnic[8] assisted us with translating this file, and using the Preform programme, generated a digital internal support scaffolding within the hollow coccolithophore form and sent the information to the centre's FormLabs 3D printer. Approximately three quarters of the file printed well in a UV Sensitive Polymer, a substance which hardens with a UV Laser. The rest of the model was disorganised and absent – ironically, a bit like an unhealthy coccolithophore – and unfortunately the result was too fragile for public handling.

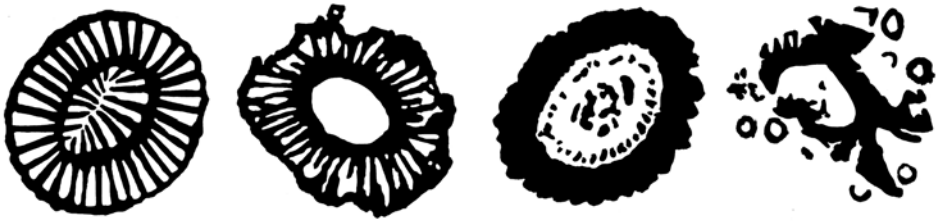

Figure 2. Drawings showing liths in increasing stages of structural disorganisation (Lynn Taylor).

In continuing to consider how to provide a tactile experience, Lynn Taylor was inspired by Ammassalik wooden maps – carved, tactile maps of the Greenland coastline made to be read by the fingers of the holder.[9] She simplified the 3D model by hand-drawing individual liths at varying stages ranging from healthy (organised) to unhealthy (disorganised) (Figure 2). These were scanned and translated into laser-cutting files through Photoshop and CorelDraw before being cut out of medium-density fibreboard. These simplified images (Figure 2), as well as the actual cut-outs (Figure 3), were used in the resulting two social art projects.

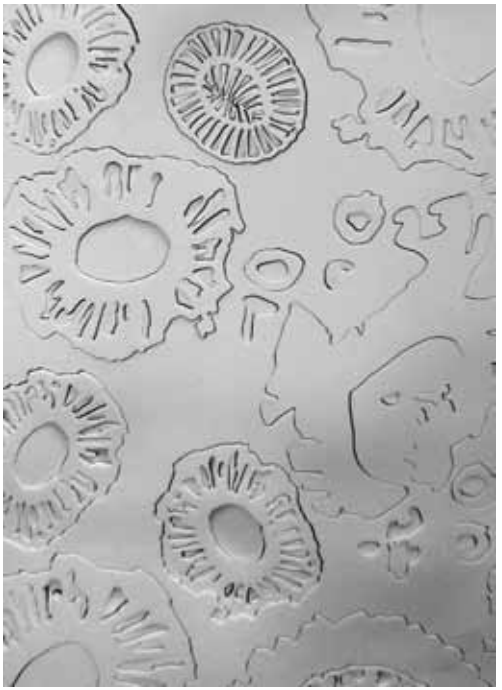

Figure 3. Laser-cuts showing healthy and unhealthy liths.

DESIGNING AND IMPLEMENTING TWO COMMUNITY SOCIAL ART PROJECTS

Both Lynn Taylor and Jenney Rock are practised in printmaking, and have used it successfully in previous community social arts practice. The opportunity for involving the public in these projects, situated in the "Ōku Moana" exhibition at the Community Gallery, Dunedin (and part of the New Zealand International Science Festival, 6-15 July 2018), constrained some methodologies. Using ink, for example, was problematic due to it being a formal gallery space. Using a relief printing approach, however, did support our aim of helping people to reflect on physical structures. Printmaking is an effective social process, as working around a press is a communal activity that provides a great opportunity to discuss the issue at hand – in this case, the role and importance of coccolithophores in trapping our carbon emissions.

We decide to use a printing press to create blind emboss prints. Blind embossing occurs when dampened paper runs through the press with no ink, allowing the paper to mould to the 'hills and valleys' of the plate. The process was chosen because it can sensitively capture detail, allowing

people to see and indeed feel the structural integrity of individual liths. The effect was also subtle and required close looking. In this way, it provided a way to visually and tactilely encounter the phytoplankton, that are too small to see with the naked eye. Moreover, the granular chalk-white colour of the embossing paper bore a remarkable resemblance to the actual biogenic calcium-carbonate mineral from which liths are made (Figure 4).

Figure 4. Blind embossing of a malformed lith.

Printing plates were made from solar plate using the stylised lith images described previously. Participants (aged 12+) were invited to make their own blind emboss prints of both healthy and unhealthy liths. As part of a reciprocal transaction, we asked that people contribute one of their prints to a community artwork – the others they could take home. We housed the donated prints in a folder printed with information about coccolithophores and ocean acidification. The community work was hung on wires suspended from two large exhibit frames. Participants clipped their work in one of two large circles – one healthy and one unhealthy (Figure 5).

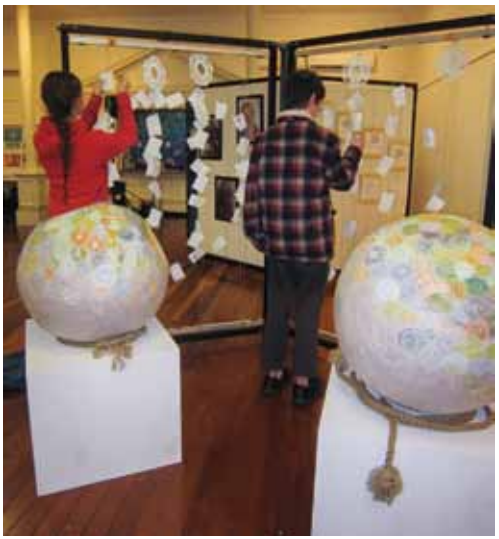

Figure 5. Community work representing unhealthy and healthy coccolithophores. "Ōku Moana" exhibition, Community Gallery, Dunedin, 6-15 July 2018.

Because of technical and safety issues with using the press, this activity was only available within two-hour daily supervised sessions and was targeted at secondary school students and adults. In some previous sci-art projects, we (Taylor and Rock) have provided multiple print experiences where participants could move around different stations. This was our first time in making an age restriction and, although this 'rule' was broken a few times, we sought to impart an experience and knowledge that engaged with higher-level thinking, not just the wonder of turning the printing press wheel, a delightful outcome for younger participants. Certainly, amongst the 'adults,' we attracted a notable number of secondary students with aspirations for studying science at university, as well as parents who indicated they were grateful for a more sophisticated encounter.

We also wanted to have an activity aimed at children, and this presented its own particular set of challenges. Taylor's 30+ years as an art educator suggested that children have less dexterous

skills and, because of our increasingly virtual world of screens and social media, they generally also expect instant gratification. It is difficult to create a quickly achievable, meaningful experience for this group that jogs their awareness of an important issue – one that they can contribute to collectively and that also results in an aesthetic outcome. During early brainstorming creative activities involving scissors, multiple joins or crochet seemed feasible in theory, but we wanted visitors' social interactions to be focused on the science issue, not technical making skills.

The laser-cut shapes of healthy and unhealthy liths invited being rubbed over with pencil and chalk on paper – an activity young and old could engage in. Individual participants could make rubbings of both healthy and unhealthy liths, but then these needed to come together into a collective expression of whole organisms, in varying states of health. Texture rubbings are most successful on fine paper, and we were challenged to impart the understanding that these shapes formed the armour of the coccolithophores. Thus another early problem to solve involved finding a round, ball-shaped support that could be easily constructed.

Figure 6. Community co-created coccolithophore, healthy model, in "Ōku Moana" exhibition, Community Gallery, Dunedin, 6-15 July 2018.

As the project ran for a week, the final organisms needed to be large enough to support the collective contribution of many children's lith rubbings. After much experimentation, a workable solution was found in an opportunity shop purchase of two Swiss (exercise) balls. Covering their surfaces with papier mâché entailed hours and hours of cutting and gluing strips of paper, but eventually produced two large white balls with an accessible height for children to approach. One was dented to create the look of a damaged coccolithophore. After doing texture rubbings to reveal various stages of disorganisation in lith formation, children (and adults – the whole process became quite addictive) cut out and attached their liths to the corresponding healthy and unhealthy coccolithophore models (Figure 5). These models were subsequently displayed in the Art + Oceans exhibition (Figure 6).

TOWARDS FUTURE SOCIAL ARTS PRACTICE

Feedback from participants indicated that although the social art experience was instant, informal and quick, it had an in-depth feel. While this was probably due to several factors, some can be pinpointed. By using printmaking as our common ground, we did not create an 'us vs them' (public vs scientist or expert) divide, so communication was fluid. Providing people with a choice of plates to print

encouraged decisive engagement. The take-home prints were packaged with an information pamphlet so people could follow up on scientific specifics after their exhibition visit. It also served as a sort of transactional agreement, whereby artwork being brought home was traded for time spent considering an issue. Over all, inviting people to make prints to build a collective work enhanced the sense of connection.

Several of the components of these two social art projects can be repurposed for future projects. The laser cut-outs can be shared (as a design concept, or indeed in physical form through a form of lending library) with schools and community groups, or indeed science societies aiming to build community engagement into conferences through sci-art activities. One of the ideas we are still exploring for future testing is to digitise a mosaic of the embossed liths (Figure 7). These could be arranged to create a gradient of uniform to malformed specimens, in a mosaic that could be constructed socially and shared digitally.

Following the de-installation of "Ōku Moana," the communal embossings were stacked, suggesting a resemblance to the sea and ocean floor – this inspired us to photograph the lith prints and place them back in their marine habitat (Figure 8). This action, while not an intentional art performance, was unusual enough to arouse the curiosity of onlookers and provided another platform for reflective conversations. 'Pop-up print studios' within a gallery space are manageable and effective, but

Figure 7. A test grid of scanned embossed liths.

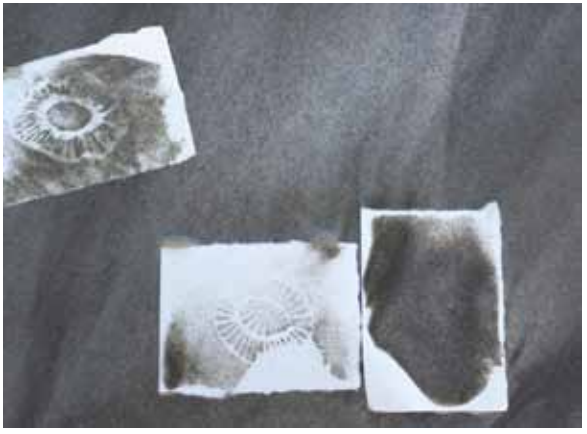

Figure 8. Liths returning to their ocean environment.

they are also relatively conventional. They rely on visitors coming to the space (often the 'same sort' of visitors), and so we are interested in developing further ways to create incidental encounters that cast the audience net more widely.

However it may be explored artistically, malformation of liths is a common consequence of ocean acidification for coccolithophores, and provides a striking illustration of human impact on the marine environment. Microscopic coccolithophores have become a visible icon for ocean acidification and constitute a global call to action.

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Lynn Taylor lives and works from the Lighthouse Studio, Portobello, Dunedin.

Ro J Allen is a postgraduate student in the Department of Botany, University of Otago, Dunedin.

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8. EPI Centre stands for Experiment Production Innovation Construction. See https://www.op.ac.nz/students/support/tile?id=593.
9. See https://en.wikipedia.org/wiki/Ammassalik_wooden_maps (accessed 5 August 2018).