EMILY TIDEY

Who Knows What's Down There?

Hydrographic surveys are one of the ways to begin to answer the question Emily Brain poses in this exhibition – using modern techniques and technologies to explore 'what's down there' underneath the waves. Advances in acoustic technology have inspired a high-resolution revival of exploration at sea and allow us to become better informed about marine processes, which in turn can lead to improved management practices.

In my research, I am working to understand the sources and implications of uncertainty in marine habitat mapping. Marine habitat mapping is an established activity. However, perhaps because modern tools are so easy to apply, relatively little attention appears to be given to the original measurements themselves. Without an understanding of the inherent uncertainty in the foundation measurements, any conclusions drawn from mapped habitats or changes in these may be overstated or simply incorrect. Additionally, maps are often treated as static phenomena, with minimal consideration of temporal and spatial processes. The creation of recommended protocols for marine researchers to follow when they are working on habitat and process mapping is much needed as the application of hydrographic measurements continues to proliferate. My research works to ensure that this very useful data is considered in the context of its suitability to the application, as well as investigating ways to improve methods that generate high-quality, repeatable scientific outcomes.

Figure 1. (L) *R/V Beryl Brewin* surveying coastal Otago with multibeam echo sounder equipment installed on a pole over the port side and on the roof. (R) *R/V Beryl Brewin* moored at Portobello Marine Lab. Photographs: E Tidey.

This process-driven approach, and data analysis that emphasises quality data collection and reduction in three-dimensional space and time, supports greater understanding of our marine habitats, and will also benefit other scientific work that is focussed on big questions in our marine environment, such as detecting and monitoring change and understanding the processes driving it.

In Aotearoa New Zealand we are very connected to our oceans and coast: food, shipping and transport, traditional Māori food-gathering areas, recreation, protection zones (MPA to mātaitai and taiapure), runoff and sedimentation, flooding events, sea-level rise and tsunami are among our key concerns.[1] Yet it is estimated that we have mapped only 13 percent of our Exclusive Economic Zone (EEZ) in detail. With an ocean territory of 5.7 million square kilometres,[2] it is clear there is much work to be done to develop our understanding of the marine environment. It is equally apparent that humankind is influencing the natural marine environment and that long-term monitoring is needed to determine how human activity directly and indirectly affects marine systems and the people who rely on them.[3] Hydrographic surveyors have skills and equipment that enrich the traditional scientific work undertaken in the marine environment – biology, oceanography and geology – by revealing the spatial context in which biological and physical processes are active and by quantifying uncertainties, scales and properties of measurements. Through hydrography, we support robust and repeatable data collection and bring our own unique surveying questions to marine research.

Acoustic sounding has been in use for decades as a method to produce bathymetric charts. Recently, echo-sounding data have been used to infer seabed properties and thus to map marine habitats. Recent advances in multibeam echo sounding (MBES) technology and increased emphasis on science-informed marine management have driven research interest in seabed habitat mapping. In much of this work, high-resolution echo sounding is used to create detailed maps of an area

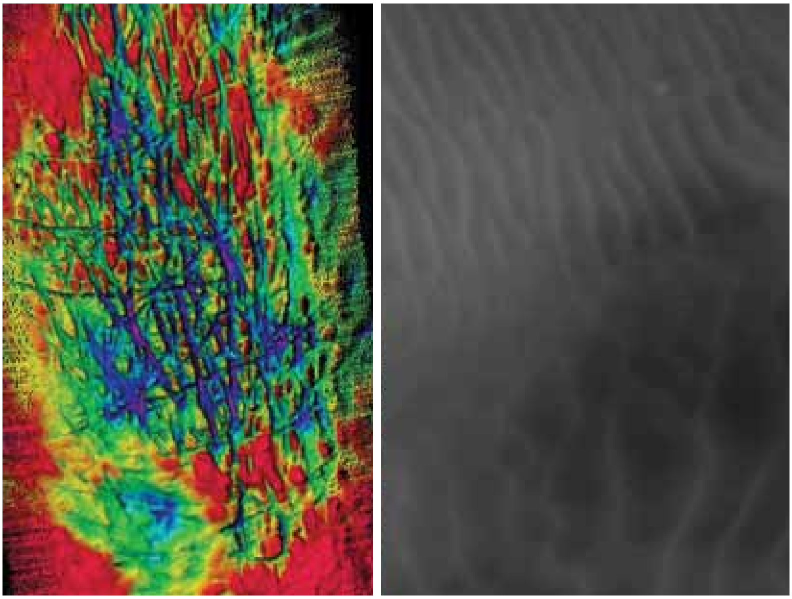

Figure 2. Raw seabed bathymetric dreadging scars (L) and backscatter from sand ripples (R) images collected with the University of Otago's R2 Sonic 2026 multibeam echo sounder. Images/data: E Tidey.

and spot sampling of substrate material, photography and diving is used to interpret the mapped intensity returns and textures as specific materials (finer sand vs coarser gravel, for example).[4] I am working on quantifying measurement uncertainty in such analyses and incorporating knowledge of coastal processes into the interpretation and resulting habitat map.

Technological advances are also increasing the range of instrument parameters available to the field user of equipment such as multibeam echo sounders. Proper selection of these parameters requires an understanding of how the MBES interacts with a particular environment. For example, different seafloor textures and sediment types will produce different reflection patterns of acoustic energy, and an understanding of the processes affecting these patterns can be used to infer key characteristics of the seafloor, or the temporal process(es) that created them. However, reflections (called backscatter) will differ for different signal frequencies, and the penetration depth of the signal into the seafloor sediment will also vary with frequency and sediment properties.

Different acoustic parameter combinations (frequency, signal power, gain and pulse length) imply trade-offs between resolution and uncertainty and can be optimised for different mapping objectives. For example, the requirements for a bathymetric survey concerned with defining the shoalest depth of features for safe navigation in an area will likely differ from acoustic measurements intended to serve as a proxy for seabed habitats. What is then required, but very rarely acknowledged, is a

Figure 3. (L) R2 Sonic 2026 multibeam echo sounder on a pole mount. As well as acoustic transmit and receive arrays mounted at 90°, the head holds a motion sensor and sound velocity probe to correct measurements made in the dynamic sea environment. (R) Equipment deployed over the port side of the vessel; the relationship of the submerged gear and the topside positioning system must be accurately measured. Photographs: E Tidey.

clear understanding of the compromises made in selecting various parameter combinations and the resulting measurement uncertainties. These factors will necessarily propagate through to the final data analysis.[5] For habitat mapping, once this is understood it can be exploited. Physical and biological features and processes are not all characterised by the same spatial scales and need not be mapped at the same scale or with the same resolution, yet habitat studies require the integration of both. For example, larger mapping projects, such as identifying reef structures, can tolerate larger measurement uncertainty than can more focused projects, such as determining how the heights of small sand waves change over time. Clear guidance is needed so that scientists are able to make the best choices when designing field campaigns. My work here can also be applied to reprocessing existing data.

Acoustic measurement also faces challenges from the dynamic marine environment. The equipment making the measurement and spatial relationships of all components, the spatial and temporal variation of the water which is being measured through (refraction, noise and scatterers), the geology and habitat of the seabed, the vertical motion of the tide and short-term heave, the full range of motion of the vessel, and the relationship of the positioning equipment with the sounder all bring uncertainty to the final result. Specific protocols for data collection for the purposes of habitat mapping and other scientific applications have yet to be established.[6] I am working to resolve this by creating clear pathways for researchers to determine the required quality of the habitat-mapping data they are using or collecting. This can greatly benefit the data collector, for example, it may result in highlighting seasons that are more appropriate for specific types of measurement, or identify traps for researchers – where seabed changes look similar at times (or that they are relating to the same process), but are in fact not.

The University of Otago owns an R2 Sonic 2026 MBES – one of the first systems in the world (and the only one in New Zealand) with a large frequency range and multi-frequency pinging capabilities. Recently, I have been collecting seabed bathymetry and multi-frequency backscatter data off the coast of Otago on the University of Otago's Research Vessel *Beryl Brewin*. One trial involved covering an area last mapped by *HMS Acheron* in 1846-51 (Chart NZ66 © LINZ)! The multibeam data exposed previously unsurveyed reef systems and an intricate pattern of changing sediments that warrant further investigation, but at this stage appear linked to outputs from the inshore estuaries. In another trial, I repeatedly passed over a section of seabed (we often refer to our fieldwork as "mowing the lawn") while acoustic parameters were systematically changed, allowing for analysis of the effects of these in our local environment. Both of these are steps towards uncertainty analysis and protocol development which will inform others of best-practise use, depending on their area of interest.

Maps of the seabed show us the "last frontier" on Earth[7] and can provide links with human experiences of and knowledge about marine environments. For example, statements like the following express spatial environmental knowledge in qualitative and quantitative ways: "I catch fish in this area, so it must have a reef-like seabed" and "there are strong currents around this headland, and on the chart we see the seabed shoaling." Maps of the seabed also provide information for research and field plans – for example, "if I want to establish current metres in the highest flow zone, I should study the bathymetry," or "if I want to study this species of cod, I will dive in the type of habitat that is mapped here."

Advances in digital acoustic technology support the exploration of our seabed and allow users of the marine environment to be better informed about its processes, which in turn can lead to better management practices. The intention of my research is to create knowledge and innovation in the range of hydrographic data applications, moving from static 2D representations of surfaces to more realistic and better understood models of the marine environment. It is expensive to undertake work at sea; greater knowledge about measurement methods and uncertainty leads to better planning, robust and repeatable data collection, and means that other users of this data are also generating high-quality, repeatable scientific outcomes – both now and in the future. In turn, this supports national and local marine interests in communities which have close connections with, and benefit from, science-informed decision-making in their marine environments.

Emily Tidey is a PhD student and lecturer in hydrographic surveying at Te Kura Kairūri, the National School of Surveying at the University of Otago.

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EMILY BRAIN

Who Knows?

Figure 1. Emily Brain, *Who Knows What's Down There?*, 2018, sterling silver, copper, patina, fabric and thread.

Hydrographic surveyors are basically undersea explorers. How cool is that?! They go out on boats, scan the ocean floor using sonar arrays, and map the last undiscovered places on the globe. Using techniques like depth sounding to map bathymetry, hydrographic surveyors like Emily Tidey peel back the ocean to reveal one of the most mysterious landscapes on earth.

Features found on the ocean floor can give clues, not only to what is down there, but also to what has been there in the past. Depth variation in an inlet can tell us about the movements of glaciers that no longer exist. Returning to a site over time can help us study the migration of sandwaves in response to ocean currents. Speckling and backscatter in a sonar scan can tell scientists about the materials which form the seabed, and dredge-mark scarring tells us about the impact we have on the existing landscape. In Emily's case, studies of the Auckland Islands can also lead to further research by other marine scientists, like biologists and geologists, and shape our plans for the future of New Zealand's coastal environment.

From my collaboration with Emily, I decided to explore the shapes and textures revealed both on the surface of the ocean and underneath it. I've experimented with reticulated silver to try to recreate features found naturally on the ocean floor. Reticulated silver forms crinkles and waves when a copper and silver alloy is treated and heated correctly. This process involves a significant lack of control for the artist, which can yield curious results. These jewellery pieces are like sections cut out of a sonar scan, a tiny depth chart of a piece of ocean that we haven't found yet. After all, who really knows what's down there?

Emily Brain is an Australian-born Jewellery and Metalsmithing graduate from the Dunedin School of Art.

Photographs: Pam McKinlay.