Tasmania's spotted handfish

Ceramics and science help save a species

Sailors plying Tasmania's Derwent River or people on ships visiting Hobart might be surprised to hear that beneath their bows, installations of ceramic spawning habitat support a rare and charismatic fish. Jane Bamford and Dr Tim Lynch explain their role in helping to save this endangered species.

THE SPOTTED HANDFISH (*Brachionichthys hirsutus*) only exists in 12 sites in the Derwent River and surrounding coastal waterways. It was the first marine fish to be listed as critically endangered on the International Union for the Conservation of Nature's red list. Unlike many fish that spawn into the water column and let their progeny travel on the ocean currents as plankton, the spotted handfish spawns on habitats attached to the sea floor and, curiously, guards its egg mass for six to eight weeks until each egg hatches as a fully formed tiny fish.

The spotted and other handfish were first collected by François Peron in 1802 when he travelled to Tasmania on Nicolas Baudin's scientific expedition. They obviously made quite an impression, as Baudin himself made note of this distinctive fish in his journal: 'amongst the fish, there is a little one which is rather unusual in that its foremost fins are exactly like hands, and that it uses them for clinging to rocks when it is out of water'. The River Derwent in the 1800s was a very different waterway to today. At the time of Baudin's expedition, its pristine waters were traversed only by Aboriginal canoes. European settlement saw a massive increase in boat traffic, from the original convict ships, whalers and vessels plying their trade and transporting goods, to today's cargo ships, cruise ships and yachts. This increase in boat traffic and the growing human population have had numerous effects on the health of the river – including a large but now collapsed scallop dredge fishery, heavy metal sediments, run-off, pollution and, as in all ports, the introduction of invasive species. In addition, anchorages have altered the condition of the seabed and affected the quality of the water. All of these factors have affected the spawning habitat of the once locally common spotted handfish, catapulting it into the category of critically endangered.

Currently the spotted handfish's battle for survival relies partially on production and deployment of artificial spawning habitats (ASH). These replace the natural spawning habitat provided by stalked ascidians (*Sycosoa pulchra*). This beautiful marine invertebrate has also been almost wiped out locally as a result of grazing from the invasive northern Pacific seastar, which was introduced into the Derwent River in the late 1980s, probably through the discharged ballast waters of Japanese bulk carriers as they collected their cargo of woodchips. Since the late 1990s, CSIRO had been using artificial spawning habitats, initially small plastic sticks, to provide somewhere for the fish to spawn. While effective, these plastic ASH are a form of pollution and are easily displaced by fouling or being dug up by various animals on the seafloor.

In an effort to continue to support spawning, Dr Tim Lynch, senior research scientist CSIRO, and Jane Bamford, a Tasmanian ceramist, began to work together with CSIRO's spotted handfish team to design and produce a ceramic ASH option. This collaboration drew on a design process inherent to both science and art, as well as the expertise of other individuals from a wide range of backgrounds: technicians, scuba divers, PhD and Masters students, yachties, engineers and marine scientists, reflecting the team's diversity of interests, as well as the colourful history of the Derwent River.

Consideration of scientific protocol determined that major features of the first design of ASH remained constant, while innovatively changing the material from plastic to ceramic. This enabled CSIRO to test how the fish accepted the new material, while controlling for all other factors. Clay was chosen as a potential material due to its composition of natural materials, the stability of these materials in seawater and, once fired in a kiln to 1280°C, its latent biosecurity. Any ceramics that broke in the dynamic marine environment would result in something similar to an inert tumbled pebble over time, unlike plastics, which eventually break down into micro-plastic pollution that absorbs dangerous chemicals, which can enter the food chain in the river. Jane selected Southern Ice porcelain for its high durability and its white colour to match the hue of the stalked ascidian. It is a filter-pressed clay, which reduces the presence of mineral salts that might affect the ASH's safety for the handfish to spawn on.

High res required

Egg masses were observed over time and eggs successfully reached maturity in the field on the ceramic ASH

A diver name known? photographing a handfish and her egg mass on a ceramic ASH in 2019. Image Alex Hormann

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The spotted handfish mating dance was witnessed in captivity for the first time in 2017

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Each handfish has a unique pattern of stripes and spots, enabling individuals to be identified. Image Laura Smith

02
A juvenile spotted handfish reared in captivity in the CSIRO's captive breeding program, pictured before its release into the Derwent River. Spotted handfish are small, growing to a maximum size of only 12 centimetres. This individual is shown at approximately life size. Image CSIRO

Initially, Jane created ceramic ASH for the CSIRO tanks, intended for the captive breeding program in aquaria, which forms an insurance policy should numbers further decline. These ASH were designed and made with a stem – the potential spawning area for the female to attach her eggs – and, for stability, a small coil stand to be buried in the thin layer of sand present in the tanks.

The spotted handfish mating dance was witnessed in captivity for the first time in 2017. This gorgeous spectacle astonished the onlookers as a gravid female, with her fins extended like sails, circled the base of an ascidian, attaching and depositing her egg mass from her swollen belly. With heightened attentiveness she was tailed by a slightly smaller male, fertilising her abundant small clear egg sacs with his milt. The pair was known to the Hobart community as Harley and Rose.

In September 2017, a gravid female spawned around a ceramic ASH at Seahorse World in Beauty Point, northern Tasmania, in what is believed to be a world first. The eggs developed naturally, with spotted handfish young hatching and surviving at rates similar to those in natural habitats. This was very exciting, as it was the first sign that there could be success with ceramic ASH in wild populations, and that it might be possible to reverse the declining numbers of this critically endangered marine species.

In 2018, CSIRO commissioned Jane to make 3,000 ceramic ASH for use in that season. The two components of ceramic ASH were designed and made to accommodate a shrinkage rate of 14–16 per cent when kiln fired. Each upright was hand rolled to compress the clay and ensure it remained straight once fired. One end was gently tapered to fit neatly through the diameter of hole in the disc, to assist with construction before each scuba deployment. The purpose of the disc was to add stability to the ASH in the river substrate. It was important to make the ASH easy to handle under water, as divers would work for long hours with thick gloves on in the late winter water temperatures off Hobart of 9–11°C. A dedicated deployment system was devised by CSIRO for divers to carry the ceramic ASH on the boats and assist in handling them under water while minimising breakage.

In June 2018, five sites were randomly selected and ASH planted along transects where the densest populations of spotted handfish had been observed in the past. Divers reported finding the ceramics easier to deploy than the plastics, as they are negatively buoyant. Astonishingly, the newly planted ASH had immediate interest from the spotted handfish, which was a very exciting and encouraging sign, and in September 2018 came the first report of egg masses on the ceramic ASH, brought by Alex Hormann, a University of Tasmania Masters student studying spotted handfish behaviour. Alex, Tim and CSIRO divers continued to dive on all the sites and collect data on spawning on both ceramic and plastic ASH, as well as on natural ascidian spawning habitat. Findings showed that the spotted handfish prefer to spawn on the natural ascidians, where present, but once ascidian numbers decline below a critical density they switch to the ceramic ASH. Most importantly, the fish preferred the ceramic to the plastic ASH that had been planted as controls, using the ceramics for breeding at nearly twice the rate of plastic. Egg masses were observed over time and eggs successfully reached maturity in the field on the ceramic ASH after the six-to-eight-week period that the female cared for them.

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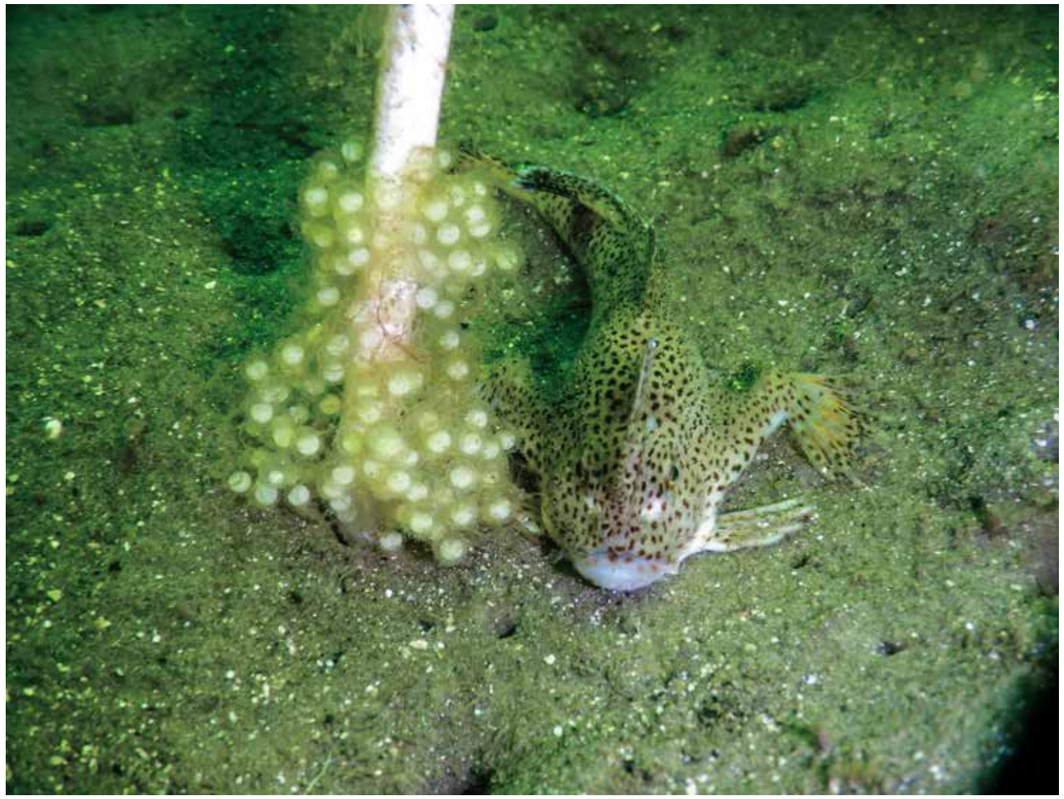

The impact of ceramic ASH design and production will further secure the spotted handfish from extinction, stabilise existing populations and allow for recovery

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Jane Bamford with two of the original-design ceramic ASH. Image Uffe Schultz

02
The female spotted handfish guards her eggs for six to eight weeks, until they hatch as tiny, fully formed fish. Image Alex Hormann

Ceramic ASH had a higher rate of losses than the plastic ASH, probably due to large skates and rays landing on the ASH arrays and snapping them off at the base. Together, we continued our design process by increasing the diameter of ASH stems to try to improve durability. In January 2019, five new diameters of ceramic stems were stress tested with the assistance of Dr Assad Taoum and his team at UTAS Engineering. On the advice of Dr Taoum, we also removed the disc component, which was an obvious weak point, and Jane made the ASH longer. No one knew if the spotted handfish would use the larger-diameter stems, and observation from divers in the field was critical to the decision. From this, two larger-diameter ASH, of 9 and 11 millimetres, were chosen to be hand made for the 2019 breeding season deployments to replace the original ASH stem size of 7 millimetres.

Our initial results from 2019 suggest that durability has increased dramatically, with losses down from 37 per cent to as little as 3 per cent, which is even better than the 8 per cent loss rate of the plastic ASH. The new design also allows for very easy cleaning. The longer ceramic ASH can be pulled out of sediments; the exposed top section is easily cleaned with dive gloves and the already clean, previously buried section then provides a clear, white surface for the next round of spawning. CSIRO divers counted stalked ascidians earlier in the year and then targeted ceramic ASH planting only where needed. With the much-improved durability and ease of cleaning, these new ceramic ASH arrays have the potential to last over the longer term. This has improved the viability of the conservation project by keeping down the cost of ASH production, deployment and maintenance. The ceramic ASH part of the project was recognised in late 2019 by winning the 'Design for Impact' category in the Design Tasmania Awards.

The Derwent River contains many small bays and safe anchorages, offering protection to yachts from the prevailing winds and locations where they can have permanent moorings. The spotted handfish also inhabit these bays, and unfortunately every time the wind changes direction, the heavy chain used to moor a vessel is dragged along the seabed, destroying the fish's habitat. To conserve handfish habitat, Lincoln Wong, a PhD student at University of Tasmanic (UTAS) and CSIRO, is working on trialling and implementing environmentally sustainable moorings with citizen scientist volunteers.

These new moorings, designed by CSIRO engineers, replace the damaging heavy chain with a rubberised strop and dramatically reduce the impact of the mooring on the seafloor, with attendant benefits not only to the spotted handfish populations but to all biodiversity in these shallow waters. It is very exciting to think that this initiative, which can help conserve spotted handfish habitat, may also have a more widespread positive legacy in reducing the damage caused by moorings all around the world's coastlines.

The impact of ceramic ASH design and production will further secure the spotted handfish from extinction, stabilise existing populations and allow for recovery. More generally, it demonstrates a successful synergistic collaboration between art/design and science. The many similarities between these two fields – the development of practice, iteration, repetition, design, experimentation, craft, observation and measurement – have merged seamlessly. In many ways the work is also a performance, by the divers, the artist and the spawning spotted handfish, which are an icon of the Derwent River. Using one of our most ancient technologies, ceramics, and creating a beautiful and tactile handmade small-scale production object, the project invites us to imagine this unseen underwater spawning performance. Furthermore, this encourages us to consider broader perspectives of the anthropogenic epoch and beyond. Is it possible for the River Derwent to return to somewhere near the condition in which the sailors and naturalists of Baudin's expedition found it? As we consider how science, creativity and design processes can actively work in collaboration to avert the spotted handfish's extinction, we might also contemplate how an innovative and collaborative approach may assist many species presently falling into the Earth's sixth mass extinction.

The spotted handfish project has been truly a community undertaking, with some of the key supporting partners being National Handfish Recovery Team, UTAS Centre for the Creative Arts, UTAS Engineering, NRM South, Derwent Estuary Project, Sea Life Melbourne Aquarium, Marine Solutions, Reef Life survey (Tas), Marine Biodiversity Hub, Department of Environment (Commonwealth), National Environmental Science Program, Department of Primary Industries, Parks, Water and Environment (Tas), Seahorse World, Clayworks Australia, Marine Life Tassie and Marine and Safety Tasmania. The project is part the larger handfish conservation project handfish.org.au/