Deep Sea Discovery for Developing Nations

Pilot Report

Start Date: November 2022

Completion date: February 2024

FRONTIER TECH HUB

Cefas

UK International Development

Partnership | Progress | Prosperity

CONTENTS

Cover image: Trial of the D4N camera system on Loch Ness in 2023.

The Team

Pioneers: The **Centre for Environment, Fisheries and Aquaculture Science (CEFAS)** is the UK Government's marine and freshwater science team, applying experience and knowledge to improve our collective understanding of the marine and aquatic environments. They are responsible for helping to keep the UK's seas, oceans and rivers healthy and productive by providing data and advice to the UK government and overseas partners.

The Frontier Technologies Hub coaches for this pilot were David Vigoureux and Nada Ibrahim.

The FCDO Pioneers involved in advising and supporting this pilot were Melissa Dawson and Patrick Halling.

The Context

The problem the pilot sought to address

The deep-sea covers approximately 60% of the Earth's surface but stands as one of the least explored and understood environments due to the technological and financial obstacles associated with deep-sea research.

Over the past century, deep-sea exploration has seen remarkable progress, facilitated by advancements in marine technology. Equipment like Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) can be used to capture high-resolution images and gather data from the ocean floor thousands of meters below the surface. However, the considerable costs associated with operating and deploying this equipment, along with the requirement for specialized crews and large research vessels, present significant barriers for many research teams, particularly in developing nations.

The idea conceived for this pilot

The idea underpinning this pilot was to develop low-cost, easy-to-deploy 'deep-sea drift cameras' by leveraging existing knowledge and technology from the Azor DriftCam, a piece of technology developed by scientists at the University of the Azores.

By using off-the-shelf cameras and lighting mounted in specialized pressure-resistant housings on a bespoke frame, the camera systems can prioritize portability, operability, and simplicity, allowing for easy transport, deployment, and maintenance.

Recording video and other scientific data to depths of at least 1000 meters, the cameras would enable teams in developing nations to collect essential data on deep-sea ecosystems without the need for external support, empowering researchers, technical advisors, and NGOs to conduct their own deep-sea research and monitoring efforts. This would ultimately support the protection and sustainable use of marine resources.

Goals of the pilot

The goal of the pilot was to understand the capabilities of low-cost camera systems for deep-sea research, and whether they could be used to support and unlock research objectives in developing nations. To explore this, the pilot was structured around three main questions::

- Can a camera rig be built to operate to depths of up to 1500m?
- Can the technology support developing nations to answer local research questions?
- Does long-term demand for the camera rigs exist, and can a model be developed to support rapid deployment?

Key Activities

To explore the key questions, the team worked with a group of researchers in St Helena and Belize.

During the first Sprint between November 2022 and June 2023, the team built and tested the deep-sea camera system capable for use down to 1000m from small (approximately 10m) boats and developed a project plan to test the equipment in St Helena.

Under the second Sprint, between August 2023 and February 2024, the team developed plans for trials in St Helena and Belize, although these ultimately did not take place. The team also looked to assess demand for the technology, including supporting the development of a grant proposal. The also explored additional sources of funding to help scale the production of the camera systems.

Findings from pilot activities

Finding 1: a camera system can be built and optimised with low-cost materials by CEFAS.

Key questions the pilot sought to a test

- A camera unit can be built that is able to operate in depths of up to 1500m

The methods used for testing:

- Fabricate camera system in the CEFAS workshop
- Conduct sea trials in Loch Ness, Scotland, aiming to replicate conditions found in remote locations.

Key findings from testing:

A camera system was successfully built that incorporated components that are readily available from commercial suppliers, so that it is as easy and cheap as possible to maintain, with basic tools by researchers without specific engineering training. The system met the crucial need for its components (lights, cameras, lasers, etc.) to be powered directly by the rig, as opposed to on the surface vessel, as is normally the case in deep sea explorations.

When the team conducted trials in Loch Ness, which has a maximum depth of around 225m, valuable practical experience and insights were gained into optimizing the camera system for deep-sea exploration. Being able to comfortably and effectively 'fly' the camera hundreds of metres below the boat was uncertain. However, the team was really pleased to see that it was easy to make small adjustments to the height of the camera above the seafloor. It was also useful to get a better sense of what someone using the camera system should expect from the vessel's skipper, and for the team to understand what the crew needs to know during deployment.

Following the successful trial in Loch Ness, several improvements and additions were made to the system. These included the development of a bespoke umbilical reel with an electric winch for power and integrated video cabling, allowing continuous communication during deployment. The housing and cabling design were updated to enable powering and data downloads without opening the housings, while purge valves were added to remove moisture and prevent electrical shorts from condensation.

Laser pointers were incorporated for image scaling, enhancing the system's functionality for measuring seafloor area and fauna size. Finally, adaptations to the camera housing design aimed to minimize openings, reducing the risk of flooding during deployments and simplifying offshore use.

Finding 2: the deployment of camera systems may encounter challenges related to international collaboration

Key Questions the pilot sort to test

- Local teams are willing and able to work with the pilot
- The St Helena research team can conduct scientific surveys using the system, without external support
- The system is scalable to different settings and can be used to address the breadth of locally driven deep-sea research questions

The methods used for testing:

- Planning of research trips with British Overseas Territories (BOTs)

Key findings from testing:

Multiple challenges were encountered when planning for full field trials of the system in St Helena which, when combined with the limited availability of local partners, resulted in considerable delays. Challenges in St Helena revolved around logistical delays in equipment delivery and the process of certifying the safety of lifting equipment, which required collaboration with qualified engineers remotely.

To help overcome this issue, the team identified Belize as an alternative where field testing would not face the same challenges as in St Helena. In Belize, efforts then focused on safety protocols, including vessel inspection procedures and standard operating protocols. Specific challenges here related to the lack of maritime safety equipment and specialist marine engineering capability, which were addressed by working closely with the territory to address safety gaps, but which added significant delays.

In general, challenges arose in nations where safety standards, particularly those set by the Marine and Coastguard Agency (MCGA) of the United Kingdom, and which pertain to UK staff working overseas, do not exist in national legislation. These will likely be challenges in multiple other contexts that will need to be considered when working directly with developing nations. They speak to the time needed to engage with new research teams and challenge the pace at which this technology can be deployed and tested.

Ultimately, the team were not able to take part in a field trial during the length of the pilot. The delays underscored the complexities involved in ensuring crew safety and, while efforts are underway to address these challenges and proceed with the trials in a safe manner, these extend beyond the scope of the pilot.

Finding 3: Nations have shown interest in the camera systems, but it is too early to tell if this will translate to high level demand

Key questions the pilot sought to test

- There is sufficient demand for the camera system and ambition for a global network to support a grant proposal
- Cameras will be bought and maintained directly by BOTs and other countries

The methods used for testing

- Potential partners were contacted to gauge their interest and were also shown a spec sheet highlighting the capabilities of the camera system

Key findings / outcomes from testing

The project received interest from various organizations and institutions, including the Blue Resources Trust in Sri Lanka (for which it has obtained funding), and the Vietnamese Research Institute for Marine Fisheries. Active discussions are underway with potential users in the Caribbean, such as the Bahamas, Cayman Islands, Anguilla, and Seychelles. Additionally, efforts are being made to engage members of the Global Ocean Wildlife Analysis Network (comprised of 13 UK overseas territories) for expressions of interest.

When it comes to scaling up production, capital expenditure from within CEFAS was deemed unsuitable due to cost limitations and lack of repayment mechanisms identified, while internal science development funding was insufficient for such costs. Initiatives to seek philanthropic support from programs like Nekton and Ocean Census have shown promise, with positive engagement observed during discussions.

CEFAS are also developing hybrid functionality, such that the system will be able to operate in a 'lander' mode and take time-lapse imagery over a period of 12 hours or more, to study deep-sea scavengers. This has been primarily driven by the demand from partners in Sri Lanka, who have ambitions to study deep-sea predators like sharks and rays.

The team ultimately decided to make funding applications while initial field trials continue to be planned and delivered but prefer to wait until a system design has been finalised before attempting to broaden the network of collaborators.

Conclusion

The initial pilot idea was to create a deep-sea camera system accessible to researchers based in developing nations and without access to deep-sea research infrastructure, to generate more data on marine ecosystems and allow for better ocean management. The project has developed a low-cost, portable deep-sea camera system that shows promise in this respect, but it is too early to tell if it will be used successfully by national teams and if it will have its intended impact.

Testing the camera equipment further will involve field trials in Belize and St Helena over the coming year, to see if teams can operate the cameras unassisted after an initial period of training.

Furthermore, challenges from similar past initiatives have suggested that when states do in fact have the technical and human capacity to conduct deep-sea research, such research trips are infrequent. For example, the Global Ocean Wildlife Analysis Network (GOWAN), funded by the FCDO Blue Belt Programme, focuses on establishing a network of Baited Remote Underwater Video Systems with 13 UK overseas territories, and has encountered challenges in achieving regular deployment by BOTs.

A fundamental question of impact is therefore whether states have the financial, infrastructural, and human resources to go out and conduct deep sea exercises regularly (for example, the availability of small boats or staff to carry out deep sea research). Overall, getting to the heart of how this project can learn from existing initiatives, as well generate specific, tangible learnings on how rigs might be used by nations, will be crucial to assessing the potential benefits of the camera system in the long-term.

With these underlying uncertainties, there is nevertheless strong potential in nations having access to a low-cost, deep-sea camera rig. This is in part because ocean research is still fundamentally important to conservation efforts. For example, in 2021, Operation Fafaia used video data collection of deep-water tropical corals across the Pitcairn Islands, with the data used to assess the resilience of Pitcairn's corals to climate change and inform management and protection of the reefs. This is an example of work undertaken that low-cost deep-sea cameras could theoretically help increase in scope and frequency, to help nations manage ocean resources and support their wider objectives.

Beyond the use of an individual camera system, the hope of the pilot was to build towards a global network of inter-connected deep-sea cameras. The long-terms sustainability of the camera systems will require testing and iteration, as will understanding how this network approach can add value to teams.

PHOTO CREDIT: James Bell | The pleasure craft ‘Deepscan’ used in Loch Ness for the D4N trial

Recommendations for further work

The hydroponic fodder team submitted a proposal for follow on funding and will continue building out the idea and business model. Suggestions for further work include:

1. Developing and testing a business model, including engagement with dairy companies. The business model will require a deep understanding of the minimum viable product to increase milk outputs and then get that milk into the market.
2. Draft a stakeholder map and engage stakeholders on a sustainability plan. Local stakeholders provided key insights during the pilot stage that gave the implementation team confidence that hydroponic grown fodder could work in Nigeria. However, many questions remain about technical elements of implementation (e.g. what is the minimum training support needed to scale up the growing system?) and logistical questions (e.g. how can this look on government land versus community owned land versus land owned by private corporations?)
3. This pilot did not focus on the beef industry, so further research would need to be done to understand the viability and impact of hydroponic fodder on beef production.
4. The same can be said of methane production, which was an interesting and unexpected finding of the work that might hold great promise in terms of a sustainable model built around carbon credits and climate-friendly cattle-rearing.

DT Global

BRINK

RESULTS FOR DEVELOPMENT

UK International Development

Partnership | Progress | Prosperity