A WATCHFUL EYE ON THE DEEP-SEA ENVIRONMENT

Japanese researchers are contributing to AFFORDABLE TECHNOLOGY AND INFORMING INTERNATIONAL GUIDELINES on how to monitor the impact of exploration in the ocean's depths.

Valuable minerals have recently been found in Japan's deep sea. Robust environmental monitoring must accompany an increase in exploration, say Japanese researchers.

The International Seabed Authority, which regulates all the mineral exploration activities in the high sea and helps set the guidelines for environmental assessment, recommends a year of video monitoring in the deep sea for baseline data. However, to date there aren't any technological standards, and deep-sea assessments are still a largely uncharted endeavour. Between 2014–2018, researchers and engineers participating in a Japanese government deep-sea initiative, began to establish affordable monitoring technologies.

A Japanese project, running until 2022, is starting to test technologies and assess possible changes to ecosystems caused by exploitation activities, such as sediment sampling. "Stirring up seafloors blow up and suspend particles. We don't know how, for example, redeposited sediment affects small benthos on the deep seafloor," explains Yoji Miyata, a researcher at the Research and Development Partnership for Next Generation Technology of Marine Resources Survey (J-MARES).

J-MARES was established in 2015 to develop Japan's deep-sea surveying capacity, including environmental monitoring techniques. It currently consists of four private companies – Japan Petroleum Exploration, JGI, Mitsubishi Materials Techno and IDEA Consultants.

THREE JAPANESE PROPOSALS WENT INTO THE FINAL DRAFT STAGE OF A NEW SET OF INTERNATIONAL STANDARDS FOR ENVIRONMENTAL MONITORING AND ASSESSMENT.

AFFORDABLE FOR ISLANDS

Existing deep-sea monitoring methods for research are often too technical, costly, and are inappropriate for long-term commercial use. Japanese researchers have designed compact, user-friendly and inexpensive systems that even small island nations can use, explains Nobuo Kawai, an executive advisor at J-MARES.

The main instrument for observations is Edokko Mark I type 365, a free-fall, lander-type observatory. It drops to the seabed via its own weight, captures video and can stay on the seabed for 12 months at a time. It's returned to the surface by a simple acoustic signal that triggers the release of a sinker.

J-MARES have invited a dozen technicians from seven Pacific Islands countries for training and seminars on marine environmental assessments in the last few years.

HAND-SHAPED GLASS

A first model, called Edokko Mark I, was completed in 2013. It consists of three glass spheres, each roughly 33cm in diameter, housing a transponder (for wireless control), an LED light, a high-definition video camera system with multiangle viewing, and a battery package.

Okamoto Glass, a specialty glass manufacturer, invented the key component – an ultra-pressure resistant glass sphere. "Plastics cannot withstand high pressure and other materials such as titanium could be 100 times more expensive. Glass was the most suitable because it's cheap, can be made stronger than steel and its transparency enables clear observation," explains Tsuyoshi Okamoto, the company's chairman and chief executive officer.

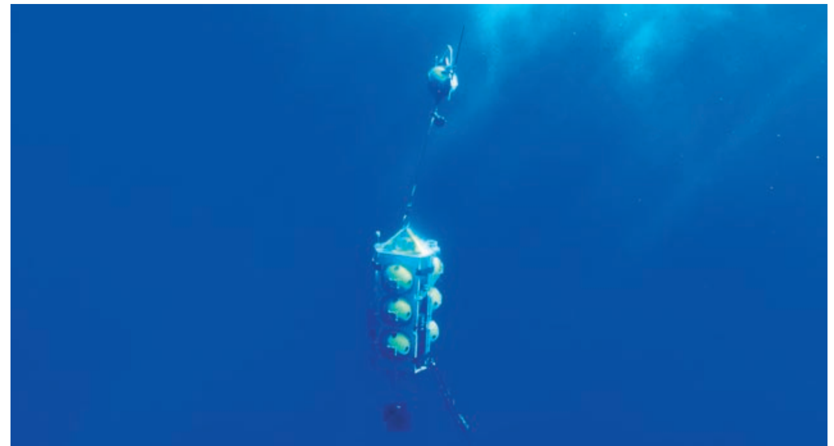
Engineers performed multiple simulations to develop a true sphere, the shape needed for even pressure to avoid implosion, as well as ensuring the faces of the two hemispheres matched precisely so they fused together without causing even nanometre-sized cracks. "We use numerically controlled machine tools until the near end of manufacturing, but the delicate finishing process to ensure high sphericity is done manually by our engineers," says Okamoto. Creating a machine to do this delicate work would make the technology too costly, he explains. "Even in this digital era, we embrace analogue skills as our strengths," he notes.

In 2013, Okamoto Glass showed the Edokko Mark I can withstand 800atm of pressure at a water depth of 8,000m. Its upgraded version, Edokko Mark I type 365, carries nine glass spheres for the transponder, camera and LED light, each of which is fed power from four spheres containing batteries, while two empty spheres are installed for buoyancy.

Researchers have already conducted months of deep-sea observations using the Edokko Mark I type 365 and an acid-resistant version of Edokko Mark I type HSG, developed for exploration of seafloor massive sulphide deposits. Based on this experience, JAMSTEC and their collaborators proposed a set of protocols to the International Organization for Standardization.

Good news arrived in November 2020, when the three Japanese proposals went into the final draft stage of a new set of international standards for marine environmental monitoring and assessment. These involve protocols for underwater image acquisition, analysis of the minute invertebrate groups using an imaging flow cytometer, environmental metagenomics analyses, as well as a bioassay method for water quality monitoring using delayed fluorescence of microalgae.

ADVERTISEMENT FEATURE



An Edokko Mark I type 365 sinks to the deep-sea bottom. It can be raised to the surface via an acoustic signal from a research vessel.

A school of rattail fish at a depth of 5,500m.

Simple equipment placed inside a number of glass spheres can affordably monitor the deep sea. Engineers and technicians from a number of Pacific Islands countries train in Japan's latest environmental assessment technology.

WORLD'S LONGEST TEST

In March 2019, Edokko Mark I type 365 went to its first one-year observation. Submerged at 5,550-6,000m near the island of Minamitorishima, Japan's easternmost territory, it was the world's longest seafloor observation at such depths. The system was also equipped with sensors to track spatial changes. Mooring systems near the landing spot of the submersible also monitored temperature, currents, turbidity and settling particles, as baseline references.

In March 2020, the three Edokko tests returned safely, and another three were installed to continue observing for another year.

"Although it is not an international requirement, we believe two years of consecutive monitoring will bring us deeper insight into the biological and physical dynamics," says Nobutoo Minegishi, director at J-MARES.

This article discusses research and development by Okamoto Glass and the Research and Development Partnership for Next Generation Technology of Marine Resources Survey (J-MARES). Their research and development programmes are part of the Cross-ministerial Strategic Innovation Promotion (SIP) Program, which is run by Cabinet Office, Government of Japan. ■

SIP

www.jamstec.go.jp/sip2/e