SIP Protocol Series No.4

Acquisition of Long-Term Monitoring Images Near the Deep Seafloor by Edokko Mark I

Cross-ministerial Strategic Innovation Promotion Program

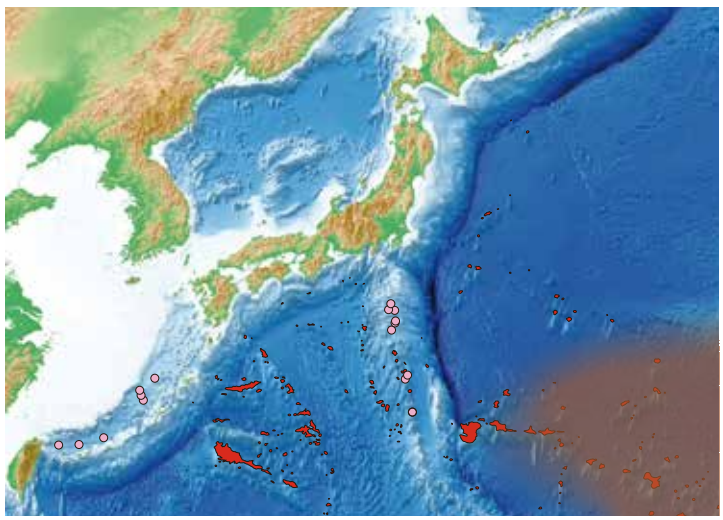
The Strategic Innovation Promotion Program (SIP) was launched by the Council for Science, Technology, and Innovation (CSTI), which oversees projects that target scientific and technological innovation in line with Japanese government directions as stated in the Comprehensive Strategy on Science Technology and Innovation and the Japan Revitalization Strategy. This interdisciplinary program among government agencies, academic institutes and private sectors addresses eleven issues. One of these issues is Next-Generation Technology for Ocean Resources Exploration.

Zipangu in the Ocean Program and Protocols for Environmental Survey Technologies

Zipangu in the Ocean Program is a technical study of the development of submarine mineral deposits that takes into consideration the wise use of these resources.

One research area is the ecological survey of organisms and their long-term monitoring. However, an ecosystem consists of various interrelated factors; thus, in addition to a comprehensive understanding of the system, observation and analysis of each component to its most elemental level are unavoidable. Recently, increased environmental awareness and the necessity of forming a consensus have become key issues in conducting development activities. Growing concern for the environment by the public and the diversification of the use of maritime areas have complicated the interests of stakeholders. To facilitate the formation of a consensus under these conditions, it is important for standardized methods to be implemented. This will ensure that research processes are transparent and that the collection of survey data is objective.

This protocol series aims to introduce more accurate, user-friendly, objective and effective underlying technologies required to understand the environmental impact of submarine mineral resource development. We believe that creating such a technology tool-kit will allow us to develop these resources in a sustainable manner.



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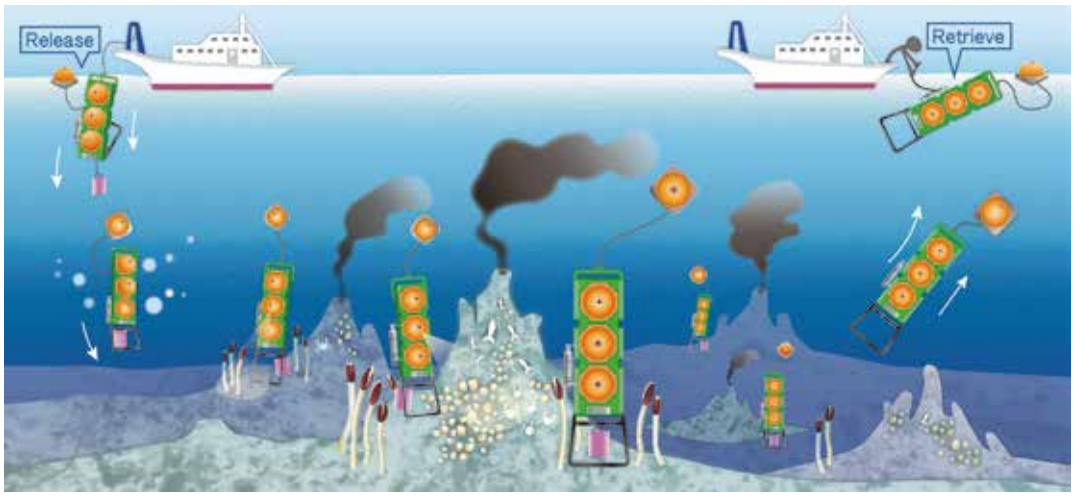

chapter 1

Introduction

Research and development of SIP "next generation survey technology for marine resource " is progressing on a method to evaluate the influence of marine resource development and a system that continuously monitors the influence. If marine resources will be mined, some change will occur in the surrounding environment such as deep sea water and seabed, and it is assumed to affect various organisms living there.

The International Seabed Authority (ISA), an organization which holds jurisdiction over deep seafloor ore resources in international waters, has established several guidelines related to this issue. Under these guidelines, the organization recommends using video surveillance as a baseline exploration procedure to understand physical changes on the seafloor and mega faunal activity. The guidelines also request obtaining video imagery of the seafloor over a long-term period of about one year within the contracted mining area.

Technology for ocean exploration has continued to develop over the years, researchers have stockpiled images taken within the ocean. Thus, there is now a huge database of deep-sea life. These images record conditions in deep-sea and give important clues to forging a deeper understanding of the environment near the seafloor and deep-sea habitats. In addition, the images are also effective tools which show the dispersion and changes of species. If full-scale mining commences, there will be a need to monitor conditions during extractions and conduct long-term environmental monitoring of the area after the process is finished. Thus, the importance of video material is thought to increase further.

As exploration technology continues to develop, the evolution of video equipment is also accelerating. For instance, video cameras used on land are miniaturizing, with increasingly higher definitions at lower prices. Also, there are many models retailed which feature underwater video capture capacity. However, specialized devices which can withstand the high pressures of the deep-sea are generally large and heavy, and are often custom-made, expensive one-of-a-kind products.

The Edokko Mark I, a machine developed by a consortium of small and medium-sized enterprises in the Japanese private sector over the course of five years, is a simple deep-sea shuttle camera which can drop itself from the sea surface to the seafloor using its own weight, capture images of the seafloor and float back to the surface. Operators can simply replace the batteries for repeated use, and researchers have already used the Edokko Mark I in various area around

Japan1.

We investigate to obtain long-term images near the deep sea floor around the hydrothermal deposit by Edokko Mark I which has been improved to rise photographing performance and to be longer mooring.

See Fig. 1 for an external view of the Edokko Mark-I and see Fig. 2 for the protocol flowchart how to acquisition of long-term monitoring images near the deep seafloor by Edokko Mark I.

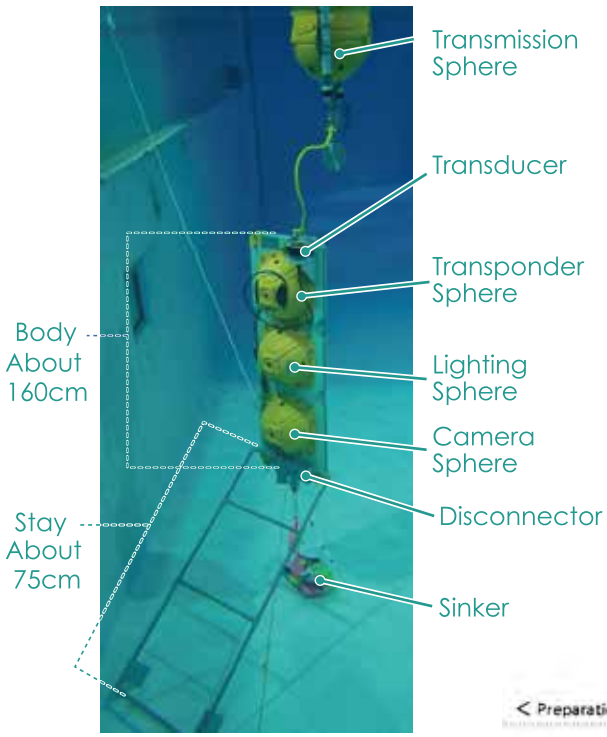

Fig. 1 External View of the Edokko Mark I

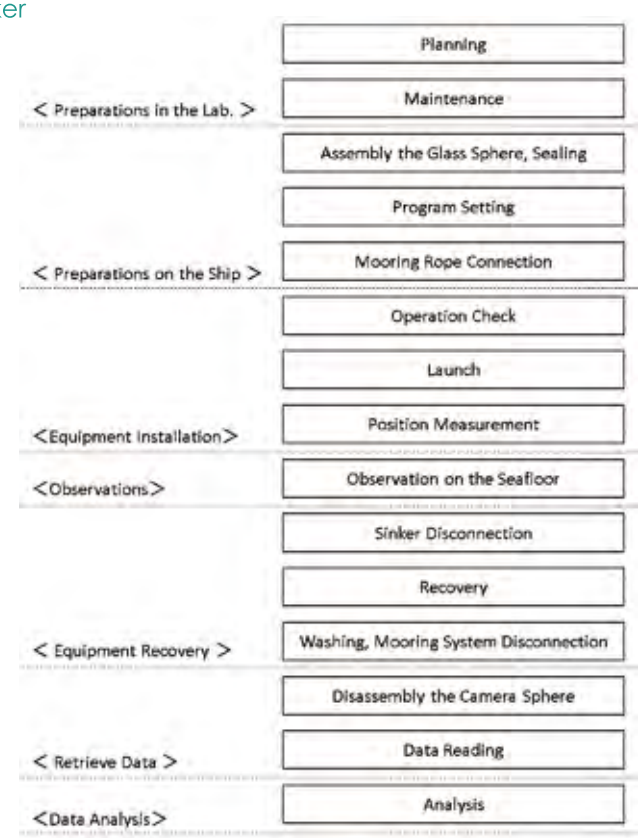

Fig. 2 Flowchart of protocol for acquire images near the deep seafloor by the Edokko Mark I

chapter 2

Protocol for Acquire Images Near the Deep Seafloor by the Edokko Mark I

The protocol for acquire images near the deep seafloor by the Edokko Mark I consists of seven steps, that is preparations in the laboratory, preparations on the ship, equipment installation, observations, equipment recovery, retrieve data, and data analysis. Note that the manual[2] contains specific details related to preparations and data retrieve.

2-1.Preparations in the Lab.

We consider processes such as observation planning, equipment maintenance as preparations in the laboratory.

A. Observation Planning

1.Observation planning step needs clarify the purpose and determine the installation point, duration and shooting interval.

Examples of observation purposes are shown below.

- Understand the physical fluctuation near the seafloor, which are strength and direction of flow near the seafloor and thickness of rework.
- Understand the ecology of mega fauna near the seafloor.
- Understand the living organisms around the installation point by attaching the bait.

Examples of observation plan are shown below.

- Installation point: Flat place near the seafloor hydrothermal deposit
- Observation duration: 1 week
- Shooting interval: Beginning 1 hour before equipment introduction and shooting 3 hours continuously. Thereafter, Shot for 1 minute at 30 minute intervals until retrieval.

B. Device Maintenance

1.Device maintenance step needs for effective observation.

Examples of the equipment list for Edokko Mark I are shown in Table 1.

2. Based on the observation plan, prepare the following materials (ropes, metal fittings, etc.), consumables (sinker, disconnector parts etc.) listed in Tables 2 and 3.

Table 1 Edokko Mark I equipment list (1 set)

	Name	Description	Qty.
1	Body	50cm × 160cm × 5cm Epoxy chemical wood material with FRP material frame Equipped with transponder and disconnector device	1
2	Camera Sphere	φ33cm Equipped with Digital HD camera board, pressure gauge in the protective hat	1
3	Light Sphere	φ33cm Equipped with LED light board, pressure gauge in the protective hat	1
4	Transponder Sphere	φ33cm Equipped with transponder assay, pressure gauge in the protective hat	1
5	Transmitter Sphere	φ33cm Equipped with radio beacon and flasher in the protective hat	1
6	Stay	145cm × 60cm × 2.5cm PVC material	1
7	Radio Beacon	NovaTech MetOcean RF-700 A3ST 7,300 m (pressure resistance)	1
8	Flasher	NovaTech MetOcean ST-400A 7,300 m (pressure resistance)	1

Table 2 List of materials used in observations (example)

	Name	Description	Qty.
1	Double Shackle (Located under the transmitter sphere)	SUS made WS-10	1
2	Transmission Sphere Sinker	1kg With carabiner	1
3	Rope(Located between the body and the transmission sphere)	φ12mm×1m PP cloth type rope Double eye-spliced	1
4	Shackle (Located in the upper section of the body)	SUS made d=25mm L=100mm 1.9kg Load: 5.75t (ESCO EA638F-60)	1
5	ROV Retrieval Rope	φ12cm×3m PP cloth rope	1
6	Jig for optional device	Epoxy chemical wood material	1
7	Counter Sinker	2 weight types: 0.5kg, 1kg	1~2
8	Transducer	Made by Kaiyo Denshi Kogyo Co., Ltd.	1
9	Transducer Grip	Made by Kaiyo Denshi Kogyo Co., Ltd. LNS600	1
10	Rotating Table	For assembly	1
11	Vacuum Pump	For assembly	1
12	Snap Shackle	For launching	1
13	Rope	For launching and retrieval Guy rope	1
14	Tools	suitable kinds	1
15	PC	For program control	1

Table 3 List of consumables used in observations (example)

	Name	Description	Qty.
1	Sinker	With carabiner, round pipe, and wire 40kg	1
2	Rechargeable Battery (For camera sphere and lighting sphere)	Turnigy 5000mAh 4S Includes charger (EOS0720i)	2
3	Primary Battery	For transponder sphere	1
4	Li-Ion Rechargeable Battery	For transponder assy Model No. 18650 2600mAh 3.7V	2
5	Alkaline Battery	For the radio beacon and flasher Size C	8
6	Ethanol	For wiping	Suitable amount
7	Desiccant	For dehumidification	3
8	Masking Tape	Low-adhesive type (Such as Nitto Denko floor masking tape No.395N)	Suitable amount
9	Anticorrosion Tape	For assembly	Suitable amount
10	Butyl Tape	For assembly	Suitable amount
11	Plastic Tape	For assembly	Suitable amount
12	Vacuum Grease	Oil compound for high vacuum seal (Such as Shin-Etsu Silicone HIVAC-G)	Suitable amount
13	Cable Tie	Various sizes	Suitable amount

3. Device maintenance step also treats optional equipment which are listed below:
   - CTD sensor
   - Thermo meter
   - In situ culture apparatus
   - Compass
   - Current direction detector

2-2. Preparations on the Ship

We consider processes such as assembly the glass sphere and sealing, program setting, mooring rope connection as preparations on the ship.

A Assembly the Glass Sphere, Sealing

Assembly the glass sphere and sealing are carried out on a rotating table.

1. Assemble the camera sphere and lighting sphere(Fig.3) following the procedure below:
   - The main parts of the camera sphere and lighting sphere (board) are assembled into the glass sphere normally.
   - Install a fully charged battery into each sphere. We use a Turnigy 5000mAh 4S battery and an EOS0720i charger. Pay attention to the recharging mode (voltage, current) during the charging process.
   - One battery is enough to power one camera continuously for three hours.

- Confirm the proper arrangement and installation of the battery, wiring, power switches and other components during the assembly process. Pay close attention to wire colors and male and female connector pins, and be careful not to connect multiple batteries to each other.
- Affix drying agent to the area where the pressure gauge is installed.

Fig.3 Interior of the glass sphere

2. Assemble the transponder sphere using the procedure below:
   - Set the transponder assembly, two Li-ion rechargeable batteries (model No. 18650, 2600mAh, 3.7V), and the transponder battery into the transponder sphere.
   - Connect the disconnector device and the cord (inside the glass sphere) connector to the transducer.
   - Affix drying agent and pressure gauge to the attachment position.

3. Seal the glass sphere using the procedure displayed below. Confirm the pressure gauge after sealing the glass sphere, and repeat the sealing process if there is an air leak.
   - Before covering the glass sphere, reconfirm the proper arrangement and installation of the battery, wiring, power switch, drying agent, pressure gauge, and other components.
   - Wipe off any dirt from the inner, outer, and mating surfaces of the glass sphere with ethanol.
   - Cover the glass sphere and adjust the sides of the mating surface as needed so they do not stick out.
   - Connect the vacuum port to the vacuum pump and create suction, and then adjust the inner pressure to 700-800hPa. Check to see that there are no scratches or dirt on the titanium bolt O ring of the vacuum port.
   - Firmly wrap the sides of the mating surface of the glass sphere with butyl (rubber) tape to prevent wrinkles from forming. In addition, cover and wrap the butyl tape three times with anticorrosion tape.
   - Put the glass sphere into the protective hat (orange cover) and bolt it shut.

B Program Setting

1. Based on the purpose of the observation and the investigation schedule, operators create programs using the associated application.
2. It is possible to set up sixteen programs on the Edokko Mark I. Programs run in order from No. 1 and the device enters sleep mode in between programs.

Parameters are listed below. It is important to consider the mooring duration and battery capacity when establishing video capture intervals and frequency.

- Video capture start date and time
- Camera mode (Video capture, still photos)
- Length of video capture time: Video length (in minutes)
- Frequency: Number of video capture rounds (1 to 9999 times)
- Interval: Time between video capture rounds (1 to 9997 minutes)

3. Operators can send setup programs to the camera sphere and lighting sphere through XBee transmission (using the USB dongle). Transmission preparations for each sphere and the PC must be made first, and then operators can send transmissions in the following order:

- Transmission of current date and time
- Transmission of program
- Setup readout and setup confirmation
- Confirmation of the start of operations

4. Operators can confirm the start of program operations by setting the start date and time of program No. 1 just before launching (for example, one hour before the planned launch time).

C Mooring Rope Connection

1. Install the glass sphere and the stay to the body using the following procedure:

- Install the camera sphere to the disconnector side, lighting sphere on the middle, and transponder sphere to the upper side on the body.
- Connect the communication code of the transponder sphere cord to the transponder and disconnector. Bundle excess cord and secure it into the protective hat for the glass sphere.
- Hold the stay between the fixing saddle and bolt it to the body. Make sure the stay moves smoothly.

2. Install optional sensors, bait and other devices such as the examples listed below as needed. (Fig. 4) If installing devices on one side of the body, counterbalance them with weight on the opposite side. Prepare bait in two methods: bind one directly to the stay and the other after wrapping it with the net. This method will attract living organisms for a long period. A uniform bait will also make it easy to compare groups of organisms between each observation.

- CTD (JFE Advantech RINKO propeller, Sea-Bird SBE for example)
- Thermometer
- In situ culture apparatus
- Current meter
- Compass
- Current direction detector

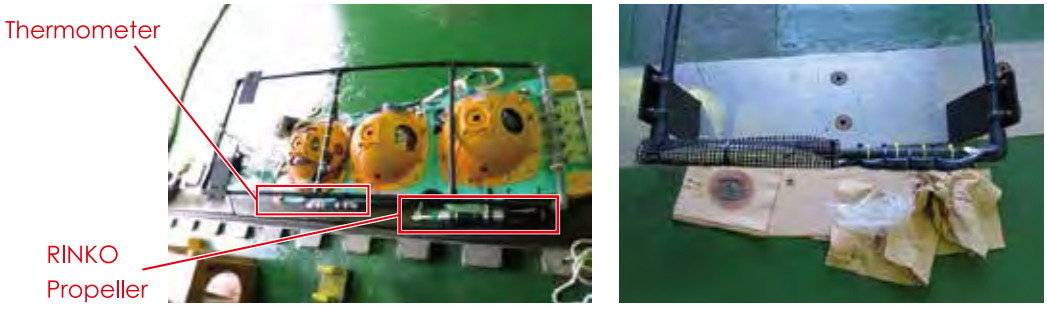

Fig. 4 Examples of optional sensor(left) and bait(right)

3. Connection the mooring system on the installation day near the launch site.

- Connect the sinker (about 40kg) and the disconnector using wire and a carabiner. The length of the wire depends on the focal length of the camera, but normal length is 75cm(Fig.5).
- Connect the transmission sphere using the shackle on the upper section of the body and the PP rope floating in the water. The length of the rope depends on the operational method of launch, but normal length is 1m. (Fig.6) In addition, install the flasher, radio beacon, and triangular flag to the transmission sphere to help find the Edokko Mark I resurfaces.
- Once the mooring system is connected, tighten and check each parts.

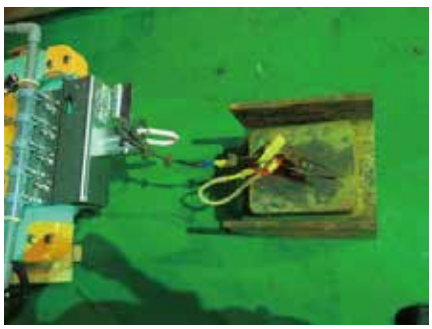

Fig.5 Attaching the sinker

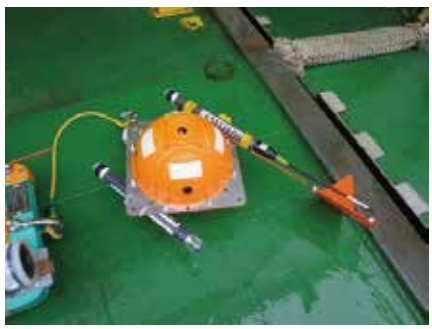

Fig.6 Attaching the transmission sphere

4. An electrolytic corrosion method or a nylon line thermofusion method can be used for the disconnector. (Fig.7and 8)The latter method is better for long-term observation around the seafloor massive sulfide.

Fig.7 Disconnector before use
(Left: electrolytic method, Right: nylon line thermofusion method)

Fig.8 Disconnector after use
(Left: electrolytic method, Right: nylon line thermofusion method)

5. In the case of the disconnector does not work, it can be used to retrieve the Edokko Mark I with the sinker by ROV work. If there is possibility of using an ROV for retrieval, attach the eye-splice rope to the body and fasten it. It is also possible to make a handgrip with rope on the upper of the transmission sphere.(Fig.9)

Fig.9 Rope for retrieval with an ROV work

2-3. Equipment Installation

We consider processes such as operation check, launch, and position measurement as equipment installation.

A Operation Check

1. Setting the video start time for program No. 1 to a time just before launch (for example one hour prior to the planned launch time) allows the user to confirm whether the program is running by viewing the lighting and LED light within the camera sphere. For long-term lighting on the boat, cool the lighting sphere with water to prevent the circuit board from burning.
2. Switch on the radio beacon and the flasher on the transmission sphere to check functionality.

B Launch

1. At the launch point, release the device using the following process.(Fig.10)
   - Connect the launch rope which passes through the davit (a simple crane) pulley to the swivel shackle on the upper section of the body of the Edokko Mark I using a snap shackle (This is a metal fitting equipped with a disconnector pin. The metal fitting unfastens by pulling the rope tied to the pin).
   - Roll up the launch rope, rotate the davit and draw the Edokko Mark I outside the ship with keeping the swing prevention rope is tight. Hoist the sinker with another rope and lift it out of the ship.
   - Roll down the Edokko Mark I to the sea surface with keeping the snap shackle rope is slack.
   - Remove the swing prevention rope once the Edokko Mark I is introduce into the sea. Then, pull and disconnect the snap shackle rope.

Fig.10 Launch operations using a davit
(Left and center: hoisting the Edokko Mark I, Right: swinging it out of the ship)

・When using an A frame, Connect the launch rope which passes through the A frame pulley to the eye splice rope on the upper part of the transmission sphere with a snap shackle. And then introduce into the sea in the same way by using davit.(Fig. 11)

Fig. 11 Launch operation using an A frame

・In the case of launching the Edokko Mark I from a small boat without an A frame or a davit, it is possible to lie down the Edokko Mark I and launch it off the side of the boat by a few people.

2. Calculate the time to reach the seafloor by using the settling speed (85m/min) of the Edokko Mark I.

3. If installation points require precision, the Edokko Mark I may be lifted by ROV after reaching the seafloor to move it.

C Position Measurement

1. Confirm that the device has reached the seafloor and the installation point by following the procedures below(Fig. 12):

・Hold the ship position at a point ca. 500m away from the launch point and introduce the transducer into the sea.

・Communicate with the Edokko Mark I, measure the distance several times and compare with the water depth (confirming the device has reached the seafloor).

・Measure distance in a similar fashion at two additional points about ca. 500m away from the launch point, and determine the installation point with a three-point surveying technique.

Fig. 12 Transducer control unit (left) and transmitting unit (right)

2-4. Observations

A Observation on the seafloor

1. While observing, there is nothing special to do, but be careful as it may recover earlier than planned due to deterioration of the sea condition.

2-5. Equipment Recovery

We consider processes such as sinker disconnection, recovery, washing, and mooring system disconnection as equipment recovery.

A Sinker Disconnection

1.Disconnect the sinker using the following process to float the Edokko Mark I.

- Hold the ship at the confirmed installation point and introduce the transducer into the sea.
- Communicate with the Edokko Mark I and measure the distance to confirm whether the device is on the seafloor.
- Send a disconnect signal and wait for confirmation from the transponder of Edokko Mark I. This signal send electrical current through the disconnector to thermally cut the metal plate or nylon line on the disconnector section. The cutting process takes 15 minutes, after which the Edokko Mark I rises from the seafloor.

2. Calculate the time to reach the sea surface by using the flotation speed (40m/min) of the Edokko Mark I.

3. Contact the rising Edokko Mark I several times to confirm flotation

B Recovery

1. When the Edokko Mark I reaches sea surface, the radio beacon operates and can determine which direction the device is located by the direction detector on ship. In addition, visual identification is possible during the day by the triangular flags and the color of the protective hats, while the night by the lights of the flasher. Note that when new batteries are used, the radio beacon can operate for about four days on the sea surface, and the flasher for about seven days.

2. Once device has been confirmed, approach the site with the ship, snag the retrieval rope to the body from the starboard side with a hook rod,and then wind it up with a winch to recover.

C Washing, Mooring System Disconnection

1. Flush the Edokko Mark I with freshwater to remove salt.

2. Disconnect the transmission sphere, rope and optional sensors. Remove the radio beacon and flasher from the transmission sphere and switch them off.

3. After retrieving the data, soak the entire parts in a tank of water to thoroughly remove the salt.

2-6. Retrieve Data

We consider processes such as disassembly the camera sphere and data reading as retrieve data.

A Disassembly the Camera Sphere

1. Open the camera sphere using the following process:

- Remove the camera sphere from the body with the protective hat and then remove the glass sphere from the hat to put onto a special rotating table. Wet glass is extremely slippery, so be sure to wipe it down sufficiently with rags to dry it before handling. In addition, remove pens and tools from shirt pockets and ensure sleeve buttons are not exposed to avoid scratching the glass.

- Peel off the anticorrosion tape and butyl tape. Proceed with caution as force is required to peel the tape off. Wipe off any remaining tape with ethanol.
- Loosen the titanium bolt on the vacuum port to revert the inside of the camera sphere to atmospheric pressure and then retighten the bolt. Make sure the glass sphere on the upper side does not slide off.
- Move the glass sphere on the upper side to a horizontal position and remove. Protect the mating plate with masking tape to prevent scratching.
- Remove the video data SD card, the battery, and the desiccant.
- Cover the glass sphere on the upper side, secure the mating surface with masking tape, and store it in the hat.

2. Use a similar process when opening other glass spheres. Proceed with caution as there is wiring in the transponder sphere that connects both the upper and lower glass spheres through the interior.

B Data Reading

1. Read image data using the following process:
   - Remove the SD card from the card slot on the bottom of the camera unit.
   - Connect the SD card to a PC and use File Explorer or another file management application to copy, delete and otherwise manage.
   - Return the SD card to the card slot after operations are complete.

2-7. Data Analysis

A Analysis

Image data obtained by the Edokko Mark I may be used for the following analyses.

1. Analysis of seafloor changes over time can help understand the frequency and cycles of bottom sediment curling up and the amount and expansion range of rework.
2. Continuous analysis of organisms which appear near the seafloor can help understand the habitat density and types of them.
3. The analysis of organisms and suspended particles that appear in the images from the time of launch until it reaches the seafloor can help understand the variety and number of species in a specific oceanic area (if set the video start at launch).

References

1. Tsuchiya, Toshio, Miwa Tetsuya, Oguri Kazumasa, Maeda Yousaku (JAMSTEC), Edokko Mark I Development Committee (2015). Retrievable Deep-sea TV Camera System 'Edokko Mark I' Development Project Outline and Actual Marine Area (Depth of 7,800m) Experiment Results. Blue Earth 2015 Summaries.

2. Okamoto Glass Co., Ltd. Edokko Mark I Observation Manual.

Memo

Memo

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Genetic Connectivity Survey Manuals

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-Direct Measurements of the Deep Sea Turbulence flow-

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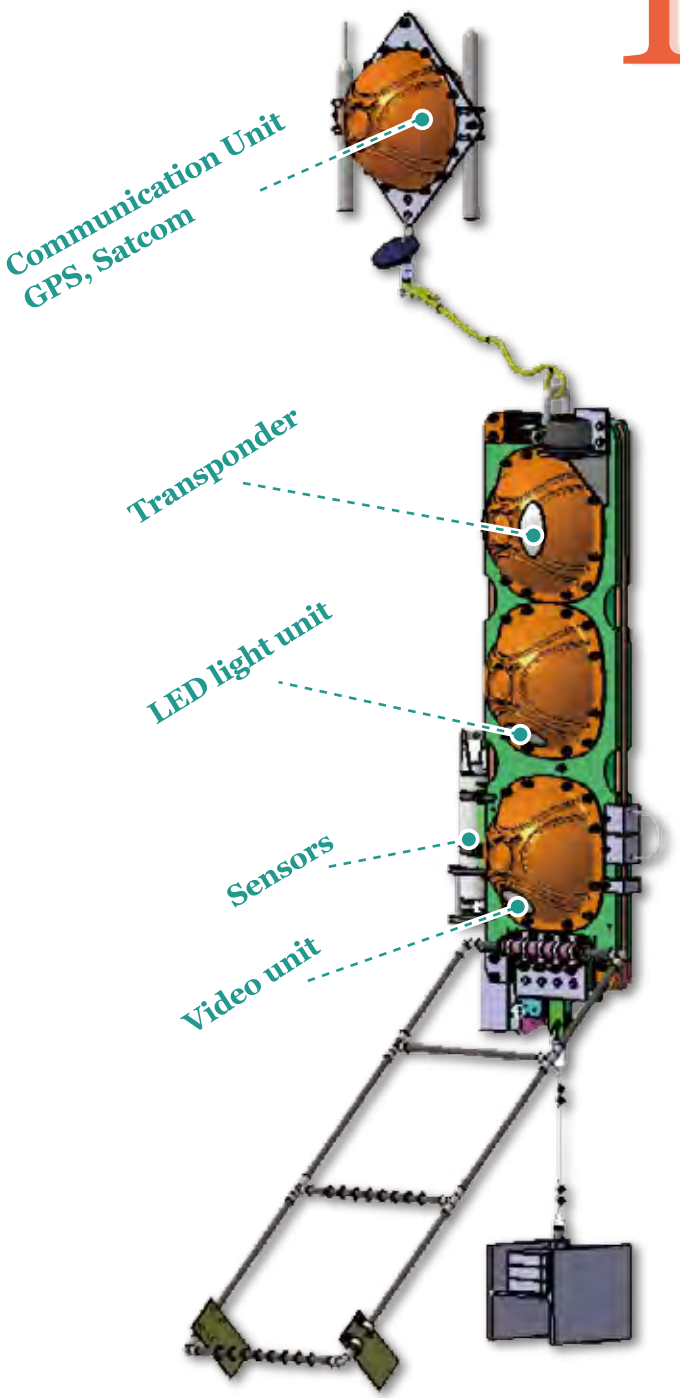

1 Quality

■Anticorrosion
(available in variety of environment i.e. reductive environment)
■Long-term observation
(weekly, monthly, yearly)
■Wide application range of water depth
(10m to 10,000m)
■High vision video camera(1080p)※
■Long recording function(10hr)※

※Customizable

2 Specification

■Body length: 1600mm, Width: 500mm
■Glass sphere size: 13 inch
■Weight in air: 50kg
■Buoyancy:300N

3 Optional functions

■Sensors: water temperature, salinity, dissolvedoxygen, turbidity, current meter etc.
■Culture apparatus (in situ) etc.

4 Research example

"Edokko Mark I" is developed by council for Science,Technology and Innovation (CSTI),Cross-ministerial Strategic Innovation Promotion Program(SIP), "Next-generation technology for ocean resources exploration". In this program, environmental impact assessment method of exploit mineral resources is developed with JAMSTEC, National Institute for Environmental Studies, YOKOHAMA National University, Tokyo University of Marine Science and Technology.

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