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Yokosuka Cruise Report
YK21-18C

# In situ biodegradability tests of newly developed biodegradable materials and investigations on their controlling factors

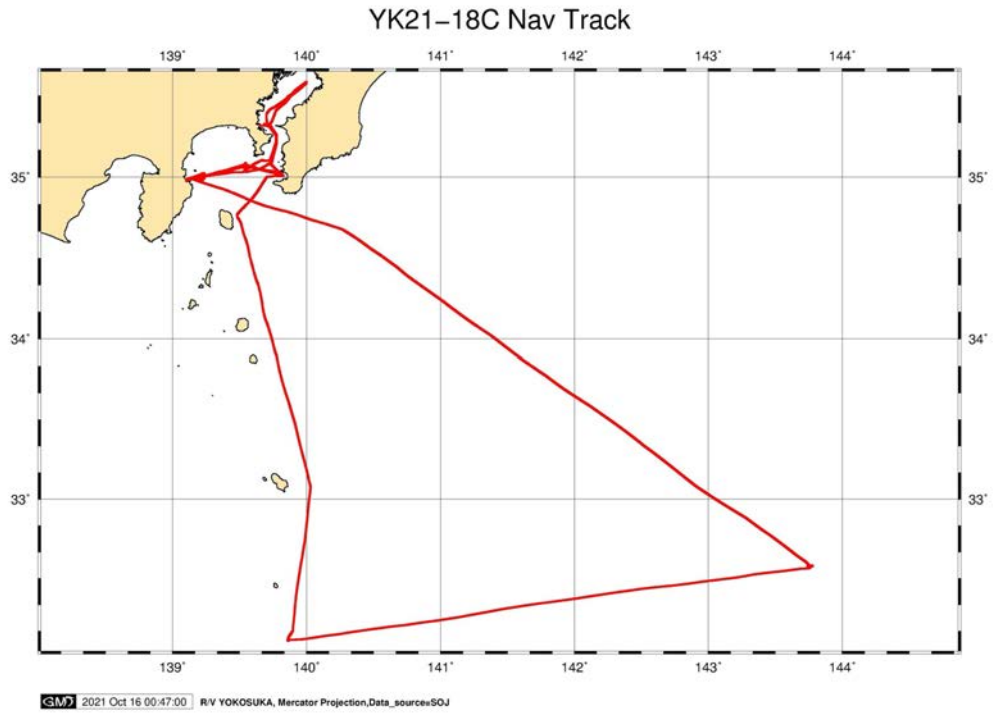
Sagami Bay, Izu-Ogasawara arc, western North Pacific abyssal plain

Sep 27- Oct 17, 2021

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

## 1. Cruise Information

● Cruise ID: YK21-18C
● Name of vessel: Yokosuka
○ Title of project: In situ biodegradability tests on newly developed biodegradable materials and investigations on their controlling factors
● Title of cruise: In situ biodegradability tests on newly developed biodegradable materials and investigations on their controlling factors
● Chief Scientist: Hidetaka Nomaki [JAMSTEC] (Sep 27th to Oct 11th), Noriyuki Isobe [JAMSTEC] (Oct 11th to Oct 17th)
● Cruise period: Sep 27th to Oct 17th, 2021
● Ports of departure / call / arrival: Sendai/Yokosuka area 4/Yokosuka
● Research area: Sagami Bay, Izu-Ogasawara arc, western North Pacific abyssal plain
● Research map




## 2. Research Proposal and Science Party

● Title of proposal
In situ biodegradability tests on newly developed biodegradable materials and investigations on their controlling factors

● Representative of Science Party [Affiliation]
Hidetaka NOMAKI[1] [Japan Agency for Marine-Earth Science and Technology]

● Science Party (List) [Affiliation, assignment etc.]
Noriyuki ISOBE[2] [Japan Agency for Marine-Earth Science and Technology]
Yuriko NAGANO[2] [Japan Agency for Marine-Earth Science and Technology]
Yuki SAKAO [Japan Agency for Marine-Earth Science and Technology]
Chong CHEN[1] [Japan Agency for Marine-Earth Science and Technology]
Iines SALONEN[1] [Japan Agency for Marine-Earth Science and Technology]

Kanae KOBAYASHI[1] [Japan Agency for Marine-Earth Science and Technology]
Akito OGAWA[1] [Japan Agency for Marine-Earth Science and Technology]
Yuto KAKU[1] [Japan Agency for Marine-Earth Science and Technology]
Katsunori MIZUNO[1] [Japan Agency for Marine-Earth Science and Technology]
Jessica Naliharifetra RANAIVOARIMANANA[2]
[Japan Agency for Marine-Earth Science and Technology]
Kenichi KASUYA[2] [Gunma Univ.]
Miwa SUZUKI[2] [Gunma Univ.]
Tadahisa IWATA[2] [Tokyo Univ.]
Satoshi KIMURA[2] [Tokyo Univ.]
1: 9/27-10/11
2: 10/11-10/17

*Marine Technician [Affiliation]*
MORIFUMI TAKAESU [Nippon Marine Enterprise Ltd.]

*Crew members*

| | |
|---|---|
| Captain | TATSUO ADACHI |
| Chief Officer | TOSHIYO OHARA |
| 2nd Officer | TOMOHIRO YUKAWA |
| 3rd Officer | DAISUKE MORIYA |
| Jr.3rd Officer | YUTO OBATA |
| Chief Engineer | KOJI FUNAE |
| 1st Engineer | KAZUNORI NOGUCHI |
| 2nd Engineer | KOTA FUJII |
| 3rd Engineer | KEITO SHIMADA |
| Chief Electronic Op. | MASAMOTO TAKAHASHI |
| 2nd Electronic Op. | TAKAYUKI MABARA |
| 3rd Electronic Op. | KEISUKE OI |
| BoatSwain | YOSUKE KUWAHARA |
| Quarter Master | TSUYOSHI CHIMOTO |
| Quarter Master | YUKI YOSHINO |
| Quarter Master | NAO ISHIZUKA |
| Quarter Master | TOSHIYA SAGA |
| Sailor | YUKI OISHI |
| Sailor | RYO NAKANISHI |
| Sailor | ITSUKI TATEMICHI |
| No.1 Oiler | MASAYUKI FUJIWARA |
| Oiler | AOI TAKAMIYA |
| Oiler | SEIYA WATANABE |
| Assistant Oiler | REO SHINZATO |
| Assistant Oiler | HARUKI MATSUMOTO |
| Chief Steward | KATSUYUKI OMIYA |
| Steward | YOSHIO OKADA |
| Steward | SEIJI HONDA |
| Steward | CHIHARU KUROSAKI |
| Steward | YUTA HANGAI |

*SHINKAI6500 Team [Position]*

| | |
|---|---|
| Submersible Operation Manager | KAZUHIRO CHIBA |
| Deputy Submersible Op. Manager | KEITA MATSUMOTO |
| 1st Submersible Staff | MITSUHIRO UEKI |

| | |
|---|---|
| 2nd Submersible Staff | HIROFUMI UEKI |
| 2nd Submersible Staff | KEIGO SUZUKI |
| 2nd Submersible Staff | RYO SAIGO |
| 2nd Submersible Staff | TAKUMA ONISHI |
| 2nd Submersible Staff | YOSHIKAZU KURAMOTO |
| 2nd Submersible Staff | SATSUKI IIJIMA |
| 3rd Submersible Staff | MOTOHIRO MATSUSAKA |
| 3rd Submersible Staff | KAISEI SATO |
| 3rd Submersible Staff | KAI TAKEDA |

## 3. Research/Development Activities

### 3.1. In situ biodegradability tests of different types of novel plastics on the deep-sea floor

#### 3.1.1. Objectives

The recently-uncovered marine plastic pollution has been attracting the social attention, thereby requesting the less-plastic society. To achieve this, there are 2 options: 1) complete recycling of conventional plastics or 2) development of marine-degradable plastics. Although the option 1 would be the ideal social system, there remain several high technical hurdles. Therefore, the option 2, the development of marine-degradable plastic, is the imminent task. However, the degradation of conventional biodegradable plastics such as polylactic acid (PLA) requires the "compostable" condition: the temperature must be higher than 40°C. This requirement does not match the marine environment, especially the deep-sea floor, where the temperature is only 1~4°C. And most importantly, all the biodegradable plastics are heavier than water, and thus accumulate on deep-sea floor. Hence, the development of materials that degrade under such deep-sea condition is in urgent need.

In this context, we launched a collaborative Moonshot project with Gunma University, University of Tokyo, Tokyo Institute of Technology, and RIKEN financially supported by NEDO. Herein, more than 100 types of novel bio-degradable materials developed by JAMSTEC, Gunma University, University of Tokyo, Tokyo Institute of Technology, and RIKEN will be subjected to the on-site degrading test on the deep-sea floor. In addition, to understand chemical and biological environment of the degradation site, the chemical profiling analyzes such as dissolved oxygen, redox potential, and pH along the depth in the push core sample have been performed.

#### 3.1.2. Methods

More than 100 types of novel bio-degradable materials were stored in the sample chamber. The chambers were deployed on the deep-sea floor off Hatsushima and off Misaki of Sagami-bay, Myojin-knoll, and west of KEO during YK21-08C cruise. During this cruise, we recovered some of those materials and examine the degradation state of them.

#### 3.1.3. Results & findings in this cruise

The samples were deployed/recovered successfully, and the chemical profiling analyzes such as dissolved oxygen, redox potential, and pH along the depth in the push core sample was also successfully performed.

#### 3.1.4. Future plan

The deployed samples will be recovered 6 months or 1 to 3 years later. The recovered samples will be scrutinized to find out a clue for the deep-sea degradable materials. In addition, the microorganisms attaching on the plastics surface will be analyzed.

### 3.2. Geochemical measurements and biological analyses

#### 3.2.1. Objectives
Geochemical conditions of the bottom water and in the sediments significantly effect on degradability of biodegradable plastics. Furthermore, compositions of prokaryotes, eukaryotic microbes, and metazoans and their metabolic pathways/activities control the biodegradability on the deep-sea floor. We thus measured the geochemical conditions of the overlying water and surface sediments using a microelectrodes. We also collected sediments, water, debris, and megabenthos to investigate biological parameters.

#### 3.2.2. Materials and Methods
We collected surface sediment cores (15 to 25 cm in length) using a push corer having an inner diameter of 8.2 cm. After recovery onboard, the microelectrode (oxygen, pH, and redox electrodes with reference electrodes) were inserted into overlying water and in the sediment down to approximately 10 to 15 cm. The surface sediments were further sampled for prokaryotic and eukaryotic microbes analyses. In some oligotrophic area, we also used an optode oxygen sensor to measure oxygen concentration of the deeper sediment layers.
Visible megabenthos were collected using a scoop or a suction sampler and were fixed with either EtOH, formaldehyde, or deep-frozen. Deep-sea debris were also collected with the *Shinkai6500* to examine the microbiome of the debris surface. They were subsampled onboard and fixed with formaldehyde, deep-frozen, and some were also preserved in a refrigerator for the isolation of biodegrading microbes in the laboratory on land.

#### 3.2.3. Onboard results and future research
The oxygen profiles showed an intense consumption of dissolve oxygen at the surface several mm in the upper bathyal sediments. At the abyssal sediments, the oxygen penetrated to the bottom of the sediment, i.e. more than 25 cm depth in sediments. The microbial and metazoans analyses will be performed on land.

## ○ 4. Cruise Log

R/V "YOKOSUKA" YK21-18C Cruise Log

| Date & Time | Description | Weather / Wind / Sea Condition |
|---|---|---|
| 2021/09/27 Mon. | Noon Position: 35-19.1N, 139-39.0E (JAMSTEC) | - / --- / - |
| 19:00 | Onboard "YOKOSUJA" at JAMSTEC | |
| | | |
| 2021/09/28 Tue. | Noon Position: 35-35.0N, 140-00.0E (off FUNAHASHI, CHIBA port) | bc / NNE-3 / 1 |
| 07:10 | Bridge meeting | |
| 09:00 | Let go all shore lines & left JAMSTEC for TOKYO Bay | |
| 10:00 | Carried out education & training for scientists | |
| 10:45 | Meeting for 6K dive operation and schedule | |
| 11:30 | Let go anchor, arrived at off FUNAHASHI, CHIBA port | |
| 13:00 | Research meeting | |
| 17:40 | Bridge meeting | |
| | | |

| | | |
|---|---|---|
| 2021/09/29 Wed. | Noon Position: 35-35.0N, 140-00.0E (off FUNAHASHI, CHIBA port) | bc / NNW-1 / 1 |
| 07:10 | Bridge meeting | |
| 09:30 | 6K dive operation briefing | |
| 17:40 | Bridge meeting | |
| 18:00 | Reseach meeting | |
| | | |
| 2021/09/30 Thu. | Noon Position: 35-35.0N, 140-00.0E (off FUNAHASHI, CHIBA port) | bc / NW-2 / 1 |
| 07:10 | Bridge meeting | |
| 08:00 | Research meeting | |
| 17:40 | Bridge meeting | |
| 18:00 | Research meeting | |
| | | |
| 2021/10/01 Fri. | Noon Position: 35-35.0N, 140-00.0E (off FUNAHASHI, CHIBA port) | r / North-8 / 4 |
| 07:10 | Bridge meeting | |
| 08:00 | Research meeting | |
| 13:00 | 6K dive operation briefing | |
| 17:40 | Bridge meeting | |
| 18:00 | Research meeting | |
| | | |
| 2021/10/02 Sat. | Noon Position: 35-04.1N, 139-32.5E (off MISAKI, Sagami Bay) | bc / South-3 / 2 |
| 06:40 | Heaving anchor, left off FUNAHASHI | |
| 10:25 | Arrived at research area, SAGAMI Bay | |
| 10:29 | Released XBT | |
| 10:53-11:09 | Commenced MBES site survey | |
| 12:29 | Hoisted up "SHINKAI 6500" | |
| 12:37 | Launched | |
| 12:46 | SHINKAI 6500 dove & started her operation 6K1600 | |
| 13:50 | Landed on the sea floor (D=756m) | |
| 16:20 | Left the sea bottom (D=706m) | |
| 16:36 | Refloated "SHINKAI 6500" | |
| 17:04 | Hoisted up | |
| 17:12 | Recovered "SHINKAI 6500" & Finished above operation | |

| | | |
|---|---|---|
| 19:00 | Research meeting | |
| 19:55 | Let go anchor, arrived at off ITO port | |
| | | |
| 2021/10/03 Sun. | Noon Position: 35-00.9N, 139-13.5E (off Hatsushima) | c / NE-4 / 2 |
| 07:40 | Heaving anchor, left off ITO port | |
| 08:32 | Released XBT | |
| 10:03 | Hoisted up "SHINKAI 6500" | |
| 10:10 | Launched | |
| 10:19 | SHINKAI 6500 dove & started her operation 6K1601 | |
| 11:22 | Landed on the sea floor (D=983m) | |
| 16:08 | Left the sea bottom (D=799m) | |
| 16:28 | Refloated "SHINKAI 6500" | |
| 16:47 | Hoisted up | |
| 16:59 | Recovered "SHINKAI 6500" & Finished above operation | |
| 17:42-18:01 | Commenced MBES site survey | |
| 18:45 | Let go anchor, arrived at off ITO port | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/04 Mon. | Noon Position: 34-59.4N, 139-13.4E (off Hatsushima) | bc / South-4 / 3 |
| 07:35 | Heaving anchor, left off ITO port | |
| 09:51 | Hoisted up "SHINKAI 6500" | |
| 09:57 | Launched | |
| 10:05 | SHINKAI 6500 dove & started her operation 6K1602 | |
| 10:46 | Landed on the sea floor (D=1,093m) | |
| 16:00 | Left the sea bottom (D=1,145m) | |
| 16:28 | Refloated "SHINKAI 6500" | |
| 16:50 | Hoisted up | |
| 17:01 | Recovered "SHINKAI 6500" & Finished above operation | |
| 18:15 | Let go anchor, arrived at off ITO port | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/05 Tue. | Noon Position: 34-42.6N, 140-07.7E (SE off NOJIMASAKI) | bc / SSW-4 / 2 |

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|---|---|---|
| 08:10 | Heaving anchor, left off ITO port | |
| 08:30 | Commenced proseeding to research area, West KEO | |
| 09:30 | 6K dive operation briefing | |
| 17:40 | Bridge meeting | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/06 Wed. | Noon Position: 32-34.8N, 143-46.6E (West of KEO) | bc / NW-3 / 2 |
| 05:50 | Arrived at research area, West of KEO | |
| 05:55-06:18 | Commenced figure 8 circle running | |
| 06:30 | Released XBT | |
| 08:48 | Hoisted up "SHINKAI 6500" | |
| 08:54 | Launched | |
| 09:02 | SHINKAI 6500 dove & started her operation 6K1603 | |
| 11:25 | Landed on the sea floor (D=5,503m) | |
| 14:30 | Left the sea bottom (D=5,503m) | |
| 16:19 | Refloated "SHINKAI 6500" | |
| 16:41 | Hoisted up | |
| 16:51 | Recovered "SHINKAI 6500" & Finished above operation | |
| 17:20 | Commenced proceeding to research area, Myojin Knoll | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/07 Thu. | Noon Position: 32-06.2N, 139-51.9E (Myojin Knoll) | bc / ESE-4 / 3 |
| 07:30 | Arrived at research area, Myojin Knoll | |
| 08:00 | Released XBT | |
| 09:51 | Hoisted up "SHINKAI 6500" | |
| 09:58 | Launched | |
| 10:06 | SHINKAI 6500 dove & started her operation 6K1604 | |
| 11:01 | Landed on the sea floor (D=1,293m) | |
| 16:01 | Left the sea bottom (D=1,213m) | |
| 16:31 | Refloated "SHINKAI 6500" | |
| 16:52 | Hoisted up | |
| 17:00 | Recovered "SHINKAI 6500" & Finished above operation | |

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|---|---|---|
| 18:10 | Commenced proceeding to research area, SAGAMI Bay | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/08 Fri. | Noon Position: 35-00.6N, 139-49.3E (TATEYAMA Bay) | bc / Calm-0 / 1 |
| 09:00 | 6K dive operation briefing | |
| 10:20 | Let go anchor, arrived at TATEYAMA Bay | |
| 18:00 | Research meeting | |
| | | |
| 2021/10/09 Sat. | Noon Position: 35-04.1N, 139-32.6E (off MISAKI) | bc / NNE-3 / 2 |
| 07:00 | Heaving anchor, left TATEYAMA Bay | |
| 08:30 | Arrived at research area, off MISAKI, SAGAMI Bay | |
| 09:56 | Hoisted up "SHINKAI 6500" | |
| 10:02 | Launched | |
| 10:11 | SHINKAI 6500 dove & started her operation 6K1605 | |
| 10:42 | Landed on the sea floor (D=759m) | |
| 14:43 | Left the sea bottom (D=798m) | |
| 15:03 | Refloated "SHINKAI 6500" | |
| 15:25 | Hoisted up | |
| 15:34 | Recovered "SHINKAI 6500" & Finished above operation | |
| 17:45 | Let go anchor, arrived at off ITO port | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/10 Sun. | Noon Position: 34-59.2N, 139-13.7E (off HATSUSHIMA) | c / NNE-3 / 2 |
| 07:35 | Heaving anchor, left off ITO port | |
| 09:49 | Hoisted up "SHINKAI 6500" | |
| 09:56 | Launched | |
| 10:04 | SHINKAI 6500 dove & started her operation 6K1606 | |
| 10:50 | Landed on the sea floor (D=1,233m) | |
| 16:07 | Left the sea bottom (D=1,175m) | |
| 16:36 | Refloated "SHINKAI 6500" | |
| 16:57 | Hoisted up | |
| 17:06 | Recovered "SHINKAI 6500" & Finished above operation | |

| | | |
|---|---|---|
| 19:00 | Research meeting | |
| | | |
| 2021/10/11 Mon. | Noon Position: 35-00.6N, 139-49.4E (TATEYAMA Bay) | bc / SSW-4 / 3 |
| 03:45 | Commenced proceeding to YOKOSUKA port | |
| 07:30 | Let go anchor, arrived at YOKOSUKA port, Section No.4 | |
| 08:10 | Scientist (7 person) onboard YOKOSUKA | |
| 08:12 | Scientist (7 person) disembarked, them cmpleted half part of YK21-18C | |
| 08:25 | Heaving anchor, left YOKOSUKA port, Section No.4 | |
| 09:30 | Carried out education & training for scientists | |
| 10:00 | Meeting for 6K dive operation and schedule | |
| 10:40 | Let go anchor, arrived at TATEYAMA Bay | |
| 13:30 | 6K dive operation briefing | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/12 Tue. | Noon Position: 35-04.0N, 139-32.4E (off MISAKI) | bc / North-5 / 3 |
| 07:00 | Heaving anchor, left TATEYAMA Bay | |
| 08:20 | Arrived at research area, off MISAKI | |
| | Hoisted up "SHINKAI 6500" | |
| | Launched | |
| 10:04 | "SHINKAI 6500" dove & started her operation 6K1607 | |
| 10:42 | Landed on the sea floor (D=751m) | |
| 14:41 | Left the sea bottom (D=755m) | |
| 14:58 | Refloated "SHINKAI 6500" | |
| | Hoisted up | |
| 15:45 | Recovered "SHINKAI 6500" & Finished above operation | |
| 18:15 | Let go anchor, arrived at off ITO port | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/13 Wed. | Noon Position: 35-00.8N, 139-13.2E (off HATSUSHIMA) | o / NE-5 / 3 |
| 07:30 | Heaving anchor, left off ITO port | |
| 09:45 | Hoisted up "SHINKAI 6500" | |
| 09:50 | Launched | |

| | | |
|---|---|---|
| 09:59 | "SHINKAI 6500" dove & started her operation 6K1608 | |
| 10:35 | Landed on the sea floor (D=992m) | |
| 15:39 | Left the sea bottom (D=790m) | |
| 15:56 | Refloated "SHINKAI 6500" | |
| 16:22 | Hoisted up | |
| 16:33 | Recovered "SHINKAI 6500" & Finished above operation | |
| 17:45 | Let go anchor, arrived at off ITO port | |
| 19:00 | Research meeting | |
| | | |
| 2021/10/14 Thu. | Noon Position: 34-59.1N, 139-06.2E (off ITO port) | bc / NE-2 / 2 |
| 07:10 | Bridge meeting | |
| 17:40 | Bridge meeting | |
| 18:00 | Research meeting | |
| | | |
| 2021/10/15 Fri. | Noon Position: 35-00.8N, 139-13.3E (off HATSUSHIMA) | bc / NNE-2 / 2 |
| 07:30 | Heaving anchor, left off ITO port | |
| 09:43 | Hoisted up "SHINKAI 6500" | |
| 09:50 | Launched | |
| 10:00 | "SHINKAI 6500" dove & started her operation 6K1609 | |
| 10:38 | Landed on the sea floor (D=991m) | |
| 14:48 | Left the sea bottom (D=951m) | |
| 15:11 | Refloated "SHINKAI 6500" | |
| 15:35 | Hoisted up | |
| 15:44 | Recovered "SHINKAI 6500" & Finished above operation | |
| 16:20 | Commenced proceeding to YOKOSUKA port, Section No.4 | |
| 19:00 | Research meeting | |
| 19:30 | Let go anchor, arrived at YOKOSUKA port, Section No.4 | |
| | | |
| 2021/10/16 Sat. | Noon Position: 35-19.1N, 139-39.0E (JAMSTEC) | - / --- / - |
| 07:55 | Heaving anchor, left YOKOSUKA port, Section No.4 | |
| 09:00 | Sent out 1st shore line, arrived at JAMSTEC | |
| 18:00 | Research meeting | |

| | | |
|---|---|---|
| | | |
| 2021/10/17<br>Sun. | | |
| 15:00 | Scientists disembarked, then completed voyage YK21-18C | |
| | | |

## ● 5. Notice on Using

This cruise report is a preliminary documentation as of the end of cruise.
This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications). This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.
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http://www.godac.jamstec.go.jp/darwin/explain/1/e#report
E-mail: submit-rv-cruise@jamstec.go.jp