

R/V Yokosuka “Cruise Report”

YK22-09C

In-situ monitoring and long-term explosion test of cement
mortar specimen at a deep sea condition and fundamental
strength evaluation of sub-seafloor

May 12th, 2022 –18th, 2022

Nankai Trough Northern Margin

Off Shimizu

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

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1. Participants aboard

1-1. Research group

Position	Name	affiliation
Chief scientists	TAKAFUMI KASAYA	Japan Agency for Marine-Earth Science and Technology
Deputy scientists	SHUN NOMURA	Japan Agency for Marine-Earth Science and Technology
Scientists	TOSHIRO YAMANAKA	Tokyo University of Marine Science and Technology
Scientists	KEISUKE TAKAHASHI	Mitsubishi UBE cement corporation
Scientists	YUICHIRO KAWABATA	Port and Airport Research Institute
Scientists	HIROKO MAKITA	Tokyo University of Marine Science and Technology
Scientists	MARI KOBAYASHI	UBE Corporation
Scientists	MANA YASUI	Waseda University
Marine technician	TOSHIMASA NASU	Nippon Marine Enterprises, LTD.

1-2. SHINKAI6500 Operation Team

Position	Name
Submersible Tec. Manager	KAZUHIRO CHIBA
1st Submersible Staff	TOMOE KONDO
1st Submersible Staff	AKIHISA ISHIKAWA
1st Submersible Staff	FUMITAKA SAITO
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	DAIKI ICHINOSE
3rd Submersible Staff	KAISEI SATO

1-3. Captain and crew of the R/V Yokosuka

Position	Name
Captain	TAKAFUMI AOKI
Chief Officer	TETSUO SHIRAYAMA
2nd Officer	TATSUYA NOZAWA
Jr.2nd Officer	TOMOYUKI TAKAHASHI
3rd Officer	DAISUKE MORIYA
Jr.3rd Officer	YUTO OBATA
Chief Engineer	TAKASHI OTA
1st Engineer	KENICHI SHIRAKATA
2nd Engineer	KOTA FUJII
3rd Engineer	KOHSUN IKEZAKI
Chief Electronic Op.	TOKINORI NASU
2nd Electronic Op.	TAKATOMO SHIROZUME
3rd Electronic Op.	KEISUKE OI
BoatSwain	YOSUKE KUWAHARA
Quarter Master	TSUYOSHI CHIMOTO
Quarter Master	SHINYA KOJIMA
Quarter Master	KENTA NASU
Quarter Master	TOSHIYA SAGA
Sailor	RYO NAKANISHI
Sailor	SHINNOSUKE INOUE
No.1 Oiler	KATSUYUKI YOSHIDA
Oiler	MASAYUKI FUJIWARA
Assistant Oiler	MASAKAZU ISHIDA
Assistant Oiler	TSUYOSHI UCHIYAMA
Assistant Oiler	HARUKI MATSUMOTO
Chief Steward	YUKIHIDE CHIKUBA
Steward	TSUYOSHI NAGATOMO
Steward	SEIJI HONDA
Steward	KANJURO MURAKAMI
Steward	TSUGUMI TANAKA

2. Cruise Summary

2-1. Cruise Information

- Cruise ID: YK22-09C
- Name of vessel: S/V Yokosuka
- Chief Scientist: Takafumi Kasaya (JAMSTEC)
- Title of cruise proposal:

In-situ monitoring and long-term explosion test of cement mortar specimen at a deep sea condition and fundamental strength evaluation of sub-seafloor

- Cruise period: May 12th –18th 2022
- Ports of departure /arrival: JAMSTEC-Yokosuka / JAMSTEC-Yokosuka
- Research area: Northern area of Nankai trough and Off Shimizu
- Research area and track map: Fig. 1

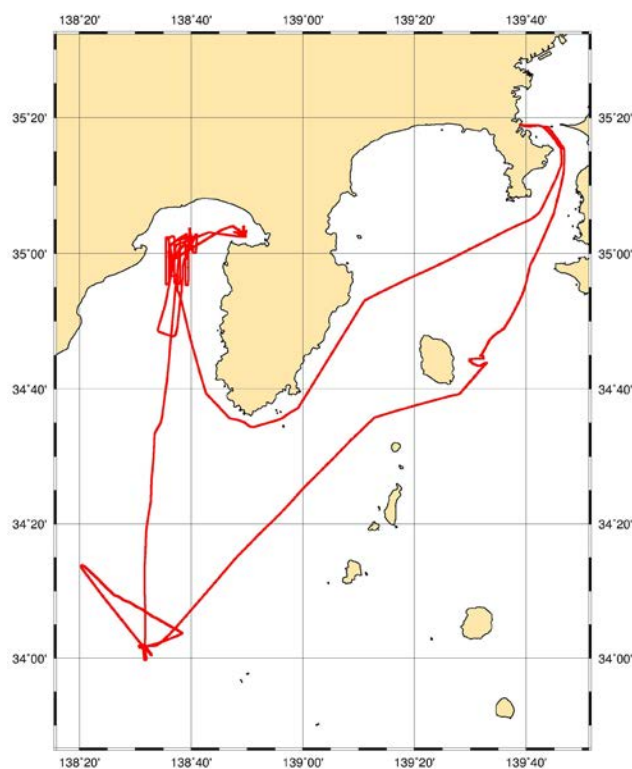


Fig. 1 Track map of YK22-09C Cruise.

2-2. Overview of the Observation

We have been conducting in-situ measurements and long-term exposure tests of concrete and mortar specimens in deep water at the depth of about 3500 m since 2018. In this cruise, various small specimen sets were set up for new long-term exposure tests on some small platform at a depth of about 1000 m. As new experiments, we conducted CPT observations for seafloor foundation strength evaluation and in-situ mortar material bonding tests (Fig. 2). The mortar material bonding test was conducted to six pairs of mortar materials using bonding injector tools. One pair was recovered on the next day dive and was confirmed to have been firmly bonded. We also carried out the same recovery and deployment operation of these specimens for long-term exposure test and in-situ measurement equipment as before (Fig. 3). The hydraulic and strain data from the in-situ instrumentation was also obtained with one year, and we plan to analyze the data as well as confirm the deterioration of the concrete materials.

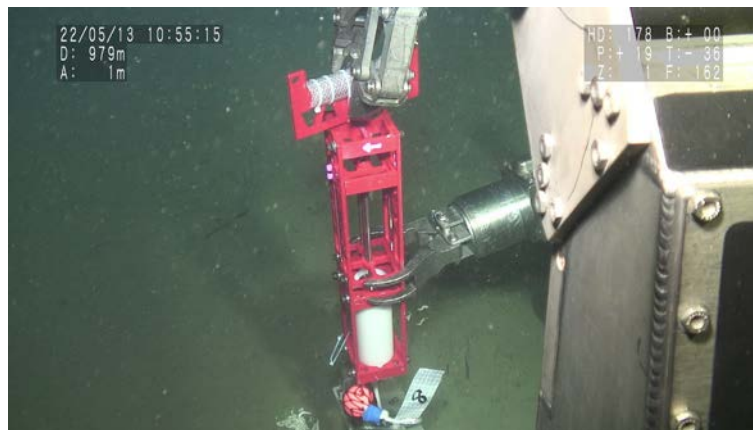


Fig. 2 Photo of the in-situ jointing test operation using injection tools and test mortar materials.

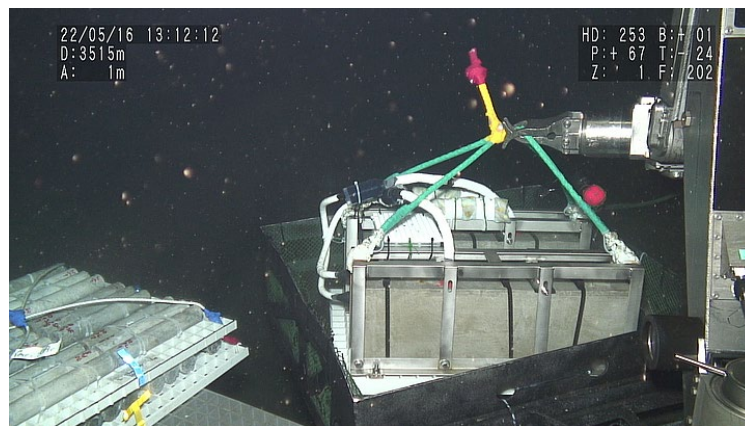


Fig. 3 Recovery operation of in-situ strain and hydraulic pressure monitoring instrument.

3. Cruise Log

日付 Date	時間 Local Time	内容 Note	特記事項 Description	本船位置／気象／海象 Position/Weather/Wind/Sea condition
12-May-22	08:00	Scientists onboarded.		12:00 (UTC+9h)
	09:00	Let go all share line and left YOKOSUKA for research area.		34-54.9N,139-15.5E
	09:30 - 10:30	Carried out education and training for scientists.		SAGAMI WAN
	10:30 - 11:00	SHINKAI 6500 team and Scientists team meeting.		Weather:o (Overcast)
	13:00 - 14:30	SHINKAI 6500 team and Scientists team briefing.		Wind:North-1(Light air)
	15:47	Arrived at research area(SAGAMI WAN).and Released XBT.	34-56.0772N,138-37.5840E	Wave scale:1 (Calm [Rippled])
	16:11 - 16:43	Carried out MBES site survey.		Swell scale:1 (Low Swell Short or Average)
	18:00 - 19:00	Scientists meeting.		Visibly: 6'
13-May-22	08:58	Hoisted up "SHINKAI6500".		12:00 (UTC+9h)
	09:05	Launched "SHINKAI6500".		34-58.8N,138-36.4E
	09:12	"SHINKAI6500" dove, and started her operation dive No.1628.		OFF SHIMIZU
	10:00	"SHINKAI6500" landed the sea	Depth =978m	Weather:r (Rain)

		bottom.		
	13:33	"SHINKAI6500" left the sea bottom.	Depth =996m	Wind:NE-4(Moderate breeze)
	13:58	Refloated "SHINKAI6500"		Wave scale:3 (Slight)
	14:16	Hoisted up "SHINKAI6500".		Swell scale:2 (Low Swell Long)
	14:24	Recovered "SHINKAI6500",and finished above operation.		Visibly: 2'
	15:21	Com'ced MBES and SBP mapping survey.		
	21:00	Finished MBES and SBP mapping survey.		
	18:00 - 18:30	Scientists meeting.		
14-May-22	09:00 - 11:00	SHINKAI 6500 tour for scirntists.		12:00 (UTC+9h)
	18:00 - 18:30	Scientists meeting.		34-58.1N,138-36.6E
				SURUGA WAN
				Weather:c (Cloudy)
				Wind:SW-4(Moderate breeze)
				Wave scale:4 (Moderate)
				Swell scale:4 (Moderate Average)
				Visibly: 7'
15-May-22	09:50	Hoisted up "SHINKAI6500".		12:00 (UTC+9h)
	09:57	Launched "SHINKAI6500".		34-59.0N,138-36.5E

	10:04	"SHINKAI6500" dove, and started her operation dive No.1629.		OFF SHIMIZU
	10:45	"SHINKAI6500" landed the sea bottom.	Depth =996m	Weather:bc (Fine but cliudy)
	16:35	"SHINKAI6500" left the sea bottom.	Depth =970m	Wind:Calm-0(Calm [Glassy])
	16:56	Refloated "SHINKAI6500"		Wave scale:1 (Calm [Rippled])
	17:15	Hoisted up "SHINKAI6500".		Swell scale:1 (Low Swell Short or Average)
	17:23	Recovered "SHINKAI6500",and finished above operation.		Visibly: 1'
	19:00 - 19:30	Scientists meeting.		
16-May-22	00:00	Left Off SHIMIZU research area,for NANKAI torough research area.		12:00 (UTC+9h)
	05:00	Arrived at NANKAI torough research area.		34-01.6N,138-31.4E
	06:56	Released XBT	34-01.6279N,138-30.9712E	North NANKAI trough
	09:52	Hoisted up "SHINKAI6500".		Weather:r (Rain)
	09:59	Launched "SHINKAI6500".		Wind:NNE-4(Moderate breeze)
	10:06	"SHINKAI6500" dove, and started her operation dive No.1630.		Wave scale:3 (Slight)
	11:49	"SHINKAI6500" landed the sea bottom.	Depth =3,517m	Swell scale:1 (Low Swell Short or Average)
	15:41	"SHINKAI6500" left the sea bottom.	Depth =3,517m	Visibly: 6'
	16:53	Refloated "SHINKAI6500"		
	17:09	Hoisted up "SHINKAI6500".		

	17:18	Recovered "SHINKAI6500",and finished above operation.		
	19:00 - 19:30	Scientists meeting.		
17-May-22	10:07	Hoisted up "SHINKAI6500".		12:00 (UTC+9h)
	10:15	Launched "SHINKAI6500".		34-01.7N,138-31.4E
	10:22	"SHINKAI6500" dove, and started her operation dive No.1631.		North NANKAI trough
	12:04	"SHINKAI6500" landed the sea bottom.	Depth =3,515m	Weather:o (Overcast)
	15:33	"SHINKAI6500" left the sea bottom.	Depth =3,507m	Wind:NNE-1(Light air)
	16:53	Refloated "SHINKAI6500"		Wave scale:1 (Calm [Rippled])
	17:13	Hoisted up "SHINKAI6500".		Swell scale:1 (Low Swell Short or Average)
	17:23	Recovered "SHINKAI6500",and finished above operation.		Visibly: 6'
	18:00	Left research area for YOKOSUKA.		
	19:00 - 19:30	Scientists meeting.		
18-May-22	09:00	Arrived at YOKOSUKA. Finished YK21-09C Cruise.		

4. Observation and Activity results

4-1. MBES survey

For collecting the detailed geographical character around new dive site off Shimizu, we obtained the bathymetric data and sub-bottom data using shipboard equipment (see Appendix). Figure 2 and 3 show the survey tracks and preliminary bathymetry map, respectively. In this cruise, these data were collected with about 8 knots ship speed.

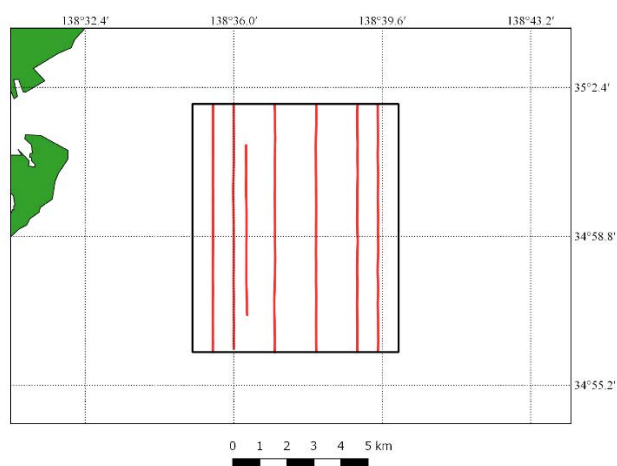


Fig. 2 MBES survey tracks.

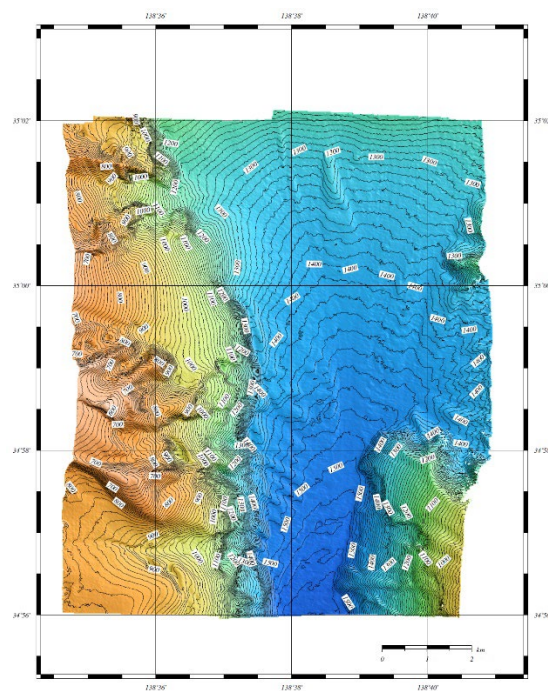


Fig. 3 Preliminary result of MBES survey.

4-2. Dive logs

● Dive 1628

Dive No.: # 1628

Date: 13/5/2022

Dive area: off Shimizu (34°58.9'N, 138°36.5'E, 980 m in depth)

Time of arriving the bottom: 10:00 (JST)

Time of leaving the bottom: 13:34 (JST)

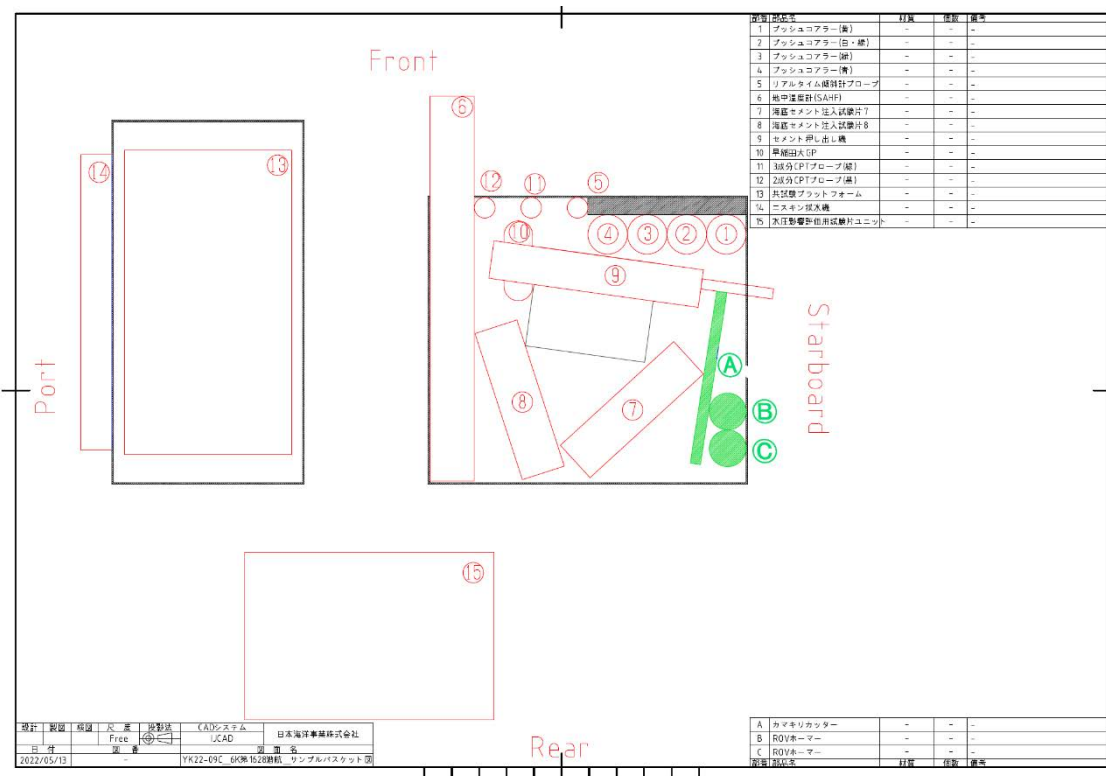
Observer: Toshiro Yamanaka

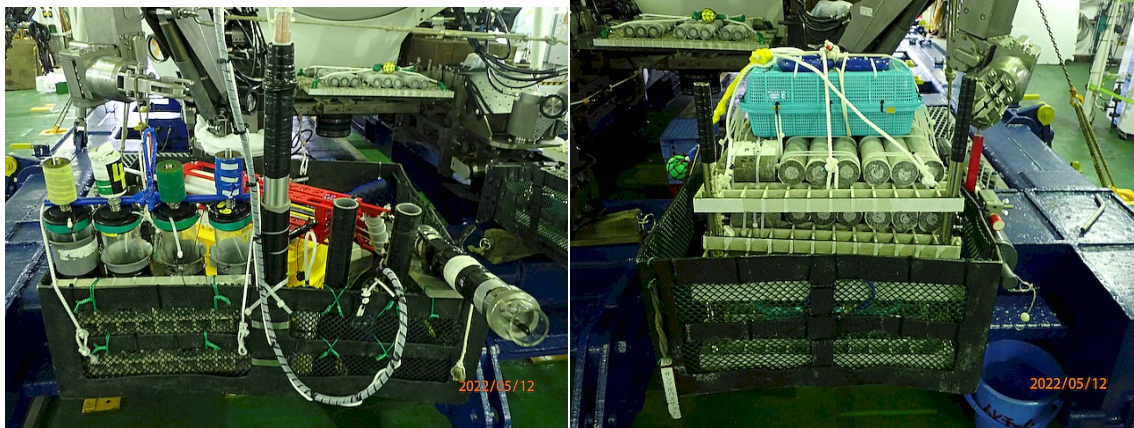
Pilot: Ishikawa, Kuramoto

Purpose of dive:

1. deploy of a platform with a set of testing materials
2. in situ jointing test of concrete blocks
3. field tests of two CPT probes and a real-time monitoring clinometer
4. observation for the structure of surface sediment using a sub-bottom profiler
5. sampling of bottom seawater and sediment cores

Payload:

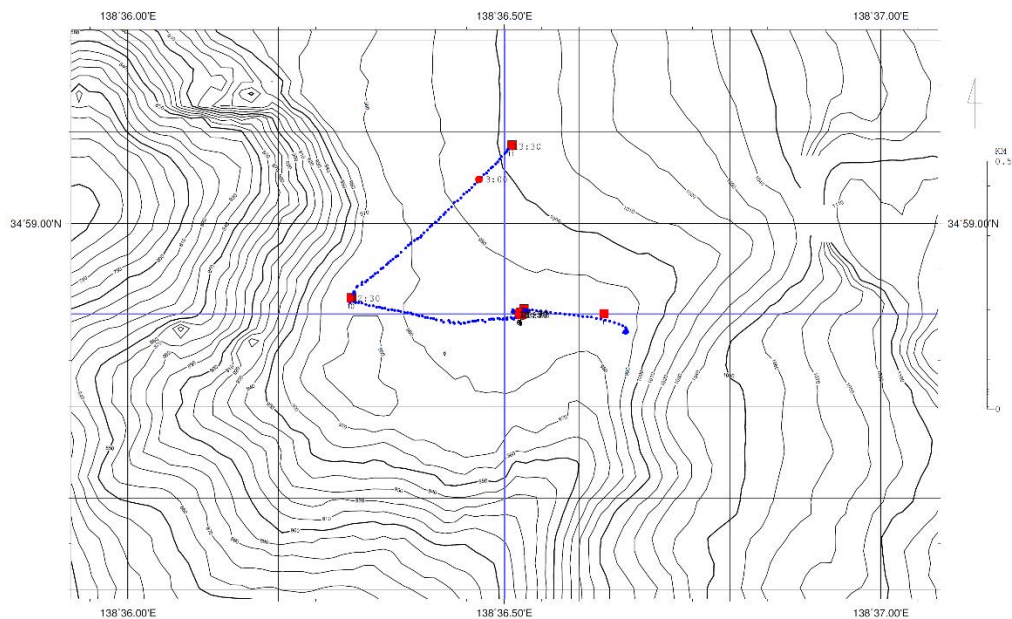




Dive summary:

Before just landing on seafloor bottom seawater was sampled using a Niskin bottle at depth 960 (altitude 20 m). Any artificial disturbance was not observed on the seafloor after a few minutes' observation, then we made a landing on the seafloor near the point #2. At there the platform was deployed, and two boards attached testing materials were stacked on it. Another testing material (WGP) was deployed beside the platform. After about 5 m slide to south the jointing test of concrete blocks, deploying SAHF, penetrating CPT probes and clinometer were done. After that, we started the observation of sub-bottom profiler and moved to the point #6 via the point #4. At those points deploying SAHF, penetrating CPT probes and clinometer were done.

Track and points of operation:



● Dive 1629

Dive No.: # 1629

Date: 15/5/2022

Dive area: off Shimizu (34°58.9'N, 138°36.5'E, 980 m in depth)

Time of arriving the bottom: 10:30 (JST)

Time of leaving the bottom: 16:30 (JST)

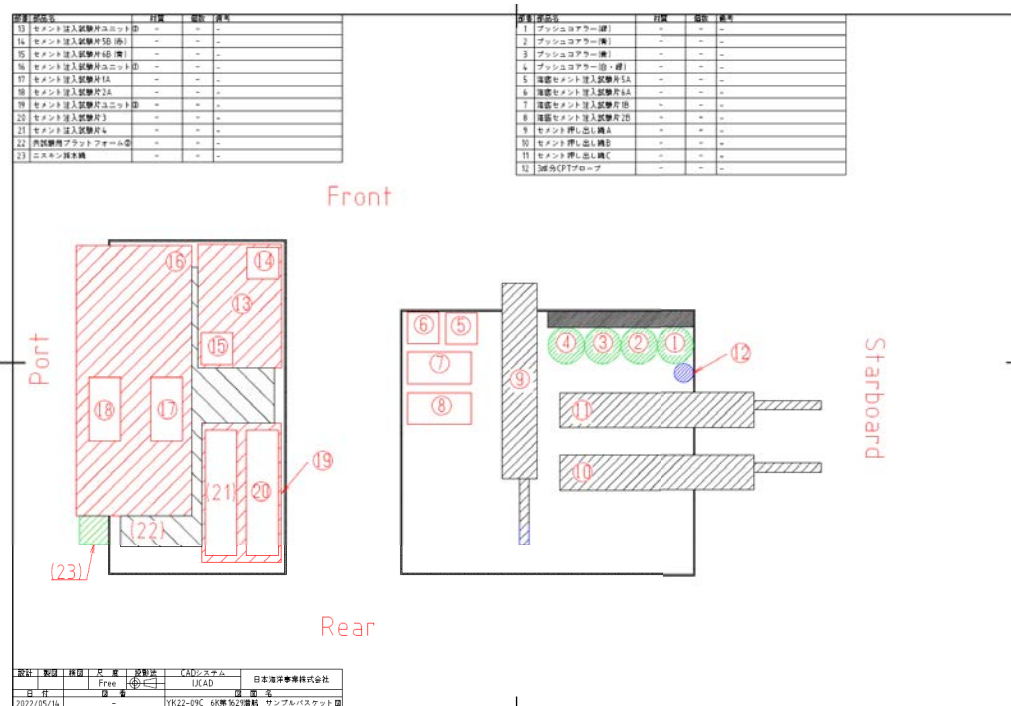
Observer: Keisuke Takahashi

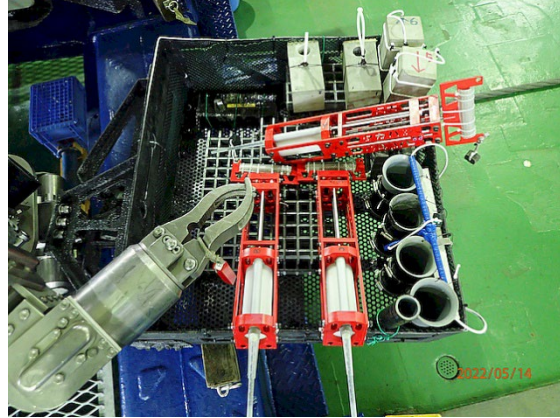
Pilot: Onishi, Saito

Purpose of dive:

1. deploy of a platform with a set of testing materials
2. in-situ joint/injection test of mortar blocks
3. field tests of two CPT probes and a real-time monitoring clinometer
4. observation for the structure of surface sediment using a sub-bottom profiler
5. sampling of bottom seawater and sediment cores

Payload:

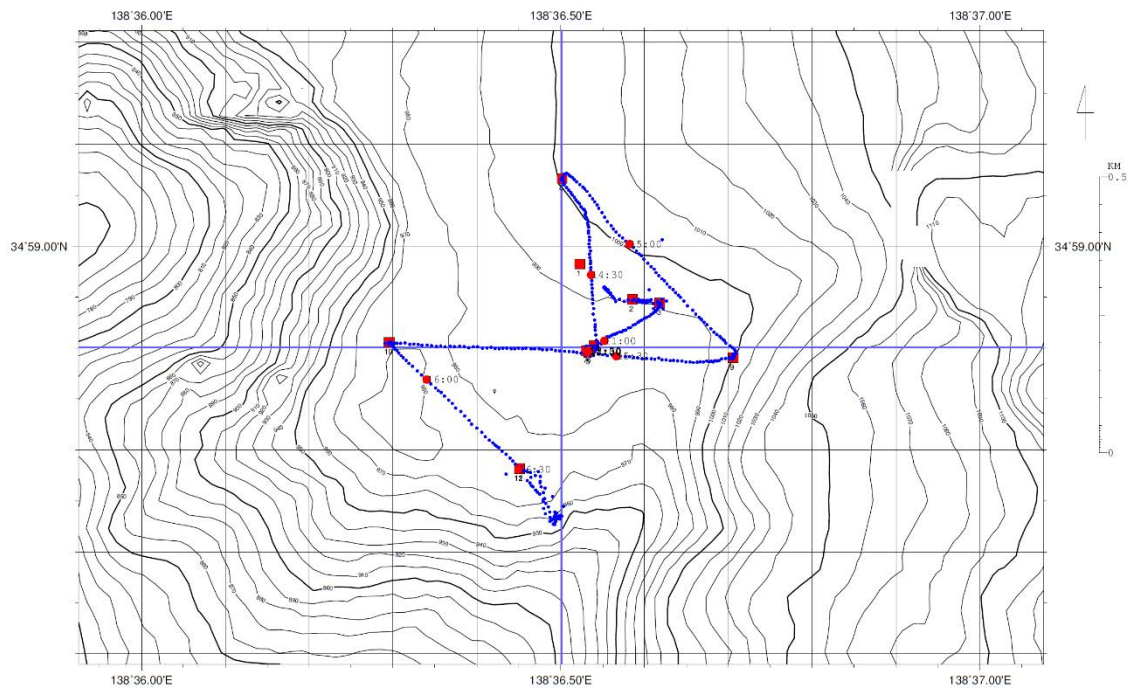




Dive summary:

Before just landing on seafloor bottom seawater was sampled using a Niskin bottle at depth 960 (altitude 20 m). Any artificial disturbance was not observed on the seafloor after a few minutes' observation, then we made a landing on the seafloor 100 m northeast from the point #2. At there the platform was deployed, in-situ joint/injection test using 6 different types of mortar blocks. Two blocks casted at the dive #1628 was retrieved. At the point #2, penetration of CPT probes was done. Then started observation of sub-bottom profiler and moved to the point #6, #3, #4 and then #5. At each point, penetrating CPT probes and clinometer were done.

Track and points of operation:



● Dive 1630

Dive No.: # 1630

Date: 16/5/2022

Dive area: Nankai Trough North Edge (34°1.8'N, 138°31.6'E, 3516 m in depth)

Time of arriving the bottom: 11:49 (JST)

Time of leaving the bottom: 15:41 (JST)

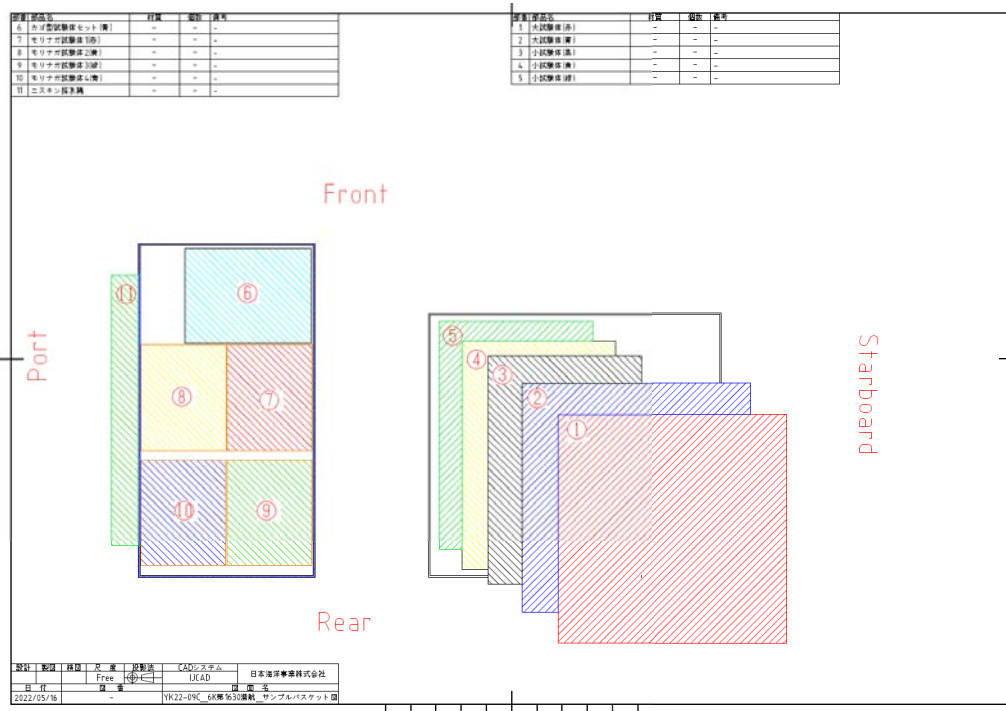
Observer: Takafumi Kasaya

Pilot: Suzuki, Saigo

Purpose of dive:

6. deploy of some set of testing materials
7. recovery of an in-situ monitoring instrument
8. observation for the structure of surface sediment using a sub-bottom profiler
9. sampling of bottom seawaters

Payload:

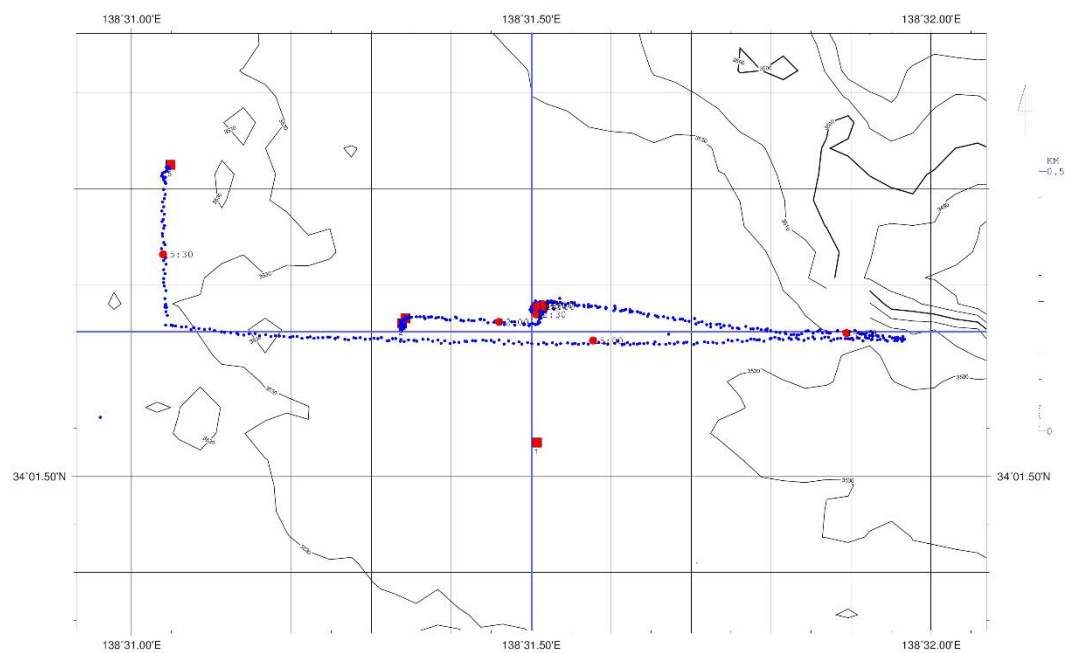




Dive summary:

Before landing on sea bottom, a seawater sample was obtained using Niskin bottles at depth 3494 m. We started to move the point #2 and our long-term exposure platform was found easily within 15 minutes. Observing samples and instrument on the platform, we landed on the edge of the platform. In this dive, recovery and deployment operation of some concrete and mortar specimens in the orange plastic case were carried out, and other specimens on FRP gratings and in a blue plastic case also set up. We also recovered the in-situ monitoring instrument which set up by the ROV dive last year. Finishing all operation on the platform, subsurface structure data were acquired on a survey line centered on the platform using a sub-bottom profiler.

Track and points of operation:



● Dive #1631

Dive No.: # 1631

Date: 17/5/2022

Dive area: Nankai Trough North Edge (34°1.8'N, 138°31.6'E, 3516 m in depth)

Time of arriving the bottom: 12:00 (JST)

Time of leaving the bottom: 15:30 (JST)

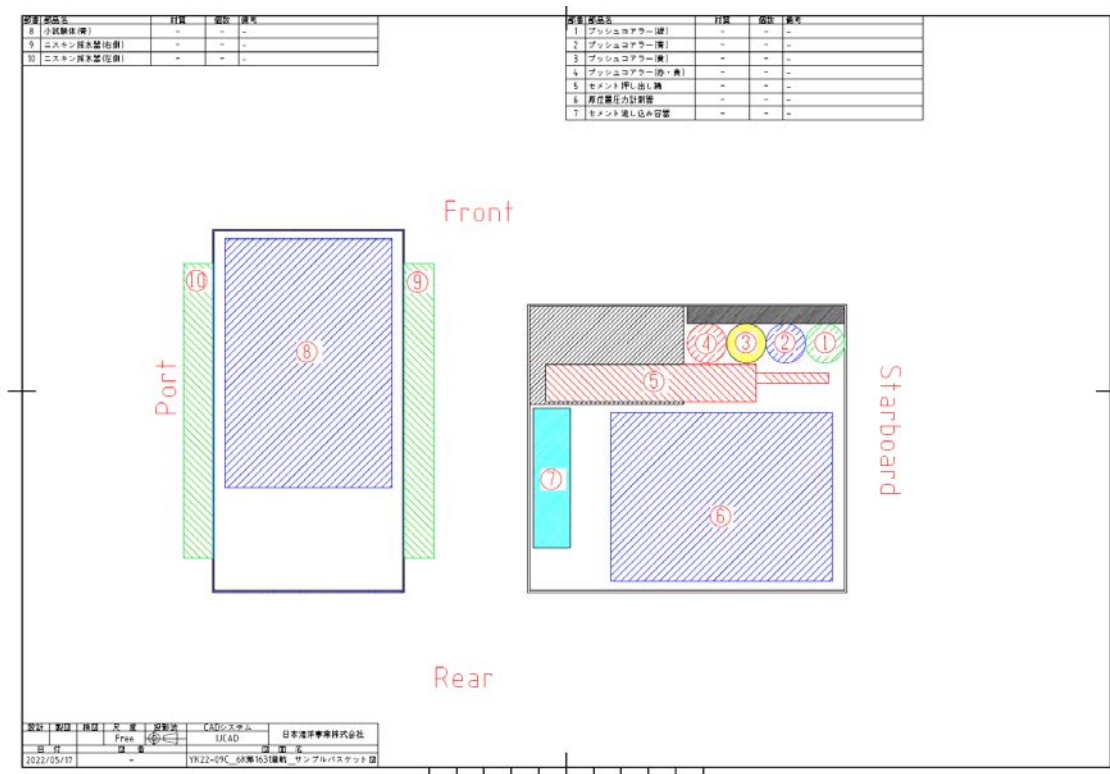
Observer: Yuichiro Kawabata

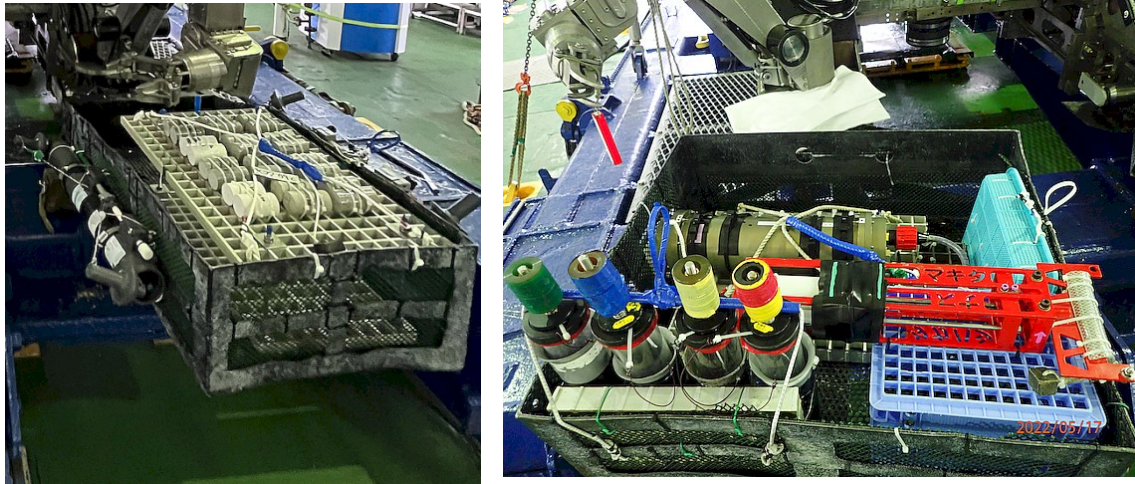
Pilot: Saito, Iijima

Purpose of dive:

10. deploy of a platform with a set of testing materials
11. in-situ injection test on plastic bottles
12. sampling of bottom seawater and sediment cores

Payload:

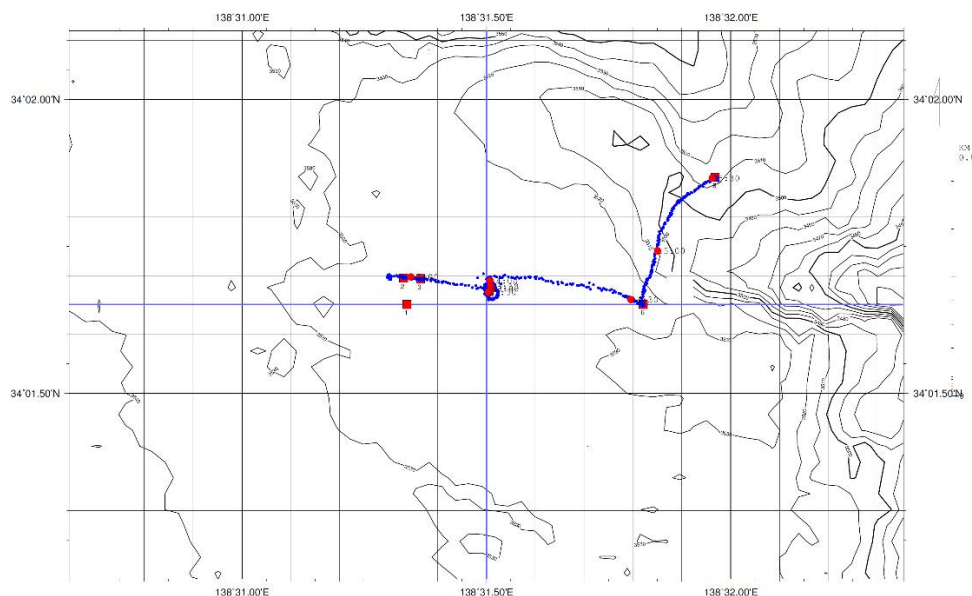




Dive summary:

Before just landing on seafloor bottom seawater was sampled using Niskin bottles at depth 3457. Any artificial disturbance was not observed on the seafloor after a few minutes' observation, then we made a landing on the seafloor at the point #2. Then the cylinder specimens connected with a data logger for measuring the pressure were deployed on the existing large platform. Afterwards, a set of testing materials was deployed on the seafloor approximately 3 m north from the existing large platform. Then cement paste was injected to the plastic bottles, and the bottles with 5 cylinder samples were stacked on the small platform. Then we moved to the points (500, 0) and coring of the sediment was done. The final point was (400, 710) where 2 sediment cores were taken.

Track and points of operation:



5. Acknowledgements

I am deeply thanking for the captain and all ship crews of S/V Yokosuka. We are grateful to the SHINKAI 6500 operation team and marine technicians of NME for their operation. We are pleased to MarE3 staff for their special supports.

6. 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.

Users of information on this report are requested to submit Publication Report to JAMSTEC.

<http://www.godac.jamstec.go.jp/darwin/explain/1/e#report>

E-mail: submit-rv-cruise@jamstec.go.jp

Appendix 1

SHINKAI 6500

SHINKAI 6500 is Human Operated Vehicle (HOV). The HOV navigation consists of two sub-system, SSBL(Super Short Base Line) and LBL(Long Base Line).

INS and DVL data logged in slc format include status of HOV, there are acoustic sonar equipments, temperature gauge and CTD sensor.

The general specifications of SHINKAI 6500

Length	9.7 m
Width	2.7 m
Height	4.1 m
Weight	27 t
Maximum operation depth	6,500 m
Speed(Cruising)	– 2.7kt
Speed(Seafloor Observation)	– 1.0knot
Positioning	SSBL/LBL

Forward Looking sonar

Frequency	105~120kHz
Detection range	6,20,60,200,600,1000m
Angle of traverse	360°

CTD/DO

The general specifications of SeaBird Electronics SBE19/SBE43

Measurement range	-5 to + 35 °C
	0 to 70 mS/cs
	0 to 15,000 psia
Initial accuracy	0.01 °C
	0.01 mS/cm
	0.015% full scale
	0.01 ml/l

INS (Inertial Navigation System)

Measurement range	$\pm 180^\circ (\Phi)$ 、 $\pm 90^\circ (\theta)$
Initial accuracy	$0.1^\circ \times 1/\cos(\text{Lat})$

Current Direction / Speed Meter

Measurement range (Speed)	0 – 6 kt
(Direction)	0 – 360 °
Initial accuracy (Speed)	2cm/sec (0-40 cm/sec)、5% FS(40-300 cm/sec)
(Direction)	5° (22.5-300m/sec)

Depth meter

Type	Crystal oscillator
Measurement range	0 – 133.8MPa
Initial accuracy	0.01 FS

Altimeter

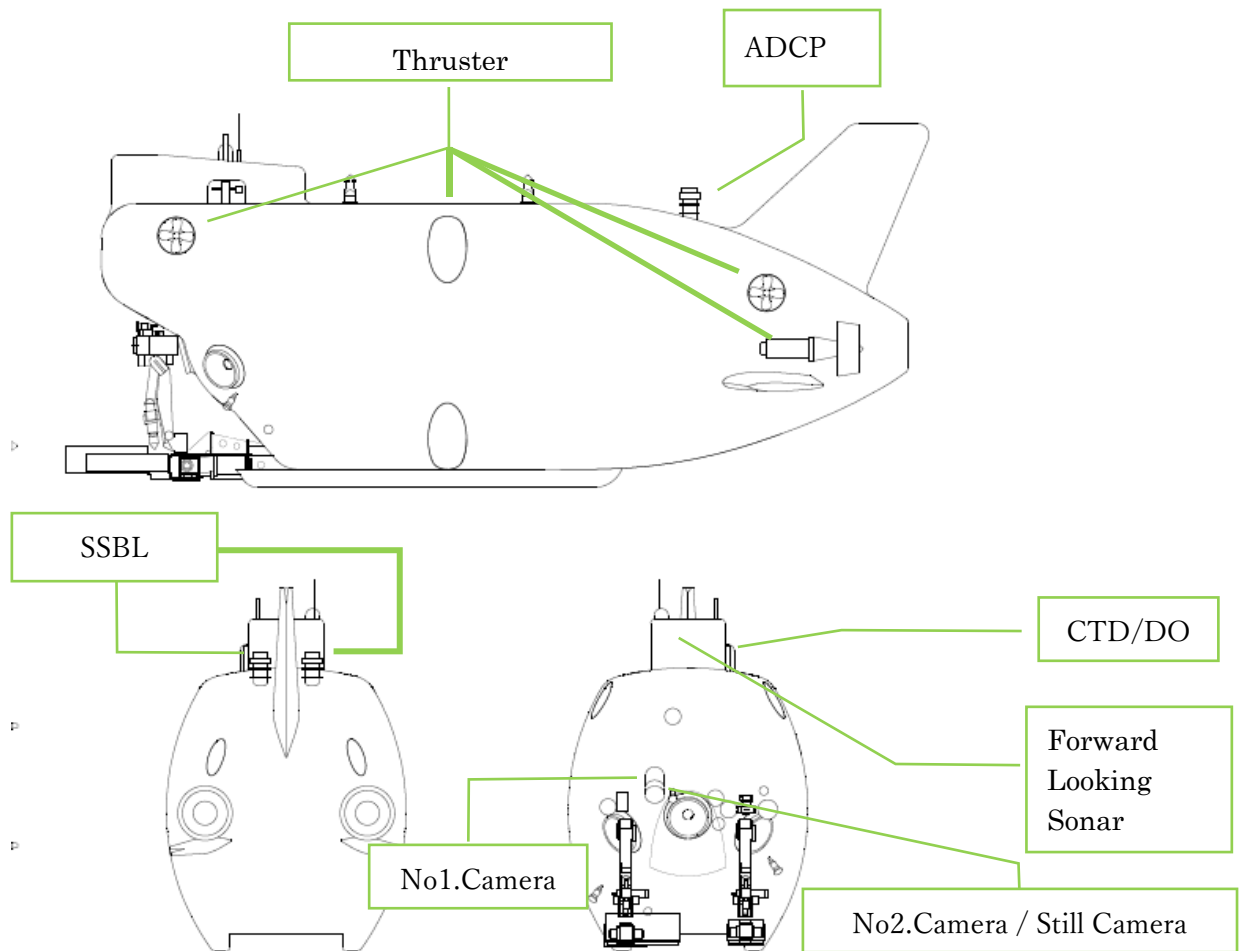
Frequency	14.829 kHz
Measurement range	2 – 1000m

ADCP

Frequency	300 kHz
Measurement range	– 128m

Temperature gauge

Measurement range	0 – 400 °C
Initial accuracy	0.15 °C (0 – 100°C)
	0.03 °C (100 – 400°C)



Appendix 2

Research Vessel YOKOSUKA

R/V YOKOSUKA was originally designed to serve as the mother vessel for SHINKAI 6500. Since the construction of an autonomous underwater vehicle (AUV), URASHIMA, YOKOSUKA has been shared by SHINKAI and URASHIMA. It has silent engine, an advanced acoustic navigation system and an underwater telephone for its state of the art operations. There are 5 laboratories on Yokosuka, No.1-No.4 laboratories and No.1 Study room. No.1 Lab. has dry space. The permanent installations are PC and a printer. No.2 Lab. has semi-dry and wet space. There are two freezers (-40 & -80 deg.C), an incubator, a Milli-Q, and a fumigation chamber at dry one, and wet one. No.3 Lab. has dry space with storage. No.4 Lab. has semi-dry and wet space. There are a rock saw and a Milli-Q. No.1 Study room has dry space, there are a gravity meter, a data acquisition system of gravity meter, a three-axis fluxgate magnet-meter and also a proton magnet-meter, a work station for data processing, and a A0 size plotter.

The general specifications of R/V YOKOSUKA

Length overall	105.2 m
Beam overall	16.0 m
Depth	7.3 m
Draft	4.5 m
Gross tonnage	4,439 tons
Service speed	16knot
Main propulsion system Diesel engines	2,206kW x 2
Main propulsion method	Controllable pitch propeller x 2

Complement

Crew	28 persons
Submersible operation staff	8 persons
Researchers	15 persons
Total 51 persons	

R/V YOKOSUKA MBES / SBP / magnetometers / gravity meter

YOKOSUKA is equipped with various kinds of underway geophysical equipment, a multi narrow beam echo sounder (EM122, Kongsberg Maritime, Inc.), a gravity meter (Type S-63, LaCoste & Romberg Gravity Meters Inc.), a ship borne three-axis magnet-meter (Type SFG-1212, Tierra Technica Inc.), and a proton magnet meter (Type STC 10, Kawasaki Geological Engineering Co., Ltd.). The specifications of these instruments are listed below.

The specifications of Multi-Beam Echo Sounder (EM122, Kongsberg Maritime, Inc.)

Measurement depth (m)	20 ~ 11,000
Measurement frequency (kHz)	12
Measurement method	cross fan beam style
Beam numbers	288
Mesurement point	432
Pulse lengths	2/5/15msec CW(∼2000m) 100msec FM(2000m∼)
Beam width (deg.)	2
Beam interval (deg.)	2
Swath width (deg.)	150 (Max)
Sampling rate (msec.)	0.33
Roll (deg.)	± 15
Pitch (deg.)	± 10
Yaw (deg.)	± 10

The specifications of Sub-Bottom Profiler (3300-HM, EdgeTec Inc.)

Transducers	4 × 4 plane array
Center frequency (kHz)	2 ~ 16
Type of pulse	FM
Band width (kHz)	2 ~ 16
Length of pulse (ms)	5 ~ 100
Resolution	8cm, for 2 ~ 12 kHz
Penetration (m)	6 for sand 80 for soft clay
Width of beam (using 4 × 4 array)	33° for 3.5 kHz 24° for 4.5 kHz 20° for 6 kHz

The specifications of Gravity meter

Measurement range (m Gal)	12,000
Drift	3mGal per month or less
<u>Stabilized platform</u>	
Platform pitch(deg.)	± 22
Platform roll(deg.)	± 25
Platform period(min.)	4 to 4.5
Beam interval(deg.)	1
<u>Control system</u>	
Recording rate(Hz)	1
Serial out put	RS-232
<u>System performance</u>	
Resolution (mGal)	0.01
Static repeatability (mGal)	0.05
50,000m Gal horizontal acceleration (mGal)	0.25
100,000m Gal horizontal acceleration (mGal)	0.50
100,000m Gal vertical acceleration (mGal)	0.25
Dimension (cm)	$71 \times 56 \times 84$
Weight (kg)	Meter:86, UPS:30

The specifications of three-axis magnet meter

System	ring core fluxgate
Number of component directly	3 axes
Cable length (m)	50
Sensor dimension (mm)	$\phi 280 \times 130H$
Measurement range (nT)	$\pm 100,000$
Resolution (nT)	1

The specifications of Proton magnet meter

Measurement range (nT)	$3 \sim 7 \times 10^{**4}$
Resolution (nT)	0.01
Sampling rate	10sec, 20sec, 1min, manual, external
Time of applying field(sec.)	3 to 10
Sensor dimension (mm)	$\phi 200 \times 1050$
Weight (kg)	28.6(in the air), 6.2(in the sea)