



YOKOSUKA “Cruise Report”
YK23-11

Demonstration of core technologies for a hadal vehicle
system without an umbilical cable

Off Boso Peninsula, Sagami Bay

Jun. 30, 2023 - July. 7, 2023

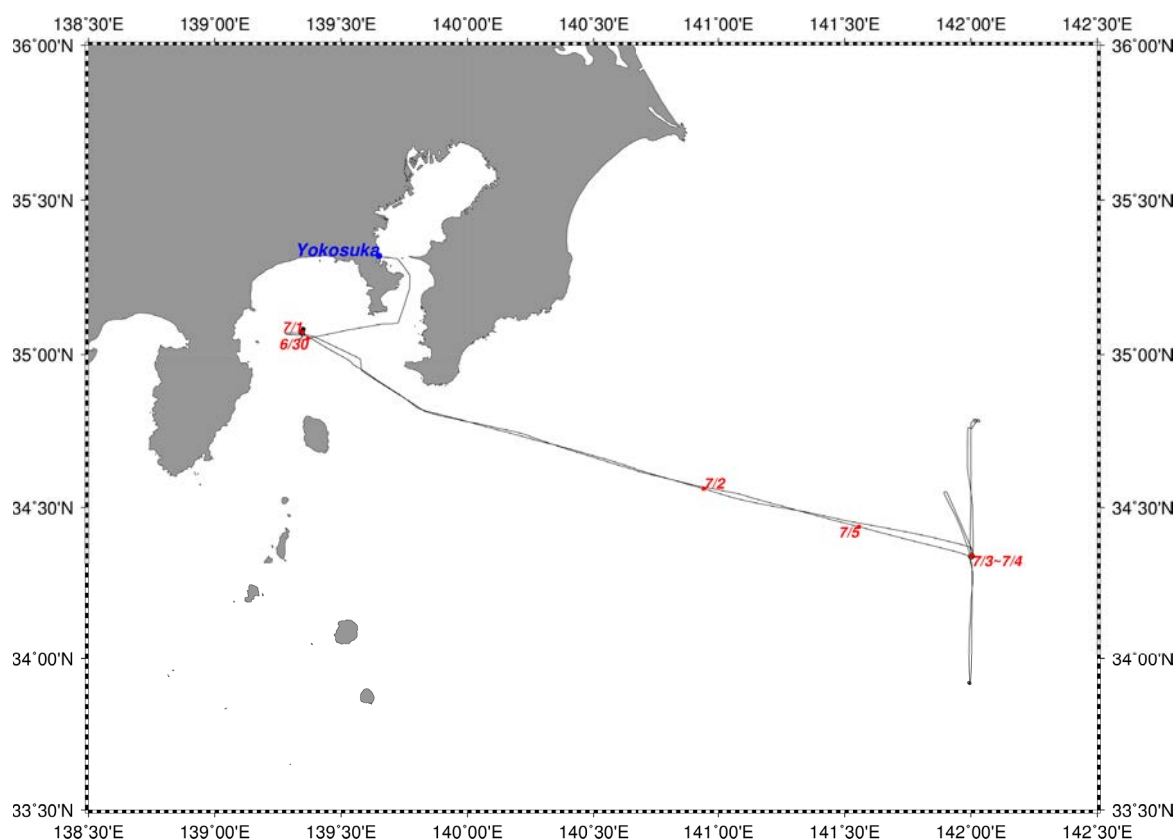
Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

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1. Cruise Information

- Cruise ID: YK23-11
- Name of vessel: R/V YOKOSUKA
- Title of cruise: Demonstration of core technologies for a hadal vehicle system without an umbilical cable
- Chief Scientist [Affiliation]: Yosaku Maeda [JAMSTEC]
- Cruise period: 2023/6/30-2023/7/7
- Ports of departure / call / arrival: Yokosuka (JAMSTEC) - Yokosuka (JAMSTEC)
- Research area: Off Boso Peninsula, Sagami Bay
- Research map:



2. Research Proposal and Science Party

- Representative of Science Party [Affiliation] : Kenji Nagahashi [JAMSTEC]
- Science Party (List) [Affiliation, assignment etc.] :

Yosaku MAEDA	[JAMSTEC (Chief Scientist)]
Hitoshi KAKAMI	[JAMSTEC (Vice Chief Scientist)]
Tatsuya ASO	[JAMSTEC (Vice Chief Scientist)]
Yoshihiro FUJIWARA	[JAMSTEC]
Satoshi KAKIZAKI	[JAMSTEC]
Koji MEGURO	[HITACHI, Ltd.]
Takeshi YAMAMOTO	[IVIS, Inc.]
Shigeo MATSUDA	[Clovertech Inc.]
Ryo KIMURA	[Nippon Marine Enterprises, Ltd.]
Haruki DOI	[Nippon Marine Enterprises, Ltd.]

3. Research/Development Activities

Purpose, background:

To acquire samples on hadal seafloor cost-effectively, we have developed a hadal vehicle system that can automatically find and take samples without umbilical cables connect to mother vessel. In this cruise, demonstration of core technologies for the hadal vehicle system was carried out using a lander “FFC11K” (Fig.1 and Table 1) . The technologies are full-ocean depth acoustic communication, lightweight and high-capacity battery inserted in ceramic pressure housing, real-time object detection, tracking and 3D measuring using a stereo camera, and 3-axis robotic arm using electric servo motor.

Methods, instruments:

Prototypes using these technologies were prepared and installed on FFC11K (Fig.2). The developed battery supplied power to all system in FFC11K. Status of FFC11K when deploying at seafloor was checked on Yokosuka via developed acoustic communication device. Images obtained the stereo camera was used for the image processing. The configuration diagram is shown in Fig.2.

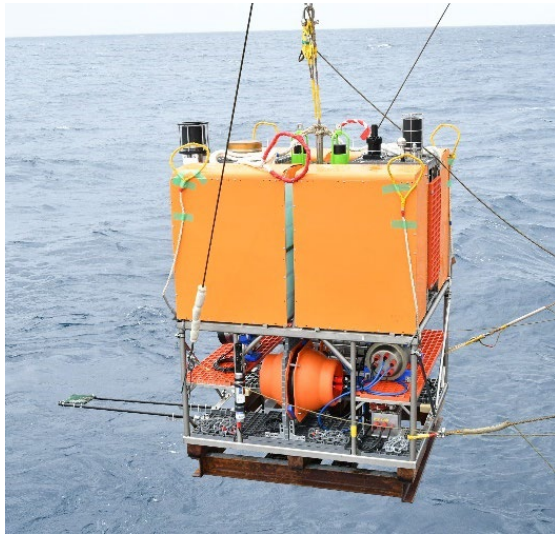


Fig. 1 FFC11K

Table 1 General specification of FFC11K

Size	1.6 × 1.7 × 2.2m
Weight	In air 1.8ton (including anchor) In water 50 kg (including anchor) / -200kg (without anchor)
Max operating depth	11,000m
Descend / Ascend speed	50 m/min
Default equipped devices	
Power	Li-ion Batteries (18650) in Ceramic tube housing 115V, 10.8kWh
Floataion	TG-115001 (Trelleborg)*24
Stand-alone Releaser	Benthos R12K and/ or 865A (parallel)
Acoustic modem	High- speed type (for image transmission) Standard type
Sensors	CTD (SBE49) AHARS HD camera LED light (400W) Iridium beacon, flasher

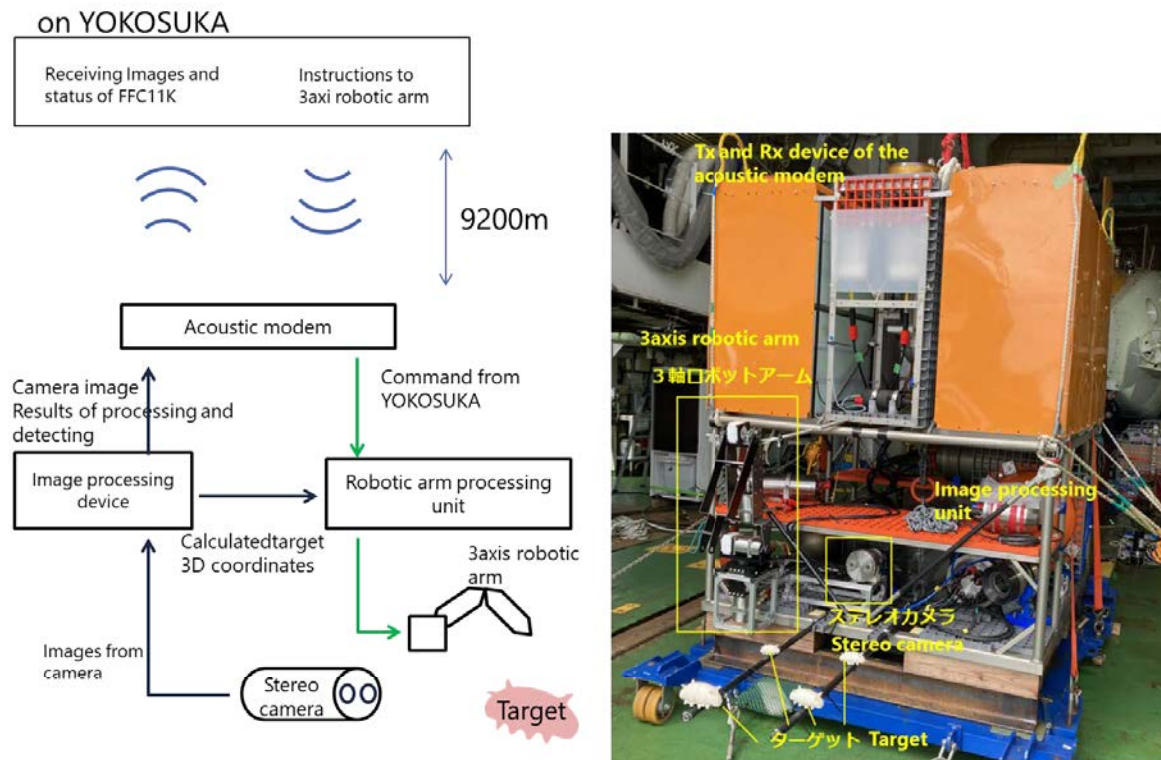


Fig. 2 Test configuration diagram and pictures.

Activities:

Table 3 shows the summary of the development in the cruise. Firstly, we conducted pre-test in shallow water at Sagami Bay. Then, two developments of FFC11K were carried out at Tripple junction off Boso.

Table 3 Summary of the developments in YK23-11 cruise

Deployment No.	date	Cruise ID	Summary	Sea area	Depth by SSBL (m)
FFC#12	2023/6/30-7/1	YK22-13	Tests of acoustic communication, batteries and its ceramic pressure housing, real-time object detection, tracking and 3D measuring using underwater stereo camera system, underwater robotic arm and Maas pumps	Sagami Bay	1446
FFC#13	2023/7/3	YK22-13	Tests of acoustic communication, batteries and its ceramic pressure housing, real-time object detection, tracking and 3D measuring using underwater stereo camera system, underwater robotic arm and Maas pumps	Tripple junction (Boso off)	9217
FFC#14	2023/7/4-5	YK22-13	Tests of acoustic communication, batteries and its ceramic pressure housing, real-time object detection, tracking and 3D measuring using underwater stereo camera system, underwater robotic arm and Maas pumps	Tripple junction (Boso off)	9211

Results:

These devices basically worked well in all deployments. Engineers on YOKOSUKA could confirm in real-time the FFC11K information including status of the target detection through the acoustic communication. Fig.4 indicates the information.



Fig 4 Image of the stereo camera from FFC11K

The robotic arm moved to the targets automatically as shown in Fig.5.

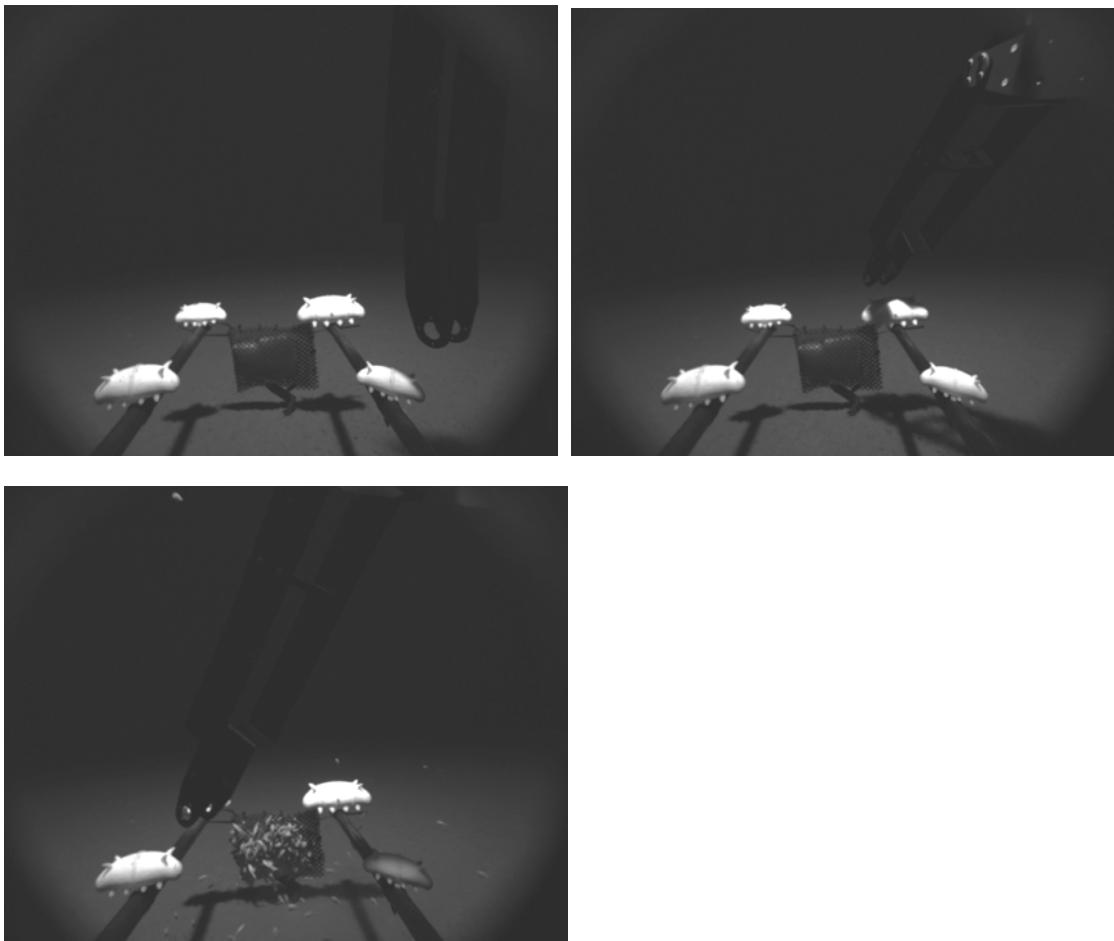


Fig 5 Raw image of the stereo camera when the robotic arm moved to targets.

We were able to obtain the information necessary to evaluate the feasibility of the vehicle concept.

Results of payload in FFC11K:

MASS Pump (large-scale water filtration system)

The “MASS Pump” is a large-scale, *in situ* water filtration system for environmental DNA research. It consists of three units: a filter unit (Sterivex filters with 0.45 μm in pore size installed), a pump unit, and a control unit containing a system controller and a lithium-ion battery (Fig. 1). During this cruise, pumps were equipped on FFC11K for the first time. Two trials of filtration were conducted in Sagami Bay and at Triple Junction. MASS Pump settings and detail filtration results were shown in Table 1 and 2.

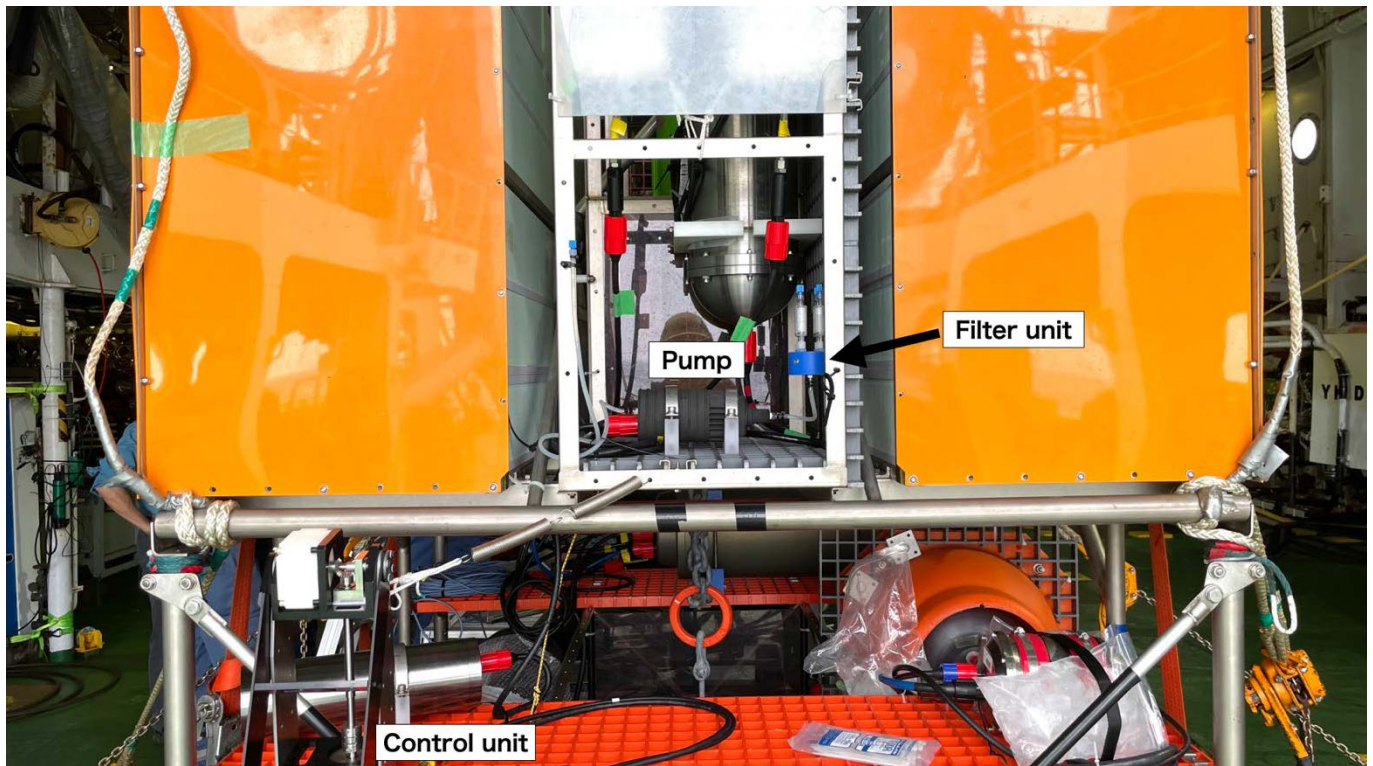


Fig 6. MASS Pump install on FFC11K

Table 1. MASS PUMP CHECK LIST & RESULTS of FFC11K#12

BEFORE DEPLOYMENT			
Deployment date (dd-mmm-yyyy)		30-JUN-2023 13:52	
Location/Target depth (m)		Sagami Bay/1500 m	
Landing time, coordinate, depth		14:22, 35°04.4626'N, 139°21.0124'E, 1446 m	
Cast (dive) number		FFC11K#12	
Start time (hh:mm dd-mmm-yyyy)		02:00 1-JUL-2023	
End time (hh:mm dd-mmm-yyyy)		05:00 1-JUL-2023	
Duration (hh:mm)		3:00	
Pump ID/Controller ID		NO. (N01)/No. (V2F01)	
Time calibration		Yes / ☒ No	
Battery ID/voltage (V)		No. (18)/16.8 V	
Number of filters	4	Bait	Squid
Filter ID(s)		YK2311L1P1- YK2311L1P4	
Inlet height from bottom (cm)		155 cm	
Line cleaning (Washing reagent/duration)		☒ Yes / No (Kitchen Haiter/5 min)	
Installation of air VENT PLUG (FD only)		☒ Yes / No	
Lid CLOSURE		☒ Yes / No	
Underwater CABLE connection		☒ Yes / No	
Filling with purified water		☒ Yes / No	
Removal of tube CAPS (number)		☒ Yes (5) / No	
AFTER RECOVERY			
Tubing Condition		☒ Good / Bad	
Flow meter counter at recovery		810827	
Estimated filtration volume (L)		113.5 L (y=0.00014x)	
Battery voltage (V) at recovery		14.743 V	
Remarks		FFC left bottom at 16:03 on JUL-1-2023 FFC at surface at 16:26 on JUL-1-2023 Filter fixation at 17:07 on JUL-1-2023	
Filter image			

Filtration record

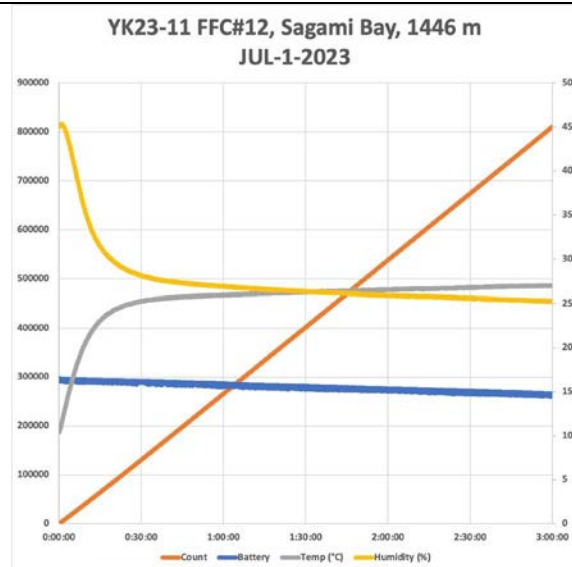
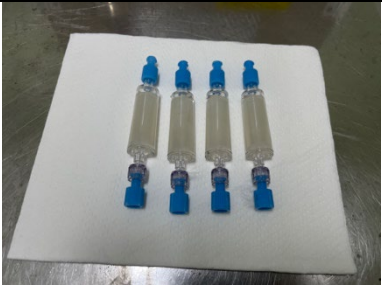
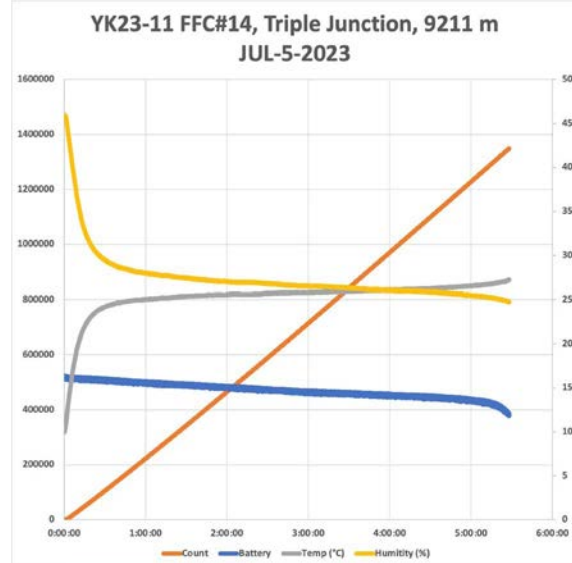


Table 2. MASS PUMP CHECK LIST & RESULTS of FFC11K#14

BEFORE DEPLOYMENT	
Deployment date (dd-mmm-yyyy)	4-JUL-2023 08:17
Location/Target depth (m)	Triple Junction/9200 m
Landing time, coordinate, depth	11:34, 34°20.3976'N, 142°00.0679'E, 9211.0 m
Cast (dive) number	FFC11K#14
Start time (hh:mm dd-mmm-yyyy)	00:00 5-JUL-2023
End time (hh:mm dd-mmm-yyyy)	06:00 5-JUL-2023
Duration (hh:mm)	5:28 (due to voltage decline)
Pump ID/Controller ID	NO. (N01)/No. (V2F01)
Time calibration	Yes / ☒ No
Battery ID/voltage (V)	No. (15)/16.9 V
Number of filters	4
Bait	Squid
Filter ID(s)	YK2311L3P1– YK2311L3P4
Inlet height from bottom (cm)	155 cm
Line cleaning (Washing reagent/duration)	☒ Yes / No (Kitchen Haiter/10 min)
Installation of air VENT PLUG (FD only)	☒ Yes / No
Lid CLOSURE	☒ Yes / No
Underwater CABLE connection	☒ Yes / No
Filling with purified water	☒ Yes / No
Removal of tube CAPS (number)	☒ Yes (5) / No
AFTER RECOVERY	
Tubing Condition	☒ Good / Bad
Flow meter counter at recovery	1,349,377
Estimated filtration volume (L)	188.9 L (y=0.00014x)
Battery voltage (V) at recovery	12.075 V
Remarks	FFC left bottom at 6:30 on JUL-5-2023 FFC at surface at 9:01 on JUL-5-2023 Filter fixation at 9:35 on JUL-5-2023
Filter image	

Filtration record



4. Cruise Log

R/V "YOKOSUKA" YK23-11 Cruise Log

Date & Time	Note	Position/Weather/Wind/Sea condition
2023/06/30 Fri.	"FFC11K" Dive #12	2023/06/30 12:00(JST)
8:00	Scientists onboard a vessel	SAGAMI Bay
9:00	Sail out, proceeding to research area from YOKOSUKA JPP	35-03.1N, 139-21.9E
09:40~10:10	Briefing about ship's life and safety	Cloudy
10:15	Commenced pre-dive check	SSW-6 (Strong breeze)
12:00	Arrived at research area (SAGAMI Bay)	3 (Sea Slight)
12:10	Released XBT (35-03.1N, 139-21.9E)	1 (Low Swell Short)
12:44~12:52	Carried out MBES mapping survey	Visibly: 4'
13:48	Hoisted up "FFC11K"	
13:52	Launched & Released "FFC11K"	
14:22	Landed on the sea floor (D=1446m)	
18:00~18:20	Scientist meeting	
2023/07/01 Sat.		2023/07/01 12:00(JST)
16:04	Left the sea bottom (D=1446m)	SAGAMI Bay
16:26	Refloated "FFC11K"	35-04.4N, 139-20.6E
16:46	Hoisted up "FFC11K"	Overcast
16:48	Recovered "FFC11K"	SSW-7 (Near gale)
18:00~18:10	Scientist meeting	5 (Sea Rough)
		3 (Moderate Short)
		Visibly: 6'
2023/07/02 Sun.		2023/07/02 12:00(JST)
6:00	Departured from research area (SAGAMI Bay)	Southeast off Nojima-saki
16:15	Arrived at research area (Off Boso Peninsula)	34-33.6N, 140-56.0E
16:16	Released XBT (34-20.4N, 142-00.2E)	Fine but Cloudy
16:46~17:16	Carried out MBES mapping survey	NE-4 (Moderate breeze)
18:00~18:10	Scientist meeting	4 (Sea Moderate)
20:01~20:22	Carried out eight figure running	3 (Moderate Short)
		Visibly: 8'
2023/07/03 Mon.	"FFC11K" Dive #13	2023/07/03 12:00(JST)
6:00	Commenced pre-dive check	Off Boso Peninsula
8:21	Hoisted up "FFC11K"	34-20.4N, 142-00.2E
8:25	Launched & Released "FFC11K"	Cloudy
11:39	Landed on the sea floor (D=9215m)	South-4 (Moderate breeze)
13:55	Left the sea bottom (D=9217m)	3 (Sea Slight)
16:24	Refloated "FFC11K"	2 (Low Swell Slong)
16:42	Hoisted up "FFC11K"	Visibly: 8'
16:45	Recovered "FFC11K"	
17:55~18:05	Scientist meeting	
20:12~20:33	Carried out eight figure running	
22:35	Finished preparation for next dive	
2023/07/04 Tue.	"FFC11K" Dive #14	2023/07/04 12:00(JST)
5:55	Commenced pre-dive check	Off Boso Peninsula
8:16	Hoisted up "FFC11K"	34-20.4N, 142-00.1E
8:17	Launched & Released "FFC11K"	Cloudy
11:34	Landed on the sea floor (D=9211m)	WSW-4 (Moderate breeze)
15:12~16:01	Carried out calibration for "FFC11K" position	3 (Sea Slight)
17:55~18:05	Scientist meeting	1 (Low Swell Short)
		Visibly: 8'
2023/07/05 Wed.		2023/07/05 12:00(JST)
6:30	Left the sea bottom (D=9211m)	Southeast off Nojima-saki
9:00	Refloated "FFC11K"	34-26.2N, 141-33.2E
9:19	Hoisted up "FFC11K"	Fine but Cloudy
9:21	Recovered "FFC11K"	South-4 (Moderate breeze)
10:00	Departured from research area (Off Boso Peninsula)	2 (Sea Smooth)
18:00~18:10	Scientist meeting	1 (Low Swell Short)
		Visibly: 8'
2023/07/06 Thu.		2023/07/06 12:00(JST)
14:00~15:15	Scientist debrief meeting	SAGAMI Bay
15:10	Let go anchor, arrived at YOKOSUKA port Section No.4	35-3.5N, 139-19.4E
		Fine but Cloudy
		NNW-1 (Light air)
		2 (Sea Smooth)
		1 (Low Swell Short)
		Visibly: 8'
2023/07/07 Fri.		2023/07/07 12:00(JST)
8:00	Heaving anchor, left YOKOSUKA port Section No.4	JAMSTEC
	Sent out 1st shore line, arrived at YOKOSUKA JPP	
	Scientists disembarked, then completed voyage YK23-11	

- **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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