Final Report for NICOP Project

Korean Support for the NRL Component of the US-Korea Collaboration on Mixing Processes in the Southwestern Japan/East Sea

Award No.: N62909-22-1-2004

Period of performance: 11/17/2021 through 11/16/2023

End of reporting period: 03/18/2024

Lead Institution: Geosystem Research Corporation (GeoSR)

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Participating U.S. Institution: U.S. Naval Research Laboratory (NRL)

Co-principal Investigators: Dr. Hemantha Wijesekera (NRL, email: hemantha.wijesekera@nrlssc.navy.mil) and Dr. Ewa Jarosz (NRL, e-mail: ewa.jarosz@nrlssc.navy.mil)

18 March 2024

Abstract

The proposed effort provided for Korean support of the US Naval Research Laboratory (NRL) component of a US-Korea collaboration on mixing processes in the southwestern Japan/East Sea (MJES). It complemented a previous NICOP grant (N62909-20-1-2049) to support the Korean component of the scientific collaboration. The overall goal of MJES is to evaluate how small-scale processes impact on the Japan/East Sea (JES) mixing and circulation. Three oceanographic surveys were completed and this report summarizes how the support was achieved with acquisition of data during the cruises.

1. Background

The Japan/East Sea (JES) has long been referred to as a miniature ocean for possessing many of the major features of global oceanic circulation, such as boundary currents, frontal zones, eddies, and deep-water formation. It is hypothesized that the majority of mixing and transformation of water masses and water mass exchanges occur in the southwestern region as mean currents, eddies, tides, and waves interact with topographic features along the coastal boundaries, islands, and submarine banks and passages. The circulation in the JES is therefore expected to be significantly affected by small-scale (O (cm)) to submesoscale (O (10km)) processes, however our present understanding of these processes is limited due to the scarcity of turbulent mixing observations in the region and lack of knowledge of the processes driving turbulence and water mass mixing. In turn, these knowledge gaps hinder accurate predictability of circulation, hydrographic structures, and bio-geochemical cycles in the JES.

2. Major goals and objectives

The overall goal of US NRL's MJES led by Dr. Hemantha Wijesekera is to study the effect of small scales and submesoscales on the overall circulation and water-mass transformation in the JES. The NRL group intended to achieve the goal by conducting a field observational program designed to measure short-term and long-term turbulent and submesoscale fluxes, bottom frictional drag, pressure (or form) drag associated with the major ocean current, East Korea Warm Current (EKWC), and associated background flow conditions and variability in the southwestern JES EEZ waters. The proposed study area encompasses the southeastern Korean shelf/slope at the southern end of the EKWC, and the downstream area behind Tsushima Island (TI) in the northern Korea Strait, where flow instabilities from mesoscale eddies are generated and the Tsushima Warm Current splits. The objective of the NICOP project is for providing the necessary research vessel (R/V) platform to achieve the NRL's MJES project goal. Three oceanographic surveys were conducted during the period of 2021 and 2022 using two R/Vs.

3. Technical approach

The technical approach of the NICOP project is to provide the R/V platform for two intensive observational period (IOP) surveys to achieve the MJES goal. The R/V Onnuri, which belongs to KIOST, was used to carry out two oceanographic surveys in the

southwestern JES in the Korean EEZ in December 2021 and August 2022. The IOP surveys (IOP 1 and IOP 2) were designed to measure and spatially map turbulent mixing processes and submesoscale structures and to evaluate localized mixing processes and their connections to the background flow. For these specific purposes, the IOP surveys included moored, ship-based profiling, and autonomous observations, and direct measurements of turbulent quantities using various observational platforms and instruments. One additional pilot survey was conducted in November 2021 prior to the first IOP 1 survey in Devember 2021.

(1) Platform: R/V Onnuri, R/V Haeyang 2000

R/V Onnuri belongs to Korea Institute of Ocean Science and Technology (KIOST), the mother port of which is Jangmok in the South Sea Research Institute of KIOST. Length, width, and tonnage of R/V Onnuri are 63.8 m, 12.0 m, and 1,370 tons, respectively. Both IOP 1 and IOP 2 surveys were conducted on board of R/V Onnuri in December 2021 and August 2022.

R/V Haeyang 2000 belongs to Korea Hydrographic and Oceanographic Agency (KHOA), the mother port of which is Busan, Korea. Length, width, and tonnage of R/V Haeyang 2000 are 89.2 m, 14.0 m, and 2,161 tons, respectively. The Pilot survey was conducted on board of R/V Haeyang 2000 in November 2021.

(2) Technical approach for observation

The project activities are organized in tasks (TA). Table 1 reports a summary of task achievements.

TA1: Long-term deployment of six Barny-TRBMs (barnacle-like shape Trawl-Resistant Bottom Mounts) in the southern boundary of the Ulleung Basin, one of the three deep basins in the JES (Figure 1)

- o Purpose: Understanding of the variability and branching mechanism of the Tsushima Warm Current (TWC) entering the East Sea through Korea Strait, and the role of small scale eddies in the variability of the TWC and basin-scale circulation
- o Method and instrumentation: Deployment of TRBMs at 6 locations with depth ranging 120-150 m near the entrance to the East Sea for about 8 months to measure currents at multiple depth levels and temperature (T) and salinity (S) near the seabed. The TRBMs carried acoustic current meters (300 kHz ADCP: acoustic Doppler current profiler), and temperature and conductivity sensors (SBE4, SBE26, SBE37, RBR).

TA2: Long-term deployment of five Barny-TRBMs with pressure-pods (Figure 1)

- o Purpose: Understanding the variability of the EKWC flowing northward along the east coast of Korea after the separation from the TWC and the effects of small-scale bathymetry variations on the intensity and steering of the EKWC
- o Method and instrumentation: Deployment of TRBMs at 5 locations across the complex bathymetry over the Hupo Bank with depth ranging 120-260 m for about 8 months to measure currents at multiple depth levels and bottom pressure, T, and S. The TRBMs

carried 300 kHz ADCP, pressure-pods which measure high-resolution pressure fluctuations, and temperature and conductivity sensors.

TA3: Long-term deployment of a subsurface mooring line (Figure 2)

- o Purpose: Together with data acquired from the TRBM moorings, data from a subsurface mooring line is used for understanding the variability and branching mechanism of the TWC, the role of small scale eddies in the variability of the TWC and basin-scale circulation, and the variability of the EKWC
- o Method and instrumentation: Deployment of a subsurface mooring line at about 920 m depth in an area of the TWC branching and in the path of the EKWC for about 8 months to measure currents, and T and S at selected depths. The mooring carries pressure-protected buoy of approximately 1.14 m diameter at 500 m above the seabed equipped with upward- and down-looking 75 kHz ADCPs which can thus measure full-depth currents. The mooring line is also equipped with 8 SBE37, 1 SBE39, 8 SBE56s, 1 Vemcos sensors below the buoy to measure water properties. To place the mooring line on the seabed, 3 train wheels each of which weighs about 300 kg are used as weight, and 2 acoustic releases are attached above the weight to recover the mooring line. The mooring position was decided after consulting captains of local fishing boats on the safe location avoiding intense bottom crabbing activities in the area. The consulting turns out to be very good strategy since it was successfully recovered afetr 8 months in this region of heavy fishing activities.

TA4: Short-term deployment of two MicroMoors and four WireWalkers (Figures 3 and 4)

- o Purpose: Two MicroMoors and 4 WireWalkers are deployed in the northeast-southwest direction across the continental slope spanning from the outer continental shelf to continental slope to acquire short-term (2~4 days) time series data of turbulence, and full-depth vertical structures of currents and water properties. The moorings are located near the mixing hotspot where the main conversion of barotropic to baroclinic tides occurs, hence aim to characterize the turbulence in the area and to understand its generation mechanism in relation to baroclinic internal tides, background flow, and vertical stratification.
- o Method and instrumentation: The MicroMoor is a moored microstructure package carrying MicroRider instrument, which enable time-series measurements of turbulent kinetic energy dissipation rate, and T/S sensors, 300 kHz ADCP, and a RCM-type current meter. WireWalkers regularly profile the entire water layer on predetermined time interval, thus provide time-series of highly-resolved vertical profiles of water properties. Two MicroMoor stations are located very close to two WireWalkers so that simultaneous measurements of turbulence, velocity shear, and background stratification can be achieved. Other two WireWalkers were deployed close to Barny-TRBM moorings, the latter providing time series of vertical structure of both tidal and low-frequency currents.

TA5: Measurements on board

- o Purpose: Two ship-based IOP surveys on board of R/V Onnuri were conducted in December 2021 and August 2022 to measure and spatially map turbulent mixing processes and submesoscale structures by operating short-term and long-term moorings, and various measurements. Main focus of the ship-borne measurements was on direct measurements of turbulent kinetic energy dissipation rates together with vertical shear of

currents and background stratification in order to spatially map turbulent mixing processes and submesoscale structures, and to evaluate localized mixing processes and their connections to the background flow. A pilot survey was also made on board of Haeyang 2000 in November 2021 prior to the first IOP survey in December 2021 to visit the study area and to collect some preliminary data of water properties and turbulent properties.

o Method and instrumentation: A vertical microstructure profiler (VMP) was mainly used on board to measure turbulent quantities together with the operation of CTD-LADCP package to measure the background stratification and vertical shear of currents. Data from CTD-LADCP also allowed to identify water masses and background currents set by the EKWC, TWC, and North Korea Cold Current (NKCC). Vessel-mounted ADCP and meteorological data and other surface underway T and S data were also acquired during the entire IOP survey periods.

Table 1. Project tasks and achievements.

Tasks	Title	Achievements description
Surveys	Pilot survey	• Total three surveys were made including a pilot survey from SNU contribution. The pilot survey aimed to visit the study area to gather turbulence and CTD data prior to IOP 1 survey. • IOP 1 was originally planned to take place from Dec. 2nd to Dec. 14th, but the departure date was delayed for one day due to Covid issue. • IOP 2 was originally planned to take place from Aug. 2nd to Aug. 8th, but the departure date was delayed for two days due to Covid issue and repair of ship engine malfunction.
	IOP 1	
	IOP 2	
2. Analyses		• Processing of data acquired from the MJES surveys has almost been completed, and analyses of data and comparison with another NICOP project targeted to collect data on the continental shelves is on-going. • A two-day workshop in March 22-23, 2024 is planned to present scientific findings from the surveys and to prepare co-authored publications.
3. Products		• Two peer-reviewed papers were published by NRL team using data taken during the IOP 1 survey, and six oral and poster presentations have been made. • All data gathered during the IOP 1 and IOP 2 surveys including R/V's underway meteorological and oceanographic data were provided to NRL team.

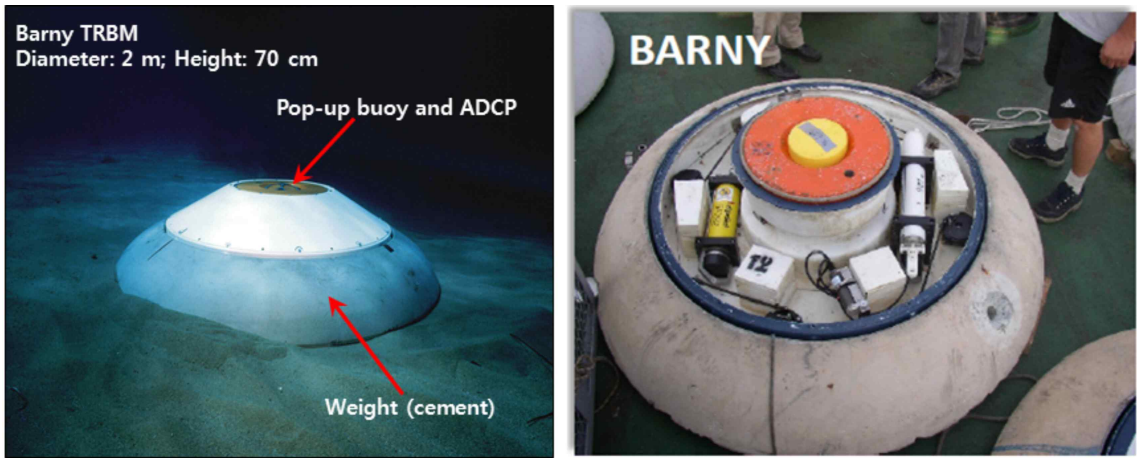


Figure 1. *Barny TRBM sitting on the bottom after deployment (left). It's barnacle-like shape without any protruding part provides little chance of damage or loss from fishing activities and also without the damage to fishing gears. All measuring instruments are mounted inside the TRBM (right).*

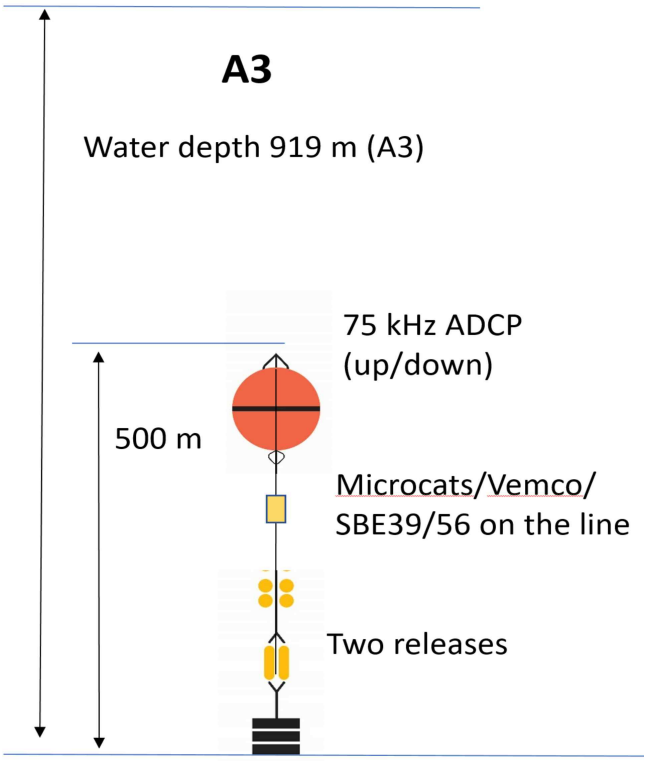


Figure 2. *Configuration of a subsurface line mooring deployed on the continental slope.*

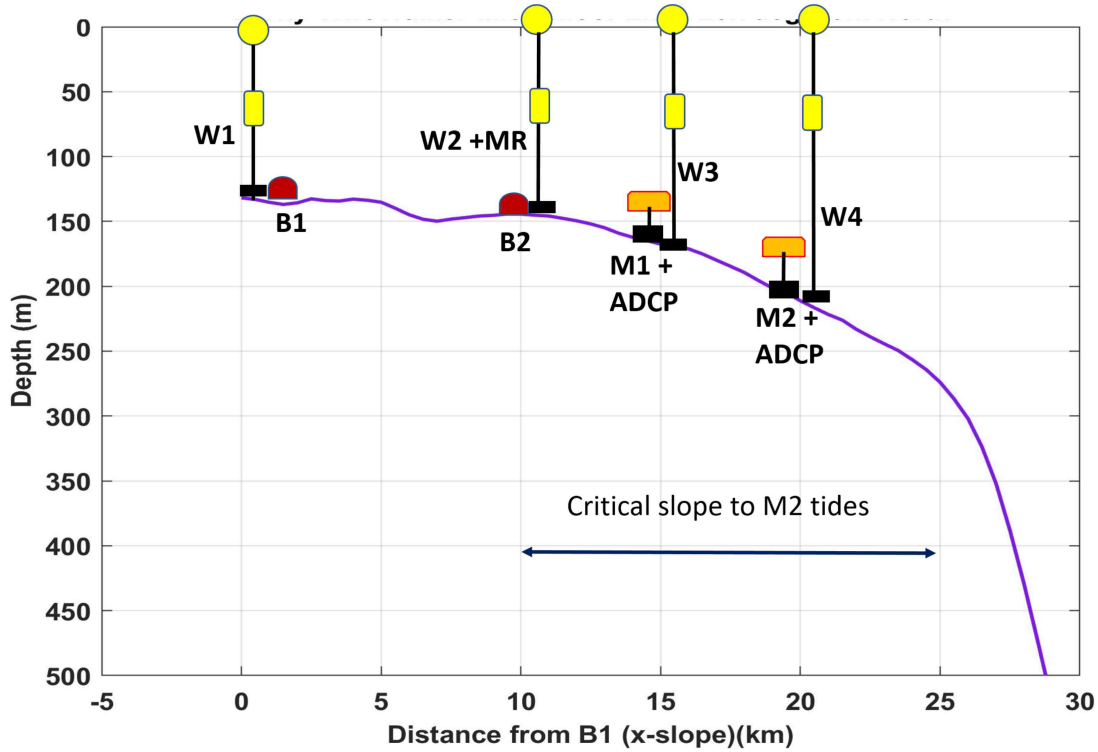


Figure 3. *Placement of MicroMoors (M1+ADCP, M2+ADCP) and WireWalkers (W1~W4). MR denotes MicroRider, and B1 and B2 denote locations of Barny TRBM moorings. Short-term moorings (2~4 days) of MicroMoors and WireWalkers were successfully recovered except (W2+MR) which seemed to be trawled by fishermen.*

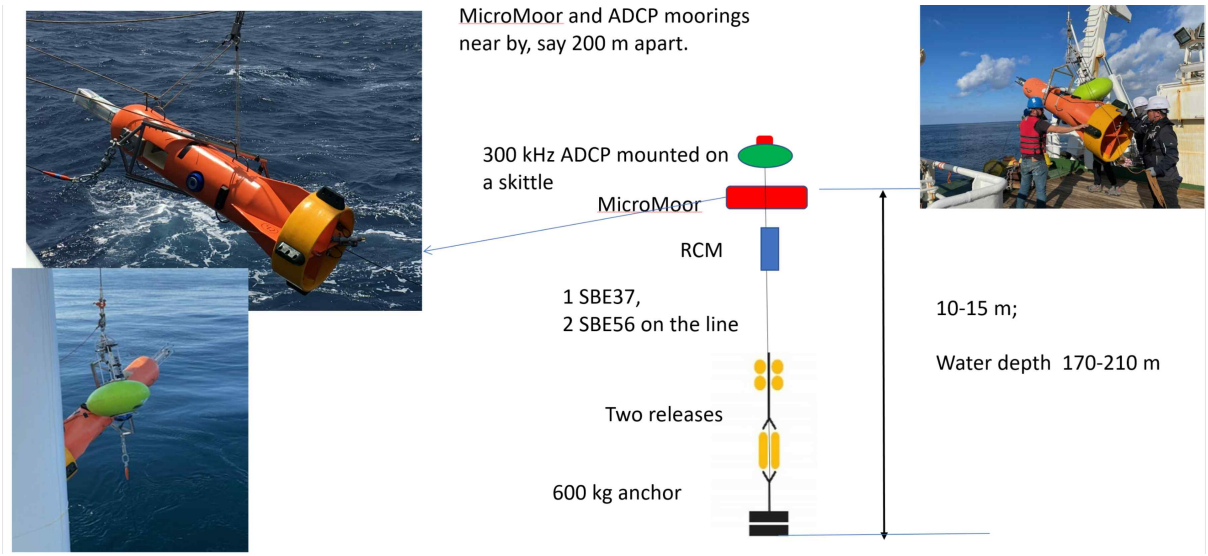


Figure 4. *Configuration of MicroMoor mooring line and photos of the deployment and recovery of the mooring line.*

4. Project Achievements

Oceanographic Surveys

The task of the NICOP project is to provide the platform support, research vessel, of the NRL component of a US-Korea collaboration on mixing processes in the southwestern Japan/East Sea (MJES). Under the NICOP project, three surveys were conducted in the Korean EEZ area, a pilot survey, IOP-1, and IOP-2. Three Korean institutions participated in the surveys, GeoSystem Research Corporation (GeoSR), Korea Institute of Ocean Science and Technology (KIOST), and Seoul National University (SNU). Two surveys were also conducted in the Korean territorial waters (Shelf Experiment 1 and 2) in Decemeber 2021 and August 2022 under the another NICOP project (N62909-20-1-2049) in conjuction with MJES IOPs in the EEZ (Table 2).

The Korean R/V used for the IOP-1 and IOP-2 was R/V Onnur, and the pilot survey was made on board of R/V Haeyang 2000. Cruise reports and ship tracks for IOP 1 and IOP 2 surveys provided by captain of R/V Onnuri are shown in Figures 5~10 together with their English versions.

This final report contains ship operation log notes for IOP 1 and IOP 2 surveys and measured parameters with their positions acquired during the three surveys, Pilot Survey, IOP 1, and IOP 2. Data and results from the two Shelf Experiments are described in the final report of NICOP N62909-20-1-2049.

Table 2. Summary of observations made during the Pilot, IOP-1, and IOP-2 surveys. Shelf Experiments 1 and 2 are also included.

Surveys (R/V)	Duration (YYYY/MM/DD)	No. of participants/ Institutions	Field works to be done and observation items					
			CTD & SADCP	LADCP	Microprofiler	Long-term moorings	Short-term moorings	Others
Pilot survey (Haeyang 2000)	2021/11/13～16	5 from SNU	O	X	VMP (SNU)	NA	NA	NA
IOP 1 (Onnuri)	2021/12/03～14	6 from NRL, 2 from GeoSR, 2 from KIOST, 1 from SNU	O	LADCP (SNU)	VMP (NRL)	Deployment of 11 Barny TRBM moorings and one subsurface mooring	Deployment and recovery of 4 WireWalkers and 2 MicroMoors except 1 lost WireWalker.	Launching 19 Carthe drifters.
IOP 2 (Onnuri)	2022/08/04～08	3 from NRL, 5 from GeoSR, 1 from KIOST, 2 from SNU	O	LADCP (SNU)	VMP (GeoSR)	Trial to recover Barny TRBM moorings but failed. The subsurface mooring was recovered.	NA	NA
Shelf Exp. 1 (Eardo)	2021/12/09～15	2 from GeoSR, 2 from KIOST, 2 from SNU	O	LADCP (KIOST)	MSP (KIOST)	Deployment of one TRBM mooring.	Deployment and recovery of 3-point ADCP moorings.	NA
Shelf Exp. 2 (Haeyang 2000)	2022/07/29～08/03	3 from GeoSR, 2 from SNU	O	X	VMP (SNU)*	TRBM mooring was recovered.	Deployment and recovery of 3-point ADCP moorings.	NA

* Acquisition of VMP data was unsuccessful because of damage of shear probes.

연구선 운항 결과 보고서

선 명 : 온 누 리	항 차 : HO-21-20	보고일자 : 2021년 12월 14일
연구과제명 : [산학연] 동해남서부 해양혼합 과정 동중국해에서 동해 유입물질의 수송과정 이해		
운 항 목 적 : 동해 남서부 해류계, 기상,ADCP, TSG, 수심 자료 획득		
수 행 부 서 : 지오시스템리치 / 해양순환연구센터	연구책임자 : 박성진 / 민홍식	
기 간 : 2021. 12. 03. ~ 2021. 12. 14. (12일간)		
주 요 작 업 : 해류계 계류 및 회수, 인공위성 추적 표류부이 투하, CTD, VMP		
사용 장비명 : 해류계, CTD, TSG, EA600, AWS, ADCP		
조 사 해 역 : 동해 남서부	총 운항거리 : 1387 해리	청수 잔량 : 114 톤

	연 료 종 류	F. O.	L. O.	비 고
연 료 유	출 항 잔 량	193.0 M/T	7,100 LTR	
	입 항 잔 량	153.2 M/T	6,700 LTR	
	소 모 량	39.8 M/T	400 LTR	

총 승선인원 : 25명	
승 무 원(14명)	강동석, 김해윤, 임진호, 심호용, 임근종, 손영우, 장승만, 고경환, 김도훈, 류승완, 김복훈, 백상엽, 김종훈, 황진호
한국해양과학기술원(2명)	장영석, 구본화
외 부 인 원(9명)	지오시스템리서치(2명)- 장경일, 방인권 서울대학교(1명)- 이경재 미국 해군연구소(6명)- Hemantha Wanapushpa Wijesekera, Ewa Jarosz, Andrew John Quaid, Ian Robert Martens, Joel Cutler Wesson, Conrad Allen Luecke

주 요 일 정 (1/2)

'21. 12. 03. 0840 : 남해연구소 출항. 조사해역 향
1420 : 조사해역 도착. 조사작업 시작
1930 : 조사작업 중지. 피항(표류) 시작
12. 04. 0855 : 피항(표류) 종료. 조사작업 재개
12. 07. 1330 : 조사작업 중지. 피항차 거제도 남부 향
2310 : 욕지도 남방해역 도착. 피항(표류) 시작
12. 08. 2140 : 피항(표류) 종료. 조사해역 향
12. 09. 0755 : 조사해역 도착. 조사작업 재개
다음 페이지에 계속

Figure 5. *Research vessel cruise report for IOP 1 provided by captain of R/V Onnuri (original copy).*

주 요 일 정 (2/2)	
'21. 12. 12. 1345 : 조사작업 중지. 피항차 거제도 남부 향	
2355 : 욕지도 남방해역 도착. 피항(표류) 시작	
12. 13. 1000 : 피항(표류) 종료. 조사해역 향	
1752 : 조사해역 도착. 조사작업 재개	
12. 14. 0425 : 조사작업 종료. 남해연구소 향	
1010 : 남해연구소 입항	
첨 부 : 항적도 1부	
현장책임자 : 장 경 일	선 장 : 강 [illegible]

Figure 5. *Continued.*

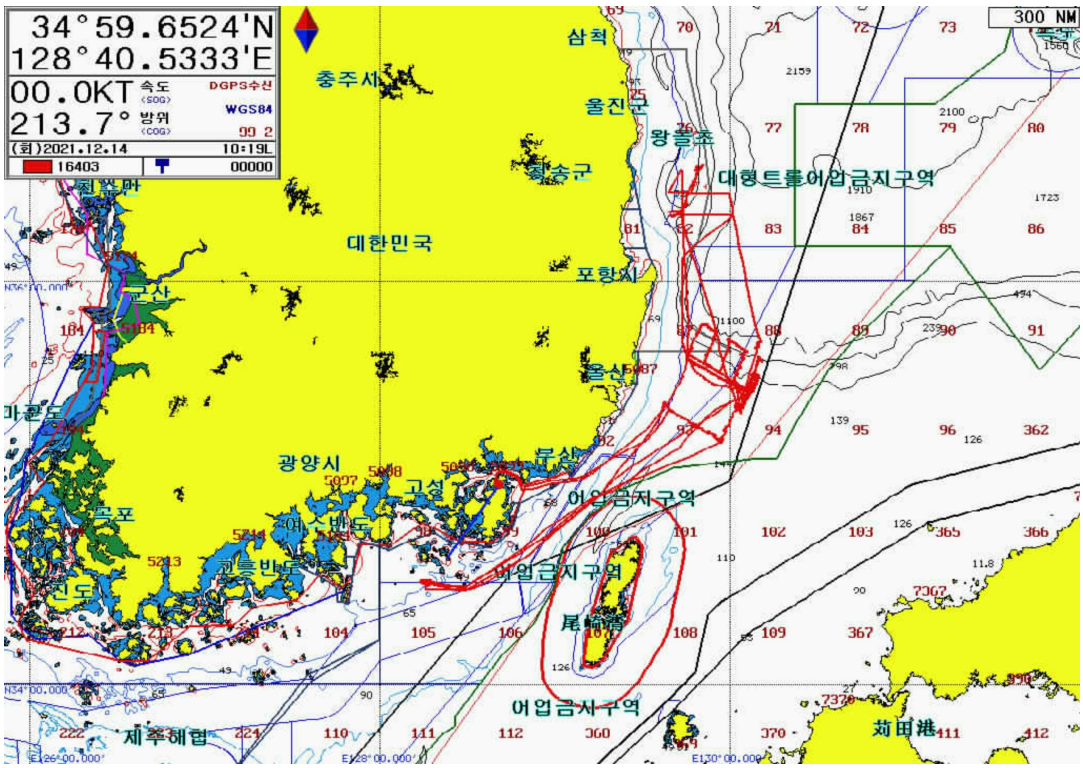


Figure 6. *Ship track of R/V Onnuri during IOP 1 provided by the captain.*

Research Vessel Cruise Report

Name of Vessel: R/V Onnuri		Sail number: HO-21-20		Date of Report: December 14, 2021
Name of research: (Industry-College-Institute Collaboration) Mixing processes in the southwestern East Sea Understanding material transport processes from the East China Sea to the East Sea				
Purpose of sail: Deployment of current meter mooring lines and acquisition of meteorology, ADCP, TSG, and depth data in the southwestern East Sea				
Operating department: GeoSystem Research Corporation/ Ocean Circulation Research Center (KIOST)		Lead researcher: Sung Jin Park / Hong Sik Min		
Period: December 3, 2021 ~ December 14, 2021 (12 days)				
Main job: Deployment and recovery of current meter moorings, lauching of satellite-tracked drifters, CTD, VMP				
Name of equipment used: Current meters, CTD, TSG, EA600, AWS, ADCP				
Sea area researched: the southwestern East Sea		Total sail distance: 1387 miles		Fresh water remaining: 114 tons
Fuel oil	**Type of fuel**	F.O.	L.O.	Note
	Remaining on departure	193.0 M/T	7,100 LTR	
	Remaining on arrival	153.2 M/T	6,700 LTR	
	Amount consumed	39.8 M/T	400 LTR	
Total number of people : 25 people				
Crewmate (14 people)		Dong Seok Kang, Hae Yoon Kim, Jin Ho Lim, Ho Yong Shim, Keun Jong Lim, Young Woo Son, Seung Man Jang, Kyung Hwan Ko, Do Hoon Kim, Seung Hwan Ryu, Bok Hoon Kim, Sang Yup Baek, Jong Hoon Kim, Jin Ho Hwang		
KIOST (2 people)		Young-Suk Jang, Bonhwa Ku		
Other staff (10 people)		GeoSystem Research (2 people) – Kyung-Il Chang, Inkweon Bang Seoul National University (1 person) – Kyung Jae Lee US Naval Research Laboratory (6 people) – Hemantha Wanapushpa Wijesekera, Ewa Jarosz, Andrew John Quaid, Ian Robert Martens, Joel Cutler Wesson, Conrad Allen Luecke		
Main schedule (1/2, 2/2)				
'21.12.03. 0840: 1420: 1930:		Departure from KIOST South Sea Research Institute. Headed towards survey area Arrived at survey area. Started investigation work Work stopped. Started refuge (drifting)		
12.04. 0855::		Ceased refuge (drifting). Started work		
12.07. 1330: 21:30:		Work stopped. Headed toward south of Geoje Island for evacuation Arrived at south of Yokji Island. Started evacuation (drifting)		
12.08. 2140:		Ceased evacuation (drifting), Headed to survey area		
12.09. 0755:		Arrived at survey area. Started work		
'21.12.12. 1345: 2355:		Work stopped. Headed towards Geoje Island for evacuation Arrived at south of Yokli Island. Started evacuation (drifting)		
12.13. 1000: 1752:		Ceased evaculation (drifting). Headed toward the survey area Arrived at survey area. Started work		
12.14. 0425: 1010:		End of investigation work. Headed toward South Sea Research Institute Arrival at South Sea Research Institute.		
* Attachment: 1 copy of track chart				
Senior scientist: Kyung-Il Chang		Captain: Dong Seok Kang		

Figure 7. *Research vessel cruise report for IOP 1 provided by captain of R/V Onnuri (English version).*

연구선 운항 결과 보고서

선 명 : 온 누 리		항 차 : HO-22-15		보고일자 : 2022년 08월 08일
연구과제명 : 동해 남서부 해양혼합 과정				
운 항 목 적 : 해류계 계류선 회수 및 정점 조사				
수 행 부 서 : 지오시스템리서치			연구책임자 : 장경일	
기 간 : 2022년 08월 04일 ~ 2022년 08월 08일 (5일간)				
주 요 작 업 : 수중 계류선 회수, Barny TRBM 회수, CTD, LADCP, VMP 조사				
사용 장비명 : CTD, ADCP, LADCP, VMP, TSG, EA600, AWS				
조 사 해 역 : 동해 남서부		총 운항거리 : 610 해리		청수 잔량 : 143 톤

	연 료 종 류	F. O.	L. O.	비 고
연 료 유	출 항 잔 량	188.6 M/T	4,200 LTR	
	입 항 잔 량	173.7 M/T	3,900 LTR	
	소 모 량	14.9 M/T	300 LTR	

총 원 : 26명	
승 무 원(15명)	강동석, 김해윤, 임진호, 심호용, 임근종, 손영우, 임성제, 고경환 김복훈, 엄석필, 김경표, 조익환, 박선명, 김종훈, 정 혁
한국해양과학기술원(1명)	민홍식
외 부 인 원(10명)	지오시스템리서치(5명) - 장경일, 이재학, 황상철, 성호현, 이동환 서울대학교(2명) - 정영석, 김주향 미국 해군연구소(3명)- Ewa Jarosz, Andrew John Quaid, Conrad Allen Luecke

주 요 일 정

'22. 08. 04. 1030 : 남해연구소 출항. 조사해역 향.
연구원 민홍식 승선. 지오시스템 장경일 외 9명 승선.

1735 : 조사해역 도착. 조사작업 시작.

08. 08. 0755 : 조사작업 종료. 남해연구소 향.

1635 : 남해연구소 입항.
연구원 민홍식 하선. 지오시스템 장경일 외 9명 하선.

※ 첨부 : 항적도 1부

수석과학자 : 장 경 일 선 장 : 강 동 석 관측장 :

Figure 8. *Research vessel cruise report for IOP 2 provided by captain of R/V Onnuri (original copy)*

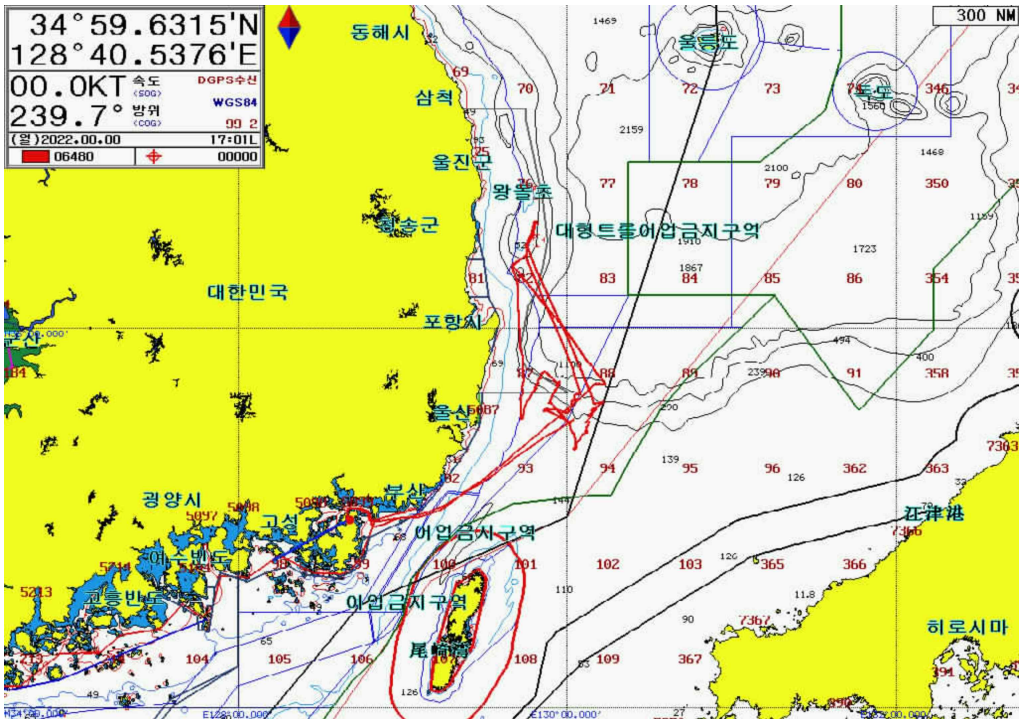


Figure 9. *Ship track of R/V Onnuri during IOP 2 provided by the captain.*

Research Vessel Cruise Report

<table>
<tr><td colspan="2">Name of Vessel: R/V Onnuri</td><td colspan="2">Sail number: HO-22-15</td><td>Date of Report: August 8, 2022</td></tr>
<tr><td colspan="5">Name of research: Mixing processes in the southwestern East Sea</td></tr>
<tr><td colspan="5">Purpose of sail: Recovery of current meter mooring lines and fixed-stations observation</td></tr>
<tr><td colspan="3">Operating department: GeoSystem Research</td><td colspan="2">Lead researcher: Kyung-Il Chang</td></tr>
<tr><td colspan="5">Period: August 4, 2022 ~ August 8, 2022 (5 days)</td></tr>
<tr><td colspan="5">Main job: Recovery of subsurface current meter mooring
, Recovery of Barny TRBMs, CTD/LADCP and VMP survey</td></tr>
<tr><td colspan="5">Name of equipment used: CTD, ADCP, LADCP, VMP, TSG, EA600, AWS</td></tr>
<tr><td colspan="2">Sea area researched: the southwestern East Sea</td><td colspan="2">Total sail distance: 610 miles</td><td>Fresh water remaining: 143 tons</td></tr>
<tr><td rowspan="4">Fuel oil</td><td>Type of fuel</td><td>F.O.</td><td>L.O.</td><td>Note</td></tr>
<tr><td>Remaining on departure</td><td>188.6 M/T</td><td>4,200 LTR</td><td rowspan="3"></td></tr>
<tr><td>Remaining on arrival</td><td>173.7 M/T</td><td>3,900 LTR</td></tr>
<tr><td>Amount consumed</td><td>14.9 M/T</td><td>300 LTR</td></tr>
<tr><td colspan="5">Total number of people : 26 people</td></tr>
<tr><td colspan="2">Crewmate (15 people)</td><td colspan="3">Dong Seok Kang, Hae Yoon Kim, Jin Ho Lim, Ho Yong Shim, Keun Jong Lim, Young Woo Son, Seong Je Lim, Kyung Hwan Ko, Bok Hoon Kim, Seok Pil Yeum, Kyung Pyo Kim, Ik Hwan Cho, Seon Myeong Park, Jong Hoon Kim, Hyeok Jung</td></tr>
<tr><td colspan="2">Korea Institute of Ocean Science and Technology (1 people)</td><td colspan="3">Hong Sik Min</td></tr>
<tr><td colspan="2">Other staff (10 people)</td><td colspan="3">GeoSystem Research (5 people) – Kyung-Il Chang, Jae Hak Lee, Sang Cheol Hwang, Ho Hyeon Sung, Dong Hwan Lee
Seoul National University (2 people) – Young Seok Jung, Joo Hyang Kim
US Naval Research Laboratory (3 people) – Ewa Jarosz* (Hemantha Wijesekera), Andrew John Quaid, Conrad Allen Luecke</td></tr>
<tr><td colspan="5">Main schedule</td></tr>
<tr><td colspan="2">'22.08.04. 1030:</td><td colspan="3">Departure from KIOST South Sea Research Institute. Headed towards survey area
Researcher Hong Sik Min embarked. Kyung-Il Chang and 9 others embarked.</td></tr>
<tr><td colspan="2">1735:</td><td colspan="3">Arrived at survey area. Started investigation work</td></tr>
<tr><td colspan="2">08.08. 0755</td><td colspan="3">End of investigation work. Headed toward South Sea Research Institute</td></tr>
<tr><td colspan="2">1635:</td><td colspan="3">Arrival at South Sea Research Institute.
Researcher Hong Sik Min disembarked. Kyung-Il Chang and 9 others disembarked.</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">* Attachment: 1 copy of track chart</td></tr>
<tr><td colspan="2">Senior scientist: Kyung-Il Chang</td><td colspan="2">Captain: Dong Seok Kang</td><td>Lead observer:</td></tr>
</table>

Figure 10. *Research vessel cruise report for IOP 2 provided by captain of R/V Onnuri (English version)*

3-1. Pilot survey (November 2021)

A pilot survey was conducted by SNU about one month prior to IOP 1 using R/V Haeyang 2000 which belongs to KHOA (Figure 11). CTD data was acquired at 22 stations and microprofiler data using VMP was acquired at 18 stations (NST1-3～NST1-5, NST2-4~NST2-5, NST3-2~NST3-5, NST4-2~NST4-5, SST3-2~SST3-6) using VMP. Continuous CTD and VMP casts at hourly intervals were made for 25 hours from November 13 14:00 to November 14 14:30 (KST) at station KU3 (Tables 2, 3).

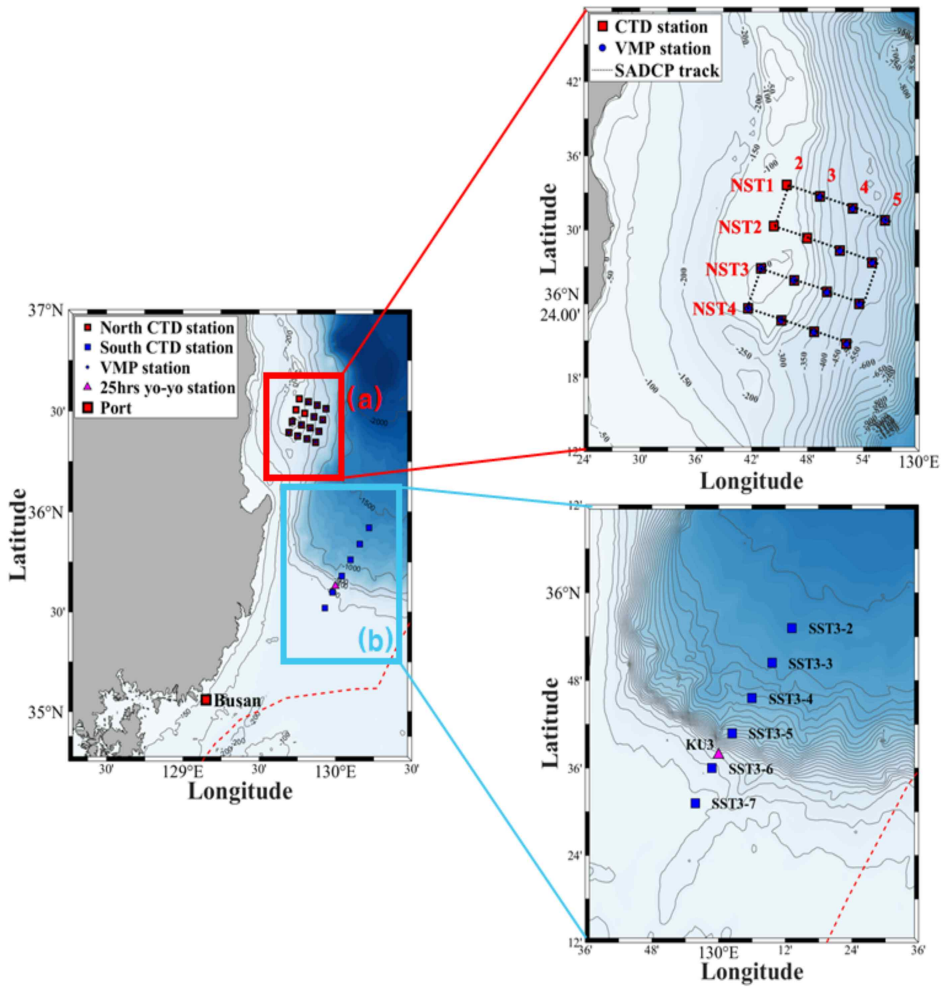


Figure 11. *Oceanographic stations occupied during the Pilot Survey in November 2021. CTD data was acquired at 22 stations (squares), and microprofiler data using VMP was acquired at 18 stations (see text). Twelve five-hour continuous CTD and VMP profile data was obtained at station KU3.*

Table 2. Station information occupied during the Pilot Survey.

No.	Station	Lat. (N)	Long. (E)	Total Depth (m)	Number*	Arrival	Departure
1	KU3	35° 37.80′	130° 0.00′	220	15/26	11/13/21 14:00	11/14/21 15:00
2	SST3-7	35° 31.20′	129° 55.80′	111	0/1	11/14/21 15:49	11/14/21 16:26
3	SST3-6	35° 36.00′	129° 58.80′	180	1/1	11/14/21 17:02	11/14/21 17:40
4	SST3-5	35° 40.80′	130° 2.40′	498	1/1	11/14/21 18:18	11/14/21 19:12
5	SST3-4	35° 45.60′	130° 6.00′	500	1/1	11/14/21 19:49	11/14/21 20:43
6	SST3-3	35° 50.40′	130° 9.60′	500	1/1	11/14/21 21:21	11/14/21 22:14
7	SST3-2	35° 55.20′	130° 13.20′	500	1/1	11/14/21 22:52	11/14/21 23:46
8	NST1-5	36° 30.78′	129° 56.34′	528	1/1	11/15/21 02:15	11/15/21 02:53
9	NST1-4	36° 31.74′	129° 52.86′	400	1/1	11/15/21 03:15	11/15/21 04:00
10	NST1-3	36° 32.70′	129° 49.32′	289	1/1	11/15/21 04:20	11/15/21 05:03
11	NST1-2	36° 33.66′	129° 45.78′	92	0/1	11/15/21 05:23	11/15/21 05:23
12	NST2-2	36° 30.30′	129° 44.40′	101	0/1	11/15/21 05:46	11/15/21 06:05
13	NST2-3	36° 29.34′	129° 47.94′	120	0/1	11/15/21 06:25	11/15/21 06:42
14	NST2-4	36° 28.32′	129° 51.48′	354	1/1	11/15/21 07:02	11/15/21 07:45
15	NST2-5	36° 27.36′	129° 54.96′	500	1/1	11/15/21 08:04	11/15/21 08:51
16	NST3-5	36° 24.00′	129° 53.58′	453	1/1	11/15/21 09:14	11/15/21 10:00
17	NST3-4	36° 24.96′	129° 50.10′	298	1/1	11/15/21 10:19	11/15/21 10:57
18	NST3-3	36° 25.92′	129° 46.56′	117	1/1	11/15/21 11:17	11/15/21 11:43
19	NST3-2	36° 26.88′	129° 43.02′	89	1/1	11/15/21 12:03	11/15/21 12:21
20	NST4-2	36° 23.64′	129° 41.64′	94	1/1	11/15/21 12:43	11/15/21 13:08
21	NST4-3	36° 22.68′	129° 45.18′	101	1/1	11/15/21 13:28	11/15/21 13:55
22	NST4-4	36° 21.72′	129° 48.72′	323	1/1	11/15/21 14:30	11/15/21 15:00
23	NST4-5	36° 20.76′	129° 52.20′	431	1/1	11/15/21 15:40	11/15/21 16:09
24	SST3-2	35° 55.20′	130° 13.20′	500	0/1	11/15/21 19:33	11/15/21 19:50
25	SST3-3	35° 50.40′	130° 9.60′	498	0/1	11/15/21 20:36	11/15/21 21:06
26	SST3-4	35° 45.60′	130° 6.00′	501	0/1	11/15/21 21:43	11/15/21 22:25
27	SST3-5	35° 40.80′	130° 2.40′	496	0/1	11/15/21 23:02	11/15/21 23:40
28	SST3-6	35° 36.00′	129° 58.80′	171	0/1	11/16/21 0:17	11/16/21 0:56

* Number of casts: VMP/CTD-LADCP package

Table 3. Continuous CTD and VMP casts at Station KU3 at about one hour intervals.

Date	Station	Lat. (N)	Long. (E)	Lowering Depth (m)	Number*	Time (CTD)	Time (VMP, #casts)
11/13/21	KU3_01	35° 38.15’	130° 00.49’	220	0/1	14:05	
	KU3_02	35° 37.80’	130° 00.24’	218	1/1	15:06	15:58 (1)
	KU3_03	35° 37.88’	130° 0.15’	220	1/1	16:17	16:44 (2)
	KU3_04	35° 37.83’	130° 0.08’	230	1/1	17:06	17:25 (2)
	KU3_05	35° 37.88’	130° 00.05’	240	1/1	18:00	18:16 (1)
	KU3_06	35° 37.76’	130° 00.04’	230	1/1	19:02	19:19 (2)
	KU3_07	35° 37.83’	130° 00.01’	230	1/1	20:02	20:16 (1)
	KU3_08	35° 37.78’	130° 00.06’	220	1/1	21:02	21:19 (1)
	KU3_09	35° 37.82’	130° 00.09’	231	1/1	22:01	22;18 (1)
	KU3_10	35° 37.77’	130° 00.05’	229	0/1	23:02	
11/14/21	KU3_11	35° 37.78’	130° 0.15’	230	0/1	00:00	
	KU3_12	35° 37.77’	129° 59.95’	228	0/1	01:04	
	KU3_13	35° 37.73’	130° 0.16’	230	0/1	02:02	
	KU3_14	35° 37.79’	129° 59.97’	230	0/1	02:56	
	KU3_15	35° 37.78’	130° 00.00’	230	0/1	03:58	
	KU3_16	35° 37.77’	129° 59.76’	229	0/1	05:01	
	KU3_17	35° 38.28’	130° 0.65’	258	0/1	05:58	
	KU3_18	35° 37.67’	129° 59.91’	230	0/1	07:00	
	KU3_19	35° 38.34’	130° 00.68’	288	1/1	07:59	08:18 (1)
	KU3_20	35° 37.28’	129° 00.16’	212	1/1	09:01	09:17 (1)
	KU3_21	35° 38.09’	129° 59.62’	276	1/1	10:01	10:21 (1)
	KU3_22	35° 37.02’	129° 59.89’	205	1/1	11:16	11:29 (1)
	KU3_23	35° 37.42’	129° 59.99’	226	1/1	11:57	12:13 (1)
	KU3_24	35° 37.72’	130° 00.07’	241	1/1	13:01	13:17 (1)
	KU3_25	35° 37.84’	130° 00.10’	250	1/1	14:02	14:18 (1)
	KU3_26	35° 38.19’	130° 0.27’	278	0/1	14:31	

3-2. IOP 1 (December 2021)

The IOP 1 survey was conducted between December 3 and 14 on board of R/V Onnuri. A list of works done and acquired data during the IOP 1 survey is shown in Tables 4 and 5.

Table 4. Summary of daily works done on board of R/V Onnuri during the IOP 1 survey.

Date & time (KST) (mm/dd/hh/mm)	Station	Work done
12/02	SSI, Geoje	Evacuation (Covid)
12/03/09/30	SSI, Geoje	Departure
	B6	Barny deployment
12/03/15/03	B6	CTD cast
	Near coast	Evcuation (bad sea state)
	P5	Barny P-pod deployment
12/04/13/25	P5	CTD-LADCP cast
	P4	Barny P-pod deployment
12/04/14/54	P4	CTD-LADCP cast
	P3	Barny P-pod deployment
12/04/16/18	P3	CTD-LADCP cast
	P2	Barny P-pod deployment
12/04/17/23	P2	CTD-LADCP cast
	P1	Barny P-pod deployment
12/04/18/41	P1	CTD-LADCP cast
12/04 ~ 12/05	P1-P5 & P1 lines	SADCP survey
12/05	B5	Barny deployment
12/05	B4	Barny deployment
12/05	B3	Barny deployment
12/05	B2	Barny deployment
12/05	B1	Barny deployment
12/05	B2W2	WireWalker deployment
12/05/16/39	B2	CTD-LADCP cast
12/05/17/43	B1	CTD-LADCP cast
12/05/19/05	B3	CTD-LADCP cast
12/05	B1W1~M2W4	SADCP survey

Table 4. (Continued)

Date & time (KST) (mm/dd/hh/mm)	Station	Work done
12/05/23/55~12/06	B2~B5 twice	SADCP survey
12/06	M1W3	MicroMoor deployment
12/06	M2W4	MicroMoor deployment
12/06	M2W4	WireWalker deployment
12/06	M1W3	WireWalker deployment
12/06	B1W1	WireWalker deployment
12/06 ~ 12/07	Hupo Bank (3 lines)	SADCP survey
12/07	A3	Deployment of subsurface line mooring
12/07	B2W2	Drifting WireWalker recovery
12/07	M1W3	Lost signal, not found visually
12/07 ~ 12/08	Near Geoje	Evacuation (bad sea state); Installation of VMP winch & tests
12/09~12/10/00/30	VB1~VB26	Continuous VMP/CTD-LADCP casts
12/10	VB1~VB26	SADCP survey
12/10/08/00	WW1	WW1 recovery
12/10	M1W3	M1 recovery (position changed, damaged, nets entangled)
12/10	M2W4	M2 recovery (position changed, damaged, nets entangled)
12/10	M2W4	W4 recovery
12/10~12/11	1~9	SADCP survey
12/11/07/30~ 12/12/09:45	VS1~VS25	Continuous VMP/CTD-LADCP casts
12/12	1km*1km box	19 Carthe drifters launch
12/12/11/30~ 12/12/13/45	WW2 last position	WW2 search 4 times
12/12/13:50~ 12/13/10/00	Near Geoje	Evacuation (bad sea state)
12/13/17/30~ 12/14//01/15	VP1~VP19	Continuous VMP casts
12/14/01/27~ 12/14//04/58	VP19~VP1	Continuous CTD-LADCP casts
12/14/10/00	Arrival at Geoje	Arrival

Table 5. Works done and acquired data during the IOP 1 survey.

<table>
<tr><td>Data</td><td colspan="4">Items</td></tr>
<tr><td rowspan="5">Underway</td><td colspan="2">Met. (AWS1, AWS2) data</td><td colspan="2">Wind & Air temp. & surface pressure</td></tr>
<tr><td rowspan="2">SADCP data</td><td rowspan="2">75 kHz (4m bin)
150 kHz (8 m bin)</td><td colspan="2">Underway</td></tr>
<tr><td>Pre-designed survey</td><td>P-section, B1W1-M2W4, B2-B5 2 times, P′-section, 1-9 section</td></tr>
<tr><td colspan="2">TSG data</td><td colspan="2">Surface temperature and salinity</td></tr>
<tr><td colspan="2">GPS data</td><td colspan="2">Time, Lat., Long.</td></tr>
<tr><td colspan="2">Bathymetry data</td><td colspan="2">Depth (Echogram)</td></tr>
<tr><td rowspan="11">NRL</td><td rowspan="3">Long-term moorings</td><td>Barny</td><td colspan="2">B1 - B6</td></tr>
<tr><td>P-pods</td><td colspan="2">P1 - P5</td></tr>
<tr><td>Subsurface</td><td colspan="2">A3</td></tr>
<tr><td rowspan="2">Short-term moorings (Micro-Moor data</td><td>MM1</td><td colspan="2">• SBE37 × 2 (SN: 6768,14471)
• SBE56 × 1 (SN: 6081)
• RCM
• MicroRider</td></tr>
<tr><td>MM2</td><td colspan="2">• SBE37 × 2 (SN: 2524,14472)
• RCM
• MicroRider</td></tr>
<tr><td rowspan="4">Short-term moorings (Wire Walker data)</td><td>WW1</td><td colspan="2">• SBE39 × 3 (SN: 7824,7826,7830)
• SBE56 × 2 (SN: 6188, 8200)
• Minilog×2: T sensor</td></tr>
<tr><td>WW2</td><td colspan="2">Lost</td></tr>
<tr><td>WW3</td><td colspan="2">• SBE39 × 3 (SN: 8524,8526,7833)
• SBE56 × 3 (SN: 6077,7753,8122)
• Minilog×3: T sensor</td></tr>
<tr><td>WW4</td><td colspan="2">• SBE39 × 1 (SN: 7832)
• Minilog×1: T sensor</td></tr>
<tr><td colspan="2">Carthe drifters</td><td colspan="2">19 drifters</td></tr>
<tr><td colspan="2" rowspan="3">Logs</td><td colspan="2">Long-, short-term moorings</td></tr>
<tr><td colspan="2">VMP</td></tr>
<tr><td colspan="2">Carthe drifters</td></tr>
<tr><td rowspan="4">GeoSR/ KIOST/ SNU</td><td colspan="2">CTD</td><td colspan="2">37 profiles**</td></tr>
<tr><td colspan="2">LADCP</td><td colspan="2">36 profiles (Slave: 36, Master: 34)</td></tr>
<tr><td colspan="2">Drifters & Argo floats</td><td colspan="2">4</td></tr>
<tr><td colspan="2" rowspan="2">Logs</td><td colspan="2">CTD/LADCP</td></tr>
<tr><td colspan="2">Drifters & Argo floats</td></tr>
</table>

(1) Deployment of long-term moorings

Six Barny-TRBMs were deployed in the southern boundary of the UB (Stations B1-B6 in Figure 12 and Table 6), and five Barny-TRBMs with pressure-pods housed were deployed in the Hupo Bank off the southeastern coast of Korea (Stations P1-P5 in Figure 12 and Table 6). A subsurface mooring line was also deployed in the lower continental slope region (Station A3 in Figure 12 and Table 6). All moorings were planned to recover in August 2022 during the IOP 2 survey, hence acquiring about a 8-month long time series of currents and water properties, and bottom pressure.

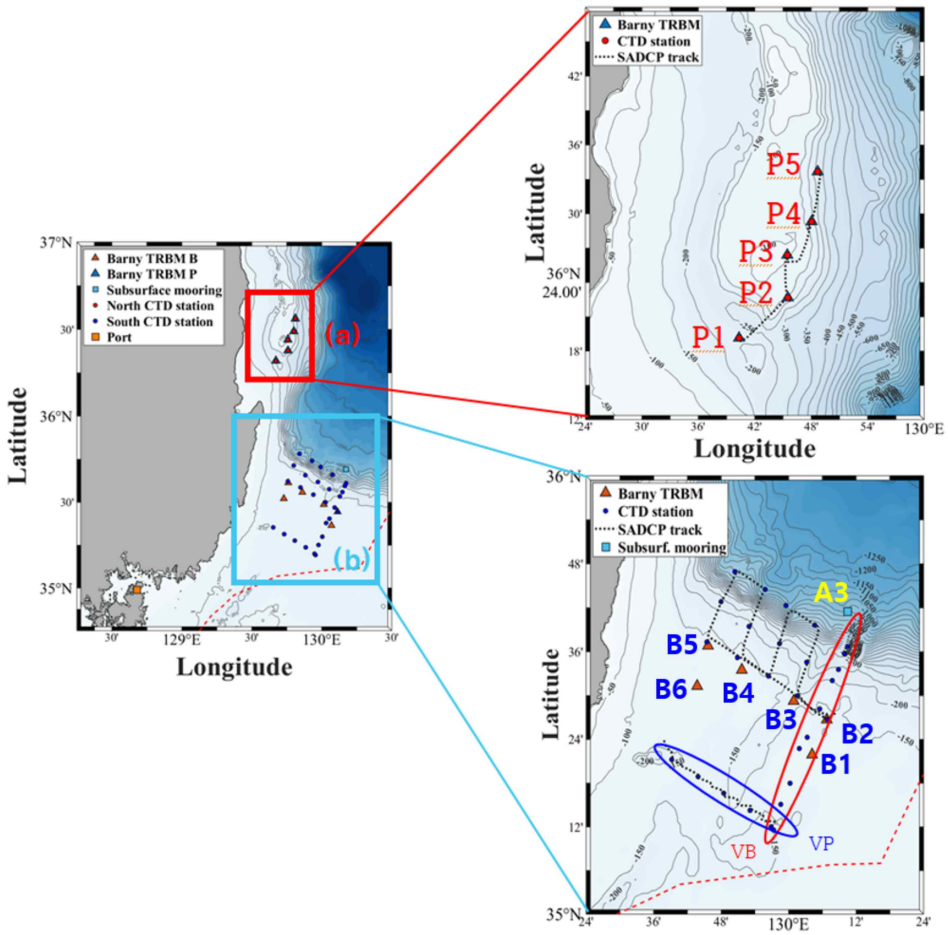


Figure 12. *Station map for long-term moorings during the IOP 1 survey. Six Barny TRBMs were deployed at Stations B1~B6 north of the Korea Strait (area b), and five Barny TRBMs with pressure-pods at Stations P1~P5 in the northern study area over the Hupo Bank (area a), and a subsurface line mooring at Station A3.*

Table 6. Location and total water depth of moorings.

Date	Station	Latitude (N)	Longitude (E)	Water Depth (m)	Remark
12/05/21	B1	35° 21.307′	130° 02.885′	132	Barny TRBM
12/05/21	B2	35° 26.739′	130° 06.834′	142.5	
12/05/21	B3	35° 29.256′	130° 00.913′	160.5	
12/05/21	B4	35° 33.508′	129° 51.687′	136.6	
12/05/21	B5	35° 36.812′	129° 45.668′	142-145	
12/03/21	B6	35° 31.404′	129° 43.777′	130	
12/04/21	P1	36° 18.911′ 36° 19.031′	129° 40.255′ 129° 40.176′	210.9	Barny TRBM with pressure-pods
12/04/21	P2	36° 22.58′ 36° 22.632′	129° 45.227′ 129° 45.280′	145 -- 133	
12/04/21	P3	36° 25.869′ 36° 25.924′	129° 45.376′ 129° 45.421′	119.5	
12/04/21	P4	36° 28.697′ 36° 28.870′	129° 47.599′ 129° 47.664′	145.6	
12/04/21	P5	36° 32.878′ 36° 33.158′	129° 48.201′ 129° 48.456′	260-262.4	
12/07/21	A3	35° 41.547′	130° 9.804′	920	Subsurface line mooring

(2) VMP, CTD-LADCP package measurements

To quantify and understand turbulence characteristics in the southwestern JES, measurements of turbulent kinetic energy dissipation rate, background stratification and water masses, and vertical shear of horizontal currents were conducted three times during the IOP 1 survey using VMP and CTD/LADCP package (Figure 13, Tables 7~11). Results from these measurements were partly published in Hemantha et al. (2022, 2023).

Table 7. VMP and CTD-LADCP measurements along lines and grid shown in Figure 13.

Date	Station	Measurement
12/09/21~12/10/21	VB line	VMP, CTD/LADCP
12/11/21~12/12/21	VS grid	VMP, CTD/LADCP
12/13/21~12/14/21	VP line	VMP (VP1-->VP19)
12/14/21	VP line	CTD/LADCP (VP19-->VP1)

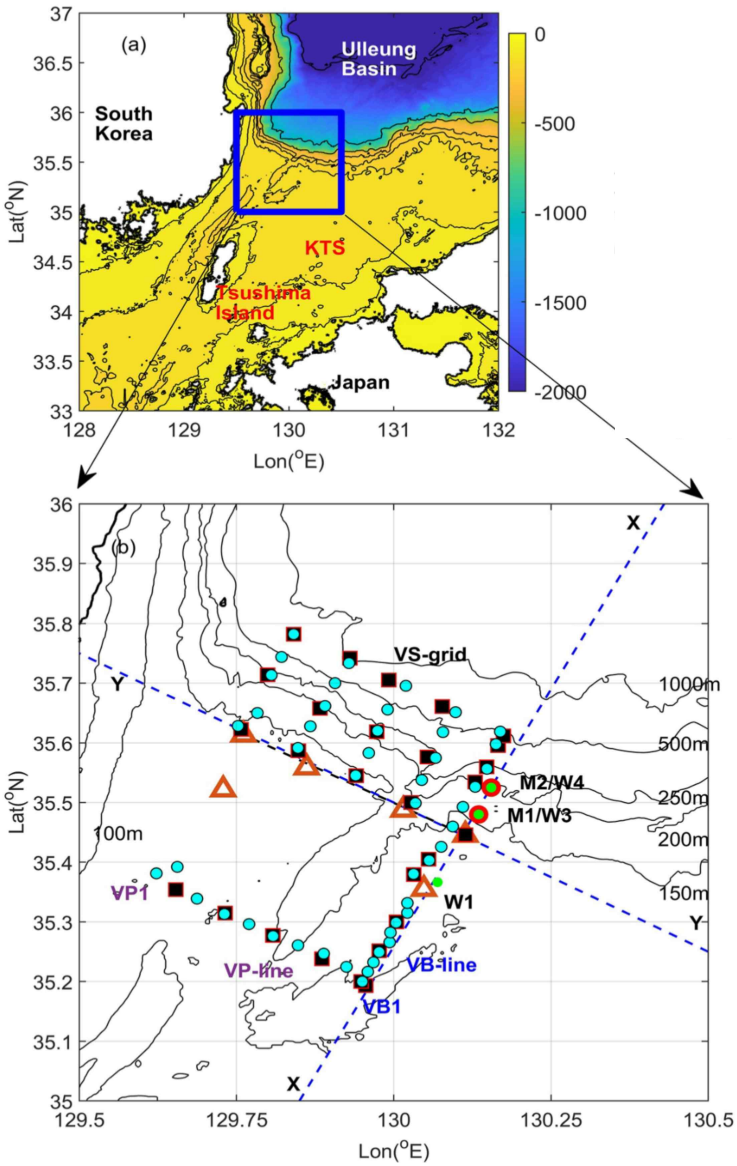


Figure 13. *(a) Bathymetric map of the southern Japan/East Sea. Thin lines are isobaths 100, 150, 200, 250, 500, 1,000, and 2,000 m. (b) Expanded view of bathymetry and observational sites. Red circles are locations of "MicroMoor" moorings (M1, M2) and green-filled circles are moored WireWalkers (W1, W3, W4). Red triangles are bottom-mounted acoustic Doppler current profilers. vertical microstructure profiler and conductivity, temperature, depth stations are marked by filled cyan-circles and filled back-squares, respectively. X-X and Y-Y show the coordinate system, parallel and perpendicular to the Korea/Tsushima Strait axis. (from Hemantha et al., 2022).*

Table 8. Station information of VMP along VB line in Figure 13.

No.	Station	Lat. (N)	Long. (E)	Water Depth (m)	Number of casts	CTD-LADCP cast
1	VB1	35° 12.000′	129° 57.000′	150.86	3	O
2	VB2	35° 12.987′	129° 57.536′	150.57	3	
3	VB3	35° 13.975′	129° 58.073′	148.13	3	
4	VB4	35° 14.963′	129° 58.610′	142.18	3	O
5	VB5	35° 15.951′	129° 59.148′	137.15	3	
6	VB6	35° 16.938′	129° 59.685′	133.49	3	
7	VB7	35° 17.926′	130° 0.223′	134.22	3	O
8	VB8	35° 18.914′	130° 0.761′	137	3	
9	VB9	35° 19.901′	130° 1.299′	132.78	3	
10	VB11	35° 21.876′	130° 2.376′	130.95	3	O
11	VB13	35° 23.851′	130° 3.454′	139.15	3	O
12	VB15	35° 25.826′	130° 4.533′	144.38	3	
13	VB17	35° 27.800′	130° 5.613′	147.60	3	O
14	VB19	35° 29.775′	130° 6.693′	159.32	3	
15	VB21	35° 31.749′	130° 7.775′	193.26	3	O
16	VB23	35° 33.723′	130° 8.857′	240.66	3	O
17	VB25	35° 35.697′	130° 9.940′	348	3	O
18	VB26	35° 36.684′	130° 10.482′	390	3	O

Table 9. Station information of VMP in VS grid in Figure 13.

No.	Station	Lat. (N)	Long. (E)	Water Depth (m)	Number of casts	CTD-LADCP package
1	VS1	35° 27.306′	130° 7.218′	145.4	2/1	O
2	VS3	35° 29.928′	130° 1.812′	178.2	2/1	O
3	VS4	35° 32.256′	130° 2.742′	238.8	2/0	
4	VS5	35° 34.584′	130° 3.678′	233.5	2/1	O
5	VS6	35° 36.906′	130° 4.608′	418.8	2/0	
6	VS7	35° 39.234′	130° 5.538′	632.4	2/1	O
7	VS9	35° 41.784′	130° 0.600′	904.8	2/1	O
8	VS10	35° 39.480′	129° 59.556′	372.9	2/0	
9	VS11	35° 37.170′	129° 58.506′	227.4	2/1	O
10	VS12	35° 34.866′	129° 57.462′	172.1	2/0	
11	VS13	35° 32.556′	129° 56.412′	145.1	2/1	O
12	VS15	35° 35.178′	129° 51.006′	138.0	2/1	O
13	VS16	35° 37.470′	129° 52.170′	155.0	2/0	
14	VS17	35° 37.756′	129° 53.334′	196.3	2/1	O
15	VS18	35° 42.048′	129° 54.492′	541.5	2/0	
16	VS19	35° 44.334′	129° 55.656′	995.4	2/1	O
17	VS21	35° 46.884′	129° 50.712′	859.7	2/1	O
18	VS22	35° 44.616′	129° 49.434′	442.8	2/0	
19	VS23	35° 42.342′	129° 48.156′	216.4	2/1	O
20	VS24	35° 40.074′	129° 46.878′	169.1	2/0	
21	VS25	35° 37.800′	129° 45.600′	146.6	2/1	O

Table 10. Station information of VMP along VP line in Figure 13.

No.	Station	Lat. (N)	Long. (E)	Water Depth (m)	Number of casts	CTD-LADCP package
1	VP1	35° 22.200′	129° 37.200′	205.40	2/0	
2	VP3	35° 21.098′	129° 39.472′	161.09	1/1	O
3	VP5	35° 19.995′	129° 41.744′	145.85	2/0	
4	VP7	35° 18.892′	129° 44.014′	144.92	2/1	O
5	VP9	35° 17.778′	129° 46.284′	132.98	2/0	
6	VP11	35° 16.684′	129° 48.552′	143.65	2/1	O
7	VP13	35° 15.579′	129° 50.819′	156.55	2/0	
8	VP15	35° 14.473′	129° 53.086′	140.50	2/1	O
9	VP17	35° 13.336′	129° 55.351′	151.74	2/0	
10	VP19	35° 12.258′	129° 57.615′	150.00	2/1	O

Table 11. Location and observation time of all CTD-LADCP package stations occupied during the IOP 1 survey.

St.	Lon. (deg)	Lat. (deg)	Obs.start (KST)	Obs.end (KST)	depth (m)	Installed Sensors
B1	130.06618	35.34056	2021-12-05 17:37	2021-12-05 17:46	134.212	Temperature, Salinity, Pressure, DO, Turbidity, Fluorscence, PAR
B2	130.11276	35.44326	2021-12-05 16:34	2021-12-05 16:43	140.275	
B3	130.01166	35.48868	2021-12-05 18:59	2021-12-05 19:09	169.898	
B6	129.7298	35.52258	2021-12-03 14:58	2021-12-03 15:06	125.93	
P1	129.6724	36.31918	2021-12-04 18:34	2021-12-04 18:46	210.289	
P2	129.75898	36.37796	2021-12-04 17:18	2021-12-04 17:25	143.385	
P3	129.75792	36.44	2021-12-04 16:13	2021-12-04 16:21	123.697	
P4	129.80096	36.48872	2021-12-04 14:49	2021-12-04 14:59	153.884	
P5	129.81102	36.56078	2021-12-04 13:16	2021-12-04 13:32	281.538	
VB1	129.94874	35.20034	2021-12-09 8:43	2021-12-09 8:50	150.257	
VB4	129.97696	35.2517	2021-12-09 11:21	2021-12-09 11:27	136.719	
VB7	130.00452	35.29946	2021-12-09 13:48	2021-12-09 13:57	136.864	
VB11	130.03184	35.37912	2021-12-09 16:16	2021-12-09 16:25	135.712	
VB13	130.05522	35.40424	2021-12-09 17:02	2021-12-09 17:10	135.419	
VB17	130.0965	35.46566667	2021-12-09 18:51	2021-12-09 19:00	145.352	
VB21	130.12958	35.53436	2021-12-09 20:49	2021-12-09 20:59	198.691	
VB23	130.14782	35.5595	2021-12-09 21:45	2021-12-09 21:56	236.956	
VB25	130.16564	35.5954	2021-12-09 22:30	2021-12-09 22:46	364.47	
VB26	130.1747	35.6115	2021-12-10 0:38	2021-12-10 1:04	424.206	
VS1	130.11446	35.44594	2021-12-11 7:41	2021-12-11 7:50	140.988	
VS3	130.0276	35.49982	2021-12-11 8:55	2021-12-11 9:05	175.906	
VS5	130.05384	35.5761	2021-12-11 11:08	2021-12-11 11:19	221.324	
VS7	130.07812	35.66094	2021-12-11 13:42	2021-12-11 14:08	663.85	
VS9	129.99294	35.70498	2021-12-11 15:28	2021-12-11 15:54	969.9	
VS11	129.9732	35.6187	2021-12-11 18:06	2021-12-11 18:19	218.211	
VS13	129.9401	35.54474	2021-12-11 19:58	2021-12-11 20:07	140.769	
VS15	129.84826	35.58692	2021-12-11 21:23	2021-12-11 21:32	139.337	
VS17	129.88308	35.65768	2021-12-11 23:23	2021-12-11 23:33	191.707	
VS19	129.9298	35.74124	2021-12-12 1:48	2021-12-12 2:18	989.9	
VS21	129.84144	35.78208	2021-12-12 4:01	2021-12-12 4:37	880.3	
VS23	129.79986	35.71376	2021-12-12 6:34	2021-12-12 6:48	227.251	
VS25	129.75716	35.62262	2021-12-12 8:38	2021-12-12 8:47	141.39	
VP19	129.9554	35.19382	2021-12-14 1:29	2021-12-14 1:40	150.031	
VP15	129.88572	35.23842	2021-12-14 2:15	2021-12-14 2:24	137.29	
VP11	129.80806	35.27764	2021-12-14 2:57	2021-12-14 3:06	146.123	
VP7	129.73242	35.3151	2021-12-14 3:36	2021-12-14 3:47	143.184	
VP3	129.6539	35.3543	2021-12-14 4:18	2021-12-14 4:29	126.024	

(3) SADCP measurements

To map the spatial current distribution, current measurements were conducted six times along selected lines during the IOP 1 survey using vessel-mounted ADCPs (SADCP) on the R/V Onnuri. To measure the currents, the R/V Onnuri continuously moved from one end point to another end point along pre-determined lines with ship's speed of about 10 kts. Bottom tracking mode was used and ancillary position data from ship's GPS was used in analyzing ADCP data (Figure 14, Tables 12).

Table 12. Summary of SADCP measurements conducted during the IOP 1 survey.

Date (MM/DD/YY)	Station	Figure	Remark
12/04/21~12/05/21	P1-P5, P1 lines		After deployment of P1~P5 moorings and CTD casts at each mooring location
12/05/21	B1W1-M2W4		Along MicroMoors and WireWalker moorings
12/06/21~12/07/21	B2-B5, B5-B2		Twice, Along Barny TRBM moorings
12/06/21~12/07	Hupo Bank		Three lines near P1~P5 moorings
12/10/21	VB1-VB26		after VB line VMP/CTD/LADCP survey
12/10/21~12/11/21	1-9		after VS grid VMP/CTD/LADCP survey

① P1-P5, P1 line measurements (Figures 14, 15)

After the deployment of Barny TRBM moorings with pressure-pods housed and CTD casts from Station P1 to Station P5 southeast of the Hupo Bank, SADCP measurement was conducted along P1-P5 line between Dec. 4 and Dec. 5, 2021.

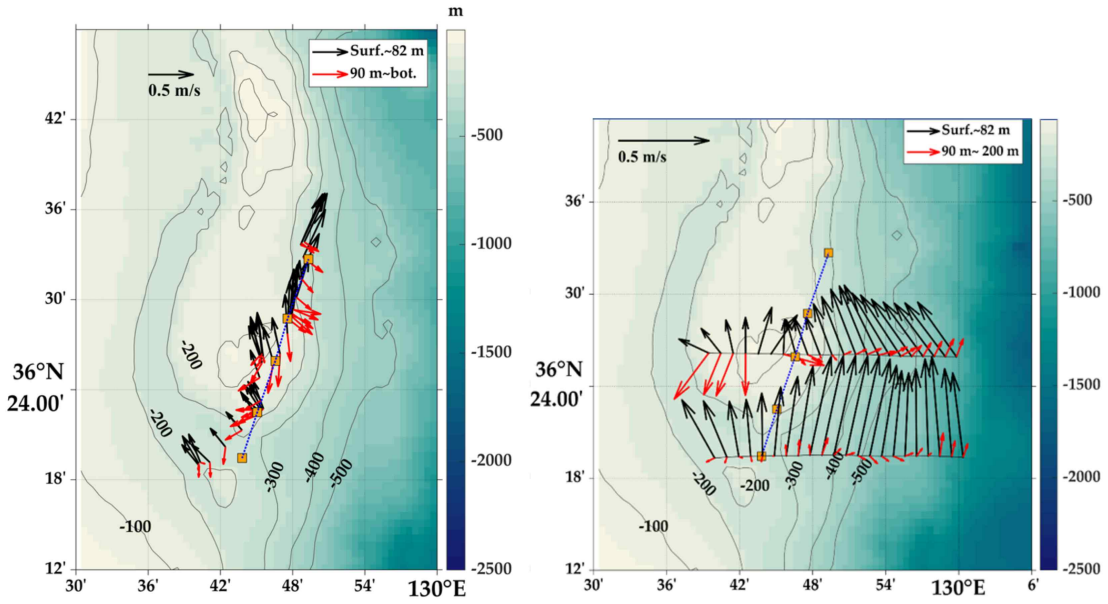


Figure 14. *SADCP surve along P1-P5 line (left) and a zonal line across Station P1 (right) taken between Dec. 4 and Dec. 5, 2021.. Five Barny TRBM moorings with pressure-pods were deployed along P1-P5 line (red squares). The upper zonal line on the right panel incates SADCP line covered between Dec. 6 and Dec. 7, 2021 during the Hupo Bank SADCP measurements shown in Figure 18 . Black and red arrows show depth averaged currents between surface to 82 m and between 90 m near to the seabed, respectively.*

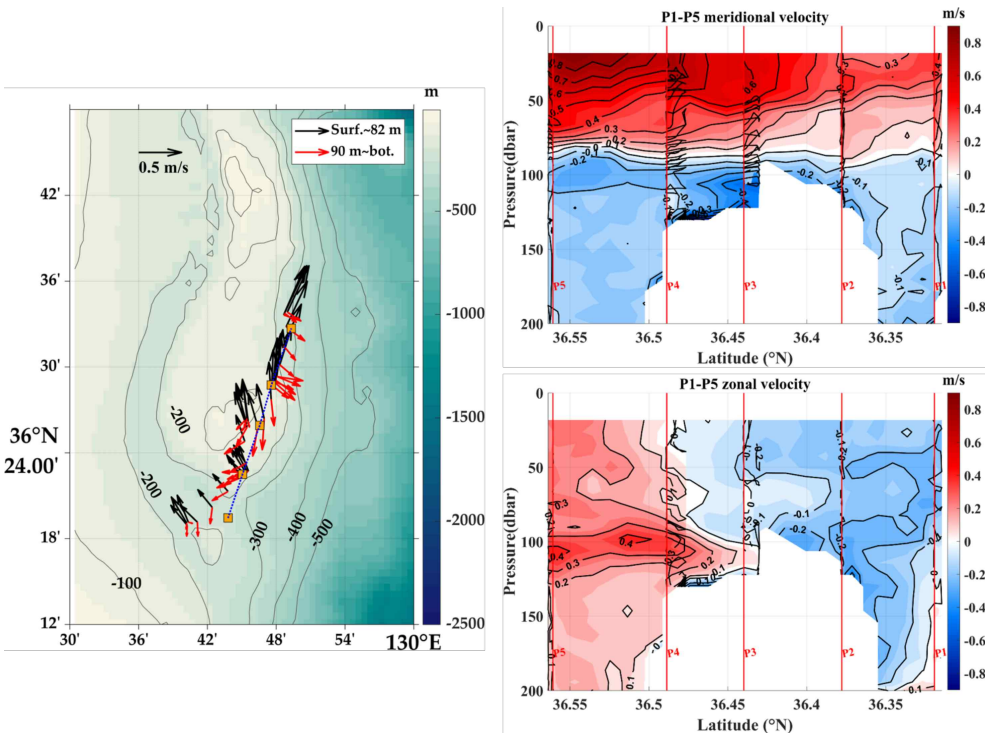


Figure 15. *Velocity distribution along P1-P5 line taken (left), and vertical sections of meridional (north-south) and zonal (east-west) velocity components (right).*

② B1W1-M2W4 line SADCP measurement (Figure 16)

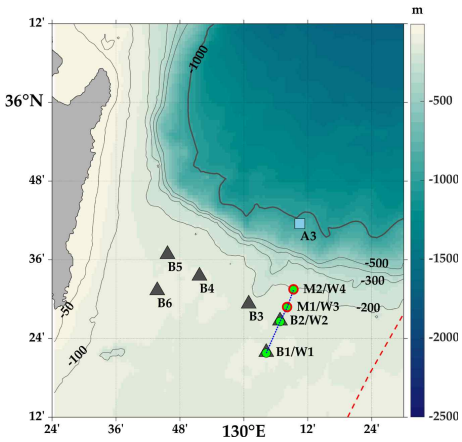


Figure 16. *SADCP measurement along B1W1-M2W4 line taken on Dec. 5, 2021. Four marked stations with filled green circles denote the short-term mooring positions of MicroMoors (M1, M2) and WireWalkers (W1~W4).*

③ B2-B5 line SADCP measurements (Figure 17)

Two times of SADCP surveys were made between Stations B2 and B5 on December 6, where Barny TRBM moorings were deployed.

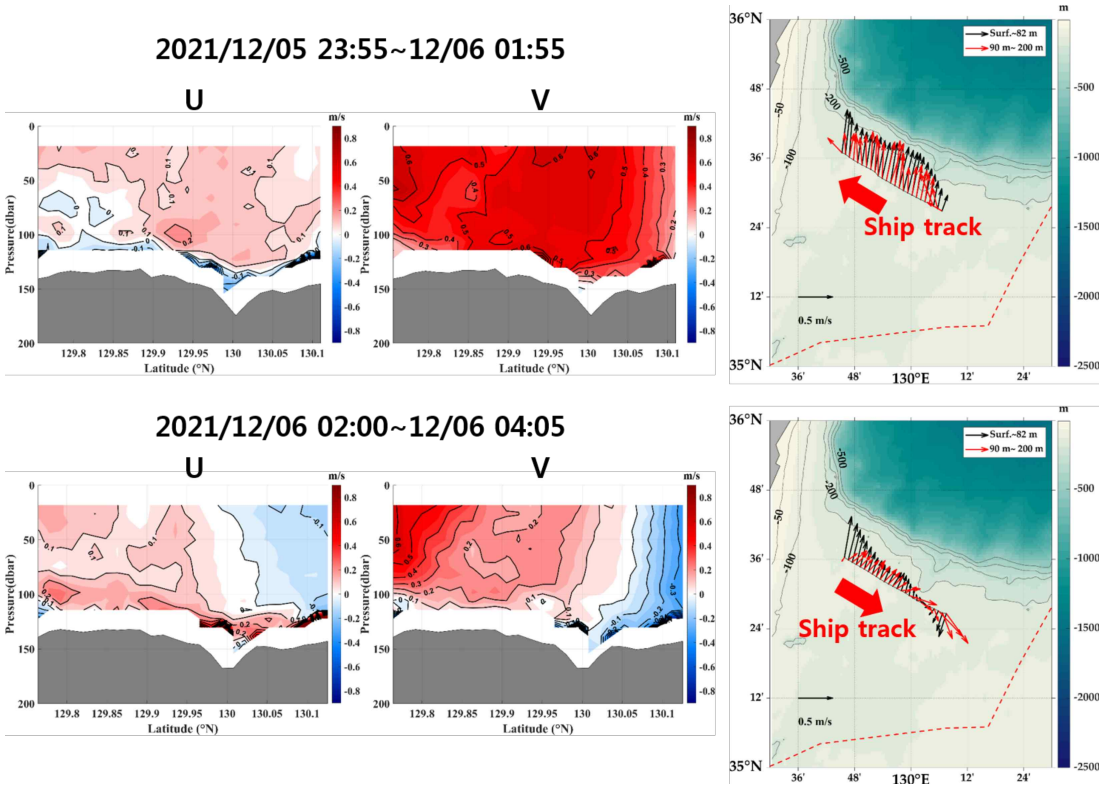


Figure 17. *SADCP surve along B2-B5 Barny TRBM mooring line taken on Dec. 6, 2021 (right). Black and red arrows show depth averaged currents between surface to 82 m and between 90 m near to the seabed, respectively. Vertical sections of meridional (north-south) and zonal (east-west) velocity components (left). Note the measured currents include both tidal and subtidal currents.*

④ Hupo Bank SADCP measurements (Figure 18)

SADCP measurements were conducted along three lines over the Hupo Bank near the Barny TRBM moorings with pressure-pods housed in at Station P1~Station P5 between Dec. 6 and Dec. 7, 2021.

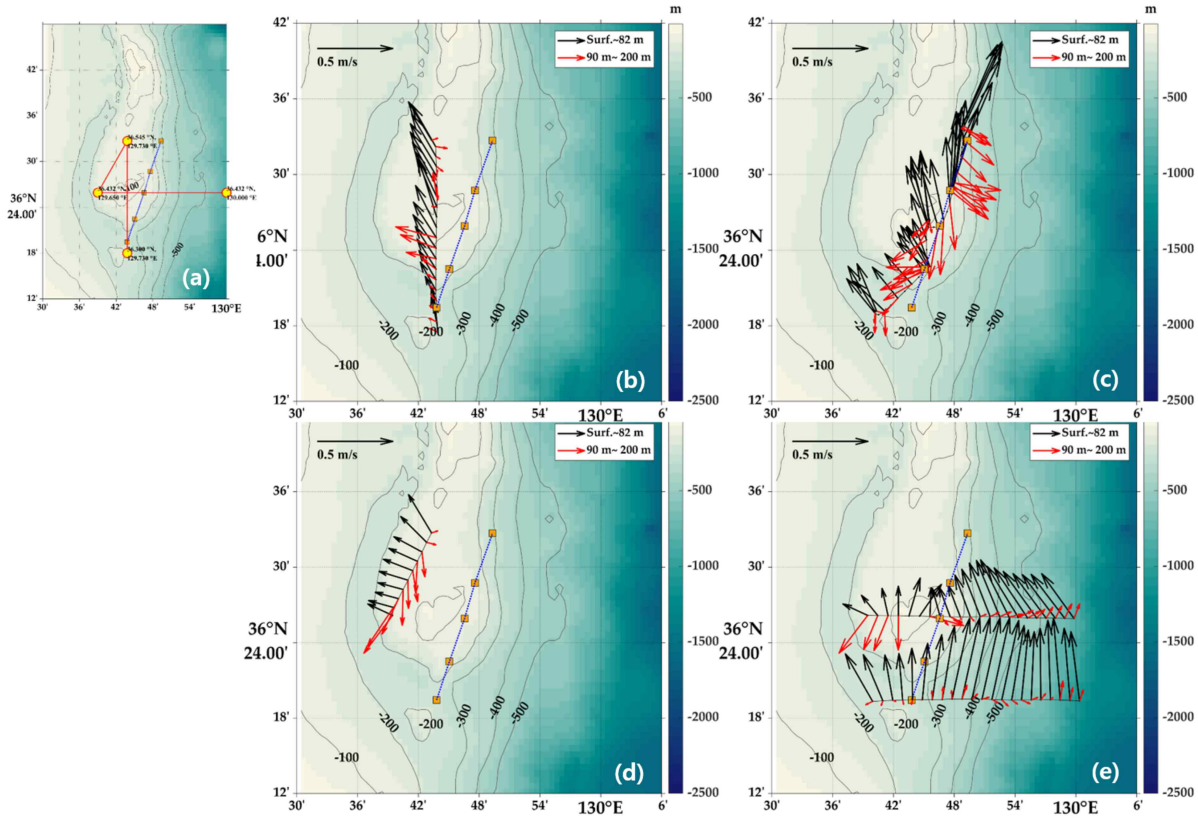


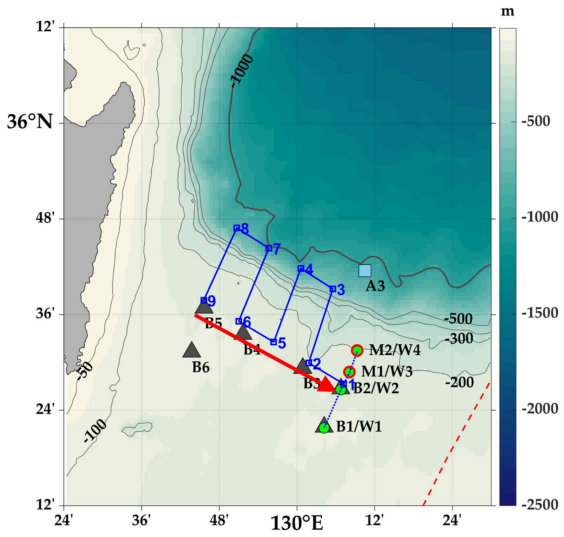
Figure 18. *SADCP measurements over the Hupo Bank taken between Dec. 6 and Dec. 7. (a) three SADCP lines and locations of Barny TRBM moorings with pressure-pods (filled square). (b, d, e) Measured velocity vectors along three lines. Lower zonal line in (e) was occupied between Dec. 4 and Dec. 5 as shown in Figure 14. (c) Velocity vectors along P1-P5 line occupide between Dec. 4 and Dec. 5 are also shown for comparison. Black and red arrows show depth averaged currents between surface to 82 m and between 90 m near to the seabed, respectively.*

⑤ VB1-VB26 line SADCP measurements (Figure 13)

SADCP measurement was conducted along VB1-VB26 line shown in Figure 13 on Dec. 10, 2021, where VMP and CTD-LADCP cast were made.

⑥ 1-9 line SADCP measurements (Figure 19)

SADCP measurement was conducted along 1-9 line between Dec. 10 and Dec. 11, 2021, which corresponds to the VS grid shown in Figure 13, where VMP and CTD-LADCP casts were made.

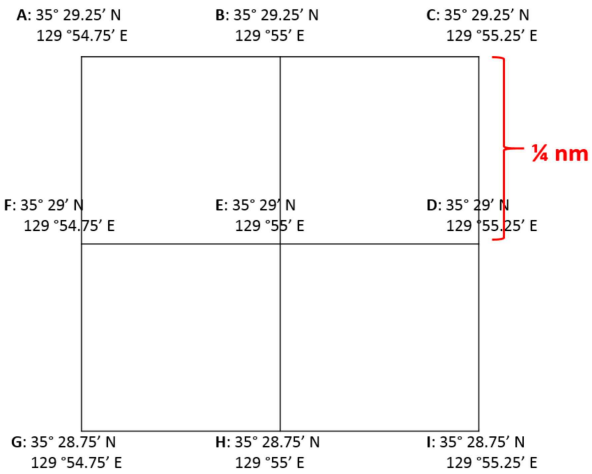


	Lon (°E)		Lat (°N)	
1	35	27.306	130	7.218
2	35	29.928	130	1.812
3	35	39.234	130	5.538
4	35	41.784	130	0.600
5	35	32.556	129	56.412
6	35	35.178	129	51.006
7	35	44.334	129	55.656
8	35	46.884	129	50.712
9	35	37.800	129	45.600

Figure 19. *SADCP measurement along 1-9 line, which corresponds to the VS grid shown in Figure 13, where VMP and CTD-LADCP casts were made. Locations of vertex points are shown on the right panel.*

(4) Launch of Carthe drifters

To map the near-surface circulation and to estimate the horizontal dispersion, 19 Carthe drifters were launched during the IOP 1 survey. Two Carthe drifters were released at nine points which constitute four grid boxes of about 450 m lenths (Figure 20).



	Lat (°N)		Lon(°E)		Num.
A	35	29.25′	129	54.75′	2
B	35	29.25′	129	55′	2
C	35	29.25′	129	55.25′	2
D	35	29′	129	55.25′	2
E	35	29′	129	55′	3
F	35	29′	129	54.75′	2
G	35	28.75′	129	54.75′	2
H	35	28.75′	129	55′	2
I	35	28.75′	129	55.25′	2

Total : 19

Figure 20. *Location of Carthe drifter release points.*

3-3. IOP 2 (August 2022)

The IOP 2 survey was conducted between August 4 and 8 on board of R/V Onnuri. Main purpose of the IOP 2 survey was to recover 11 Barny TRBM moorings and a subsurface line mooring at Station A3, all of which were deployed during the IOP 1 survey in December 2021.

All 11 Barny TRBM mooring sites were visited and it was confirmed through acoustic release communication that all moorings are in their original deployment positions marked during the IOP 1 survey. Pop-up buoys inside the Barny TRBM, however, did not surface even though the acoustic release command issued and the underwater acoustic release inside the Barny TRBM responded that it released the pop-up buoy. All the Barny TRBM moorings that we visited during the IOP 2 survey showed the similar response, which means there could be some systematic problem that hinders the surfacing of pop-up buoys. So it was failed to recover the Barny-TRBM moorings. Out 11 Barny TRBMs, one TRBM was recovered using a ROV in July 2023 on board of Onnuri under other NICOP project, and the recovered TRBM was found in an upside down position. The 2023 survey was abandoned due to the outbreak of Covid in the ship.

During the IOP2 survey, NRL's subsurface mooring at Station A3 was successfully recovered, and VMP and CTD-LADCP measurements were made at a number of stations in the northern and southern portions of the southwestern JES (Figure 21, Table 13).

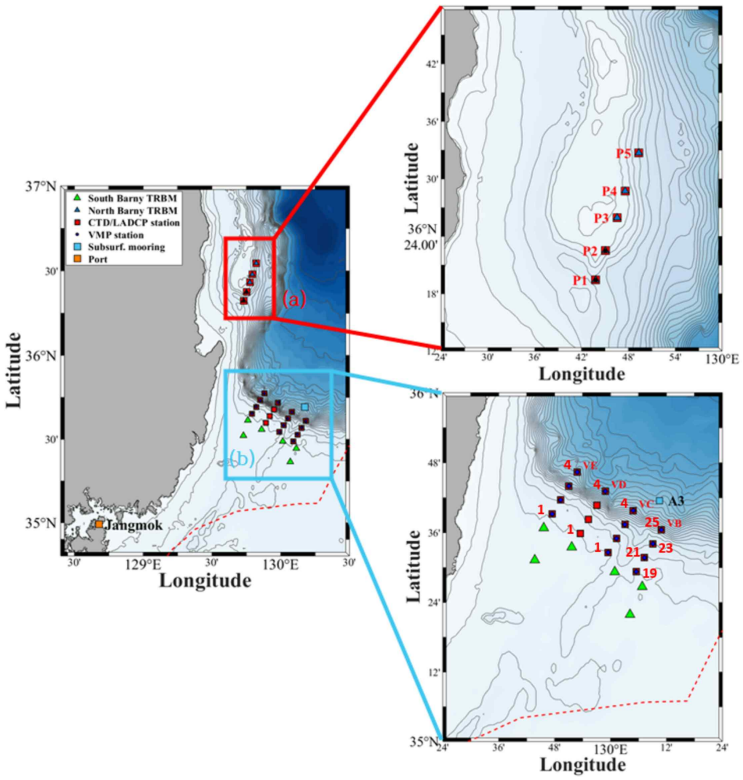


Figure 21. *Oceanographic stations occupied during the IOP2 Survey in August 2022. CTD and LADCP data was acquired at 21 station, and ε data was acquired at 16 stations (see text) using VMP. Locations of NRL's subsurface mooring (A3, green square) and Barny moorings (green triangles) are also shown.*

Table 13. Location and observation time of CTD-LADCP package VMP stations occupied during the IOP 2 survey.

No.	CTD-LADCP				VMP			
	Station	Lat. (N)	Long. (E)	Total Depth (m)	Lat. (N)	Long. (E)	Lowering Depth (m)	Observation Time
1	A3	35° 41.51′	130° 10.52′	944				
2	P1	36° 19.44′	129° 43.80′	208	36° 19.44′	129° 43.80′	200	08/05/22 02:35～02:58
3	P2	36° 22.50′	129° 45.06′	145				
4	P3	36° 25.95′	129° 46.55′	126				
5	P4	36° 28.74′	129° 47.58′	148				
6	P5	36° 32.71′	129° 49.33′	273	36° 32.71′	129° 49.33′	210	08/05/22 06:24～06:40
7	VB25	35° 35.70′	130° 09.94′	531	35° 36.51′	130° 10.89′	190	08/06/22 01:48～02:20
8	VB23	35° 33.72′	130° 08.86′	249	35° 34.11′	130° 09.09′	200	08/06/22 03:20～03:53
9	VB21	35° 31.75′	130° 07.78′	199	35° 31.71′	130° 07.29′	190	08/06/22 04:39～05:10
10	VB19	35° 29.78′	130° 06.69′	165	35° 29.31′	130° 05.49′	170	08/06/22 05:54～06:22
11	VC1	35° 32.61′	129° 59.48′	163	35° 32.61′	129° 59.4′	110, 140	08/06/22 20:40～21:28
12	VC2	35° 34.58′	130° 00.56′	202	35° 35.01′	130° 01.28′	140	08/06/22 22:02～22:52
13	VC3	35° 36.56′	130° 01.63′	262	35° 37.41′	130° 03.08′	140	08/06/22/23:34 ～ 08/07/22/00:31
14	VC4	35° 38.54′	130° 02.70′	490	35° 39.81′	130° 04.88′	210	08/07/22 01:22～02:19
15	VE1	35° 39.21′	129° 47.47′	162	35° 29.21′	129° 47.47′	90, 140	08/07/22 19:31～20:21
16	VE2	35° 41.19′	129° 48.54′	209	35° 41.61′	129° 49.27′	150, 160	08/07/22 21:21～22:07
17	VE3	35° 43.16′	129° 49.61′	311	35° 44.01′	129° 51.07′	180	08/07/22 23:05～23:41
18	VE4	35° 45.14′	129° 50.69′	686	35° 46.41′	129° 52.87′	170, 190	08/07/22/23:56 ～ 08/08/22/00:32
19	VD4	35° 41.84′	129° 56.69′	636	35° 43.11′	129° 58.87′	220	08/08/22 02:57～03:38
20	VD3	35° 39.86′	129° 55.62′	259				
21	VD2	35° 37.89′	129° 54.55′	196				
22	VD1	35° 35.91′	129° 53.48′	158				

5. Training Opportunities

A total eight university students from SNU at the times of surveys, seven postgraduate students and one undergraduate student, participated in the Pilot, IOP 1, and IOP 2 surveys and data analysis for the project (see Appendix 1). The surveys get the students to know most recent ocean observing technology. Also the project offers unique opportunities to the students to have improved knowledge on the turbulence and submesoscale physics in the southwestern JES.

6. Honor/Awards

None

7. Technology Transfer and Interaction with DoD Laboratories

The technical approach of the MJES project consists of moored current measurements and shipboard surveys in Economic Exclusion Zone (EEZ) waters (i.e. waters >12 nm from the coast). The platform support through the NICOP project enables NRL researchers to achieve the MJES objectives by providing with R/V platform service to perform two IOP 1 and IOP 2 surveys to acquire various datasets designed from the beginning of the project.

Researchers and two young technicians from GeoSR participated in the IOP 1 and IOP 2 surveys and data analysis for the project (see Appendix 1). The surveys provided researchers and young technicians from GeoSR with good opportunities in operating all moorings and to have knowledge about most recent technology and instruments for ocean observation such as Barny TRBM, MicroMoor, and WireWalker. The technicians from GeoSR had previous experience in operating VMP on the shallow shelf areas with total depth of shallower than 50 m, and the VMP operation in the JES on board of R/V Onnuri provided the techncians with valuable experience in operating VMP in deep waters by watching NRL technician's VMP operation on the ship.

Since the completion of field campaigns, NRL researchers have been interacting with Korean partners from KIOST, SNU, and GeoSR to share acquired data from the surveys and compare analyzed results. There will be a two-day workshop in March 2024 in Korea to discuss and present results from the NICOP projects (see Appendix 2).

8. List of publications

Peer-reviewed publications

The following two papers have been published using data acquired during the IOP 1 survey.

Wijesekera, H. W., Jarosz, E., Wang, D. W., Luecke, C. A., Teague, W. J., K.-I. Chang, J. H. Lee, S. Nam, H.-S. Min, and K. J. Lee (2022). Tidally driven mixing “hot spot” at the entrance of the Japan/East Sea. Geophysical Research Letters, 49, https://doi.org/10.1029/2022GL100315

Wijesekera, H. W., Luecke, C. A., Wang, D. W., Jarosz, E., Teague, W. J., K.-I. Chang, J. H. Lee, H.-S. Min, and S. Nam (2023). Mixing processes at the southwestern entrance to the Japan/East Sea. Journal of Physical Oceanography, https://doi.org/10.1175/JPO-D-23-0061.1

Presentations

Chang, K.-I., K. M. Kim, J. H. Lee, H.-S. Min, and S. Nam (2021) Oceanographic observation plan in the southwestern East/Japan Sea through Industry-University-Institute Cooperative Use of Research Vessels Program. Korean Society of Oceanography Fall Meeting, 4 Nov., 2021, Jeju, Republic of Korea

Jeong, Y. and S. Nam (2022) Observations on enhanced mixing over the steep continental slope in the southwestern East Sea (Japan Sea). PICES Annual Meeting, 29 Sept., 2022, Busan, Republic of Korea

Chang, K.-I. and H. W. Wijesekera et al. (2023) Introduction of MJES project: Mixing in the southwestern East Sea. Korean Society of Oceanography Fall Meeting, 1-3 Nov., 2023, SNU Siheung Campus, Republic of Korea (accepted)

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Lee, J. H. (2023) Role of ocean mixing and research trends. Korean Society of Oceanography Fall Meeting, 1-3 Nov., 2023, SNU Siheung Campus, Republic of Korea (accepted)

Lee, J. H., H.-S. Min, K.-I. Chang, I. Bang, K.-M. Kim, S.-O. Lee, and D. G. Kim (2023) Results of turbulence measurements on the continental shelf of the southwestern East Sea. Korean Society of Oceanography Fall Meeting, 1-3 Nov., 2023, SNU Siheung Campus, Republic of Korea (accepted)

9. Distribution/Availability Statement

Approved for public release

Appendix: List of cruise participants

Survey	R/V	Period	Name	Current email	Institution*	Student status*
Pilot survey	Haeyang 2000	Nov. 2021	Suyun Noh	synoh@kiost.ac.kr	SNU	PhD course
			Hyung-Bo Kim	hbkim1017@gmail.com		PhD course
			Hojun Lee	generalhojun@gmail.com		PhD course
			Day Hong Kim	dhkim@geosr.com		MSc course
			Yeon Choi	king.yeon505@gmail.com		PhD course
Shelf Exp. 1	Eardo	Dec. 2021	Hong Sik Min	hsmin@kiost.ac.kr	KIOST	NA
			Dong Guk Kim	kdk21ca@kiost.ac.kr		
			Sung-Oh Lee	solee@geosr.com	GeoSR	
			Hee Yeop Jung	guldoya@naver.com		
			Seung-Woo Lee	lsw.ocean@kiost.ac.kr	SNU	PhD course
			Yeon Choi	king.yeon505@gmail.com		PhD course
IOP 1	Onnuri	Dec. 2021	Kyung-Il Chang	kichang@geosr.com	GeoSR	NA
			Inkweon Bang	bangik@geosr.com		
			Young-Suk Jang	ysjang@kiost.ac.kr	KIOST	
			Bonhwa Ku	bhku@kiost.ac.kr		
			KyungJae Lee	kjlee83@kiost.ac.kr	SNU	PhD course
Shelf Exp. 2	Haeyang 2000	Aug. 2022	Sung-Oh Lee	solee@geosr.com	GeoSR	NA
			Hee Yeop Jung	guldoya@naver.com		
			Tae Il Bae	tibae@geosr.com		
			Day Hong Kim	dhkim@geosr.com	SNU	MSc course
			JeongHyun Kim	jhkimee@snu.ac.kr		Undergraduate
IOP 2	Onnuri	Aug. 2022	Hong Sik Min	hsmin@kiost.ac.kr	KIOST	NA
			Kyung-Il Chang	kichang@geosr.com	GeoSR	
			Sang-Chul Hwang	schwang@naver.com		
			Jae Hak Lee	leejh@geosr.com		
			Hohyun Sung	hhsung@geosr.com		
			Dong Hwan Lee	ehdqhks0320@naver.com		
			Yeongseok Jeong	jysen11@gmail.com	SNU	Undergraduate
			JooHyang Kim	joohyang7993@gmail.com		MSc course

Other participant (data analyst): Hyeonyeong Kwak (GeoSR, hykwak@geosr.com)
* Institutions and student status are those at the time of surveys.

Appendix 2. MJES Workshop Program

Workshop Program:

Role of Mixing in the Southwestern Japan/East Sea (MJES)

March 22-23, Seogwipo KAL Hotel (Hallajung)

Hosted by

Korea Institute of Ocean Science and Technology (Hong Sik Min, hsmin@kiost.ac.kr)
GeoSystem Research Corporation (Kyung-Il Chang, kichang@geosr.com)
Naval Research Laboratory (Hemantha Wijesekera, hemantha.wijesekera@nrlssc.navy.mil)

Friday 22 March, 2024

Time	Speaker	Title
Chair:	**Hong Sik Min, KIOST**	40 min. talks
10:00-10:20	KI Chang, GeoSR	Welcome, introduction
10:20-10:50	KI Chang, GeoSR Hemantha Wijesekera, NRL	Overview of MJES field campaigns
10:50-11:30	Hemantha Wijesekera, NRL	Small-scale processes at the southwestern entrance to the Japan/East Sea
11:30-12:10	Jae-Hak Lee, GeoSR	The observation of turbulence in the souwestern continental shelf
12:10 – 14:00	Lunch	
Chair:	**Jae-Hak Lee, GeoSR**	40 min. talk
14:00 – 14:40	Young Gyu Park, KIOST	Estimation of vertical eddy diffusivity over the southwestern East/Japan Sea
14:40 – 15:20	Hemantha Wijesekera, NRL	Observed and simulated sub-seasonal, mesoscale variability in the southern Japan/East Sea
15:20 – 16:00	KI Chang, GeoSR	Low-frequency currents in the upwelling zone off the southeastern coast of Korea
16:00-16:30	Jae-Hyoung Park, PKNU	Temporal change in bottom water temperature in the southwestern coast of the East Sea
17:30	Dinner	Hosted by KIOST & GeoSR

Saturday 23 March, 2024

Time	Speaker	Title
Chair:	KI Chang, GeoSR	40 min. talks
09:00-09:40	Conrad Luecke, NRL	A transport pathway in the East Sea/Sea of Japan
09:40 – 10:20	Sergio Derada, NRL	Meteorology and Oceanography (METOC) modeling in the Japan/East Sea
10:20 – 11:00	Young Ho Kim, PKNU	Impact of regional observing system in the Korean marginal seas on northwestern Pacific prediction
11:00 – 11:20	Break	
11:20 – 12:20	Hemantha Wijesekera, NRL	Discussion, Questions, Future collaboration
12:20 – 12:30	KI Chang	Wrap-up

Appendix 3. Number of CTD-LADCP and VMP stations occupied during the period of MJES project

Report	Surveys (R/V)	Duration (YYYY/MM/DD)	Number of stations		
			CTD	LADCP	Microprofiler
Curise report (SNU)	Pilot survey (Haeyang 2000)	2021/11/13～16	28 stations including 1 continuous station for 25 hours (26 profiles)	X	SNU VMP: 19 stations including 1 continuous station for 25 hours (15 profiles)
Cruise diary (GeoSR)	IOP 1 (Onnuri)	2021/12/03～14	VB line 10 stations VS grid 13 stations VP line 5 stations Barny mooring lines 9 stations	VB line 10 stations VS grid 13 stations VP line 5 stations Barny mooring lines 9 stations	NRL VMP: VB line 18 stations VS grid 21 stations VP line 10 stations
NA	IOP 2 (Onnuri)	2022/08/04～08	22 stations	22 stations	GeoSR VMP: 15 stations
Project Report (KIOST)	Shelf Exp. 1 (Eardo)	2021/12/09～15	1 continuous station (63 profiles)	1 continuous station (62 profiles)	KIOST MSP: 1 continuous station (62 profiles)
NA	Shelf Exp. 2 (Haeyang 2000)	2022/07/29～08/03	1 continuous station (21 profiles)	X	X
Total stations			89 stations including 3 continuous stations	60 stations including 1 continuous station	84 stations including 2 continuous stations

Appendix 4. Data storage and sharing for MJES data taken during 5 cruises.

Stations	Items	Data storage		Web sites
		Raw	Processed	
Pilot survey (including KU3 data)	CTD	√	√	www.dropbox.com
	VMP	√	√	
	Underway	√	√	
	Log note	SNU cruise report		
	Reports	NICOP report, SNU report		
Shelf Exp. 1	CTD	√	√	
	LADCP	√	√	
	MSP	√	√	
	M1 ADCP	√	√	
	M2 ADCP	√	√	
	M3 ADCP	√	√	
	Underway	√	√	
	Log note	?		
	Reports	NICOP report, KIOST report, SNU report		
Shelf Exp. 2	CTD	√	√	
	M1 ADCP	√	√	
	M2 ADCP	√	√	
	Underway	√	√	
	Log note	?		
	Reports	NICOP report		
Station L1	ADCP	√	√	
IOP 1	Underway	NRL, KJ Lee		
	MicroMoor	NRL, KJ Lee	NRL	
	Line mooring A3	NRL	NRL	
	WireWalker	NRL, KJ Lee	NRL	
	VMP	NRL, KJ Lee	NRL	
	Carthe drifter	Pacific Gyre?		
	Log notes	KI Chang (cruise summary), NRL (NRL items), KJ Lee (CTD-LADCP)		
	Reports	NICOP report (GeoSR), SNU report		
IOP 2	CTD	SNU	SNU	
	LADCP	SNU	not processed	
	VMP	GeoSR	GeoSR	
	Underway	SNU?		
	Log notes	SNU (CTD-LADCP), GeoSR (VMP)		
	Reports	NICOP (GeoSR), SNU report		

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14. ABSTRACT

The proposed effort provided for Korean support of the US Naval Research Laboratory (NRL) component of a US-Korea collaboration on mixing processes in the southwestern Japan/East Sea (MJES). It complemented a previous NICOP grant (N62909-20-1-2049) to support the Korean component of the scientific collaboration. The overall goal of MJES is to evaluate how small-scale processes impact on the Japan/East Sea (JES) mixing and circulation. Three oceanographic surveys were completed and this report summarizes how the support was achieved with acquisition of data during the cruises.

15. SUBJECT TERMS

oceanographic observations, research vessel, turbulence, mixing, currents, water masses, Japan/East Sea

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES
a. REPORT	b. ABSTRACT	C. THIS PAGE		
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