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YK17-E01

(19-25 December 2017)

Preliminary Cruise Report

JAMSTEC / NOAA

January 2018

https://www.pmel.noaa.gov/ocs/KEO

Contents

YK17-E01 Preliminary Cruise Report

1. Cruise information

Makio Honda (JAMSTEC)

(1) Cruise designation (research vessel)

YK17-E01 (R/V YOKOSUKA)

(2) Cruise title and introduction

=Title=

Emergency Cruise for recovery/re-deployment of drifting NOAA KEO buoy

=Introduction=

The KEO time-series station in the western Pacific subtropical gyre was established in 2004 by Pacific Marine Environmental Laboratory (PMEL) of National Ocean and Atmosphere Administration (NOAA). For the sake of investigation of air-sea heat and carbon fluxes, a surface buoy mooring which is equipped with various physical and meteorological sensors has been deployed at KEO and has been turned around approximately once a year. In July 2017, the latest mooring system (S/N: KE-015) was deployed (sinker position: 32°25.24'N / 144°31.83'E) and started time-series observation. Since July 2014, adjacent to KEO buoy, JAMSTEC time-series sediment trap experiment has been conducted in order to investigate nutrient supply mechanism to the oligotrophic subtropical upper layer. For this purpose, JAMSTEC backscatter meters with fluorometer were also installed on KE-015 KEO buoy mooring line.

However, KEO buoy accidentally started to leave its nominal position on 19th October 2017. According to position data from GPS system on KEO buoy, in the early stage, KEO buoy drifted westward. Based on sensor signal, mooring system was suspected to be partitioned below 425 m and KEO buoy was suspected to drift with sensors upper 425 m including JAMSTEC backscatter meters. After KEO buoy met the Kuroshio current, it headed to north. Sequentially, in middle November, KEO buoy started to drift eastward along the Kuroshio extension. Although we were afraid of the worst scenario: KEO buoy would drift too far east to be recovered, fortunately, drifting KEO buoy left the Kuroshio extension in late November and headed to south. In early December, along weak clockwise flow south of the Kuroshio extension, KEO buoy was getting closer to its initial position. Indeed, it could have been worse.

After occurrence of this accident, NOAA informed this accident to the world and looked for

any ships available for rescue of drifting KEO buoy, including ships from government (US / Japan coastguard) and private salvage company. On the other hand, NOAA consulted JAMSTE about rescue of drifting KEO buoy. After long discussion, negotiation and big efforts, JAMSTEC decided to send JAMSTEC research vessel, R/V Yokosuka, for this mission under umbrella of Memorandum of Understanding (MOU) between JAMSTEC and NOAA.

After rigging mooring gears such as winch and winding machine and loading NOAA equipment, R/V Yokosuka sailed on 19th December 2017 from JAMSTEC Yokosuka headquarter pier.

(3) Principal Investigator (PI)

Makio Honda

Principal Research Scientist

Research and Development Center for Global Change (RCGC)

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

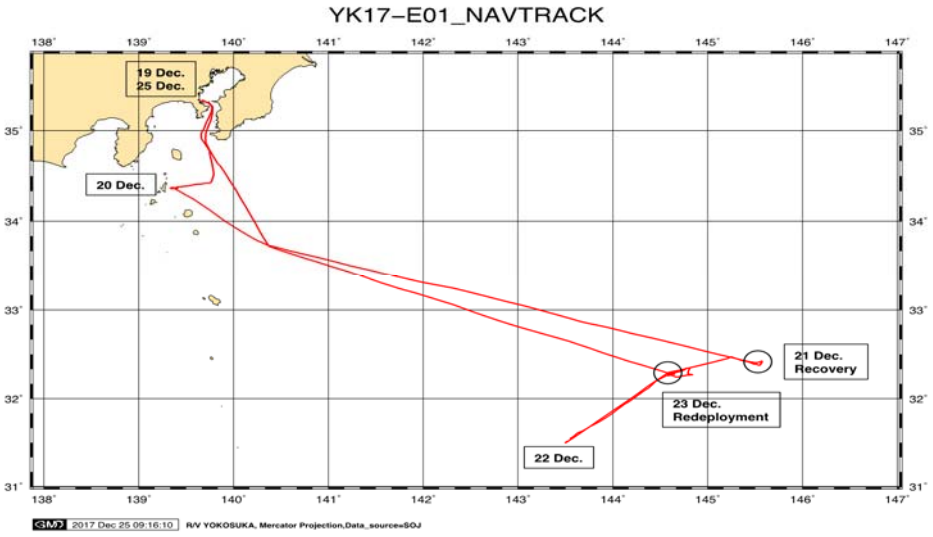
(4) Cruise period (port call)

19 December 2017 (JAMSTEC Yokosuka HQ) - 25 December 2017 (JAMSTEC Yokosuka HQ)

(5) Cruise region (geographical boundary)

The western North Pacific Subtropical area (30°N – 35°N / 140°E – 150°E)

(6) Cruise track



2. Outline of YK17-E01

Makio Honda (JAMSTEC)

(1) Objective of this cruise

To recover drifting KEO buoy

To re-deploy KEO buoy

To recover partitioned mooring remnants

(2) Cruise summary

Weather and sea condition was not always good for mooring work. We were forced to wait days of recovery and redeployment of KEO buoy for one day each. However we successfully completed this “mission impossible”.

1) Recovery of drifting KEO buoy

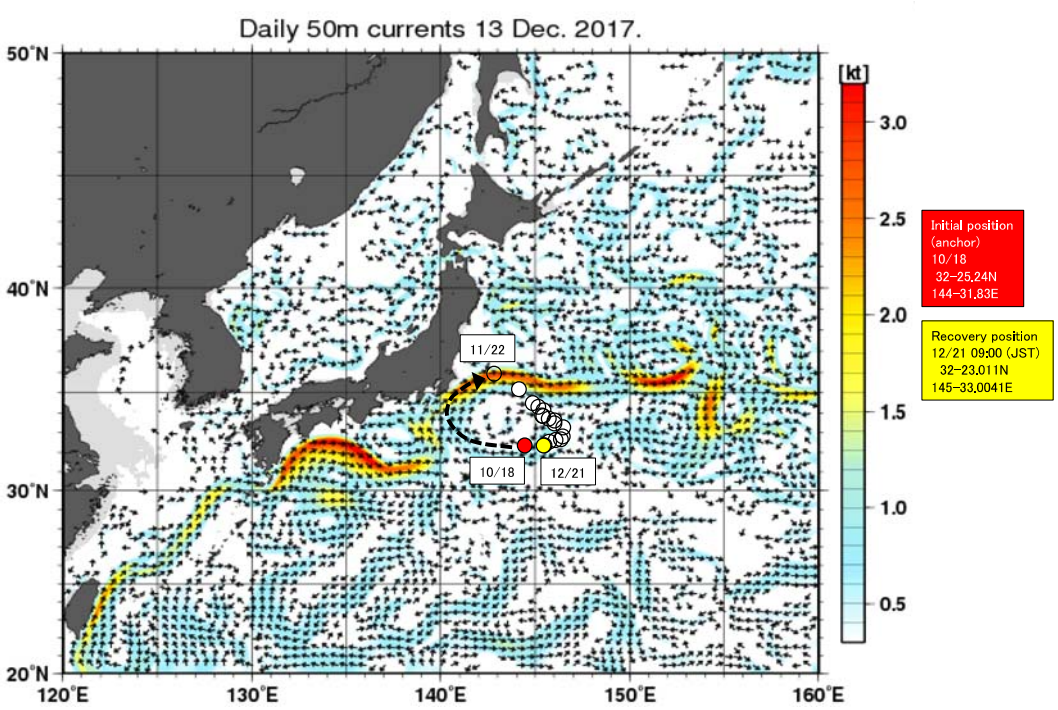


Fig. 1 Drifting track of KEO surface buoy between 18 October and 21 December 2017. Background is current direction and velocity on 13 December 2017 predicted by Japan Meteorological Agency.

In the early morning on 21st December 2017, the drifting KEO buoy was found at only about 60 miles eastward form the latest anchor position (Fig. 1).

Recovery work was conducted safely and successfully. It was found that wire rope was partitioned at about 425 m water depth, just below 425 m CTD sensor. Curiously, there was a knot (or hitch) of wire rope about 13 m above 425 m CTD sensor. Working record for recovery was as follows:

TIME RECORD

RECOVERY

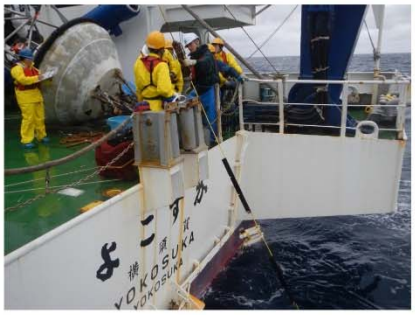
Cruise:	YK17-E01		Wave Hight:	2.0-2.5m	
Start Position:			WIND Direction/Speed	Date(UTC):	21-Dec-17
32-22.7477N	N		329deg/ 8.4m/s	Start time(UTC)	00:04
145-33.2190E	E		Crrent Direction/Speed	Finish time(UTC)	05:15
Water Depth:	5,901m		225.6deg/ 0.5m/s	Recorder:	M.Honda

Component	S/N	TIME(UTC)	MEMO	
KEO BUOY	----			
TP-5m		03:15	biofouling	
AQUADOPP-8.46m		03:28	biofouling	
TC-10m		03:34	biofouling	
TC-15m		03:35	biofouling	
AQUADOPP-18.46m		03:37	biofouling	
T-20m		03:39	biofouling	
Backscatter-23m		03:42	biofouling	
TC-25m		03:44	biofouling	
TC-35m		03:59	change to No10wintch	biofouling
AQUADOPP-36.46m		04:01		
T-40m		04:03		
TCP-50m		04:05		
AQUADOPP-68m		04:08		
TCP-75m		04:11		
TCP-100m		04:15		
Backscatter-103m		04:18		
TCP-125m		04:25	No biofouling	
TCP-150m		04:33		
TCP-175m		04:36		
PAL-200m		NA		
TCP-225m		04:38		
TCP-275m		04:50		
TCP-325m		05:02		
TP-375m		05:12		
TCP-425m		05:15	(1) Partitioned just below 425 m sensor (2) Hitch exists at wire of 12.75 m above 425 m CTD sensor	
TP-475m				
TCP-525m				
End of WIRE	----			
NYLON-10m	----			
NYLON-380m	----			
NYLON-349m	----			
NYLON-342m	----			
NYLON-4941m	----			
POLY-2322m	----			
GLASS BALL	----			
A/R	----			

find out KEO buoy	2017/12/20/20:07			
let down the boat	00:20			
connect Working line to buoy	00:50			
pick up the boat	01:05			
KEO buoy top-section on deck	01:55			
end of Mooring rope on deck	05:15			

Photo library: Recovery of drifting KEO buoy


↑UP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2) Redeployment

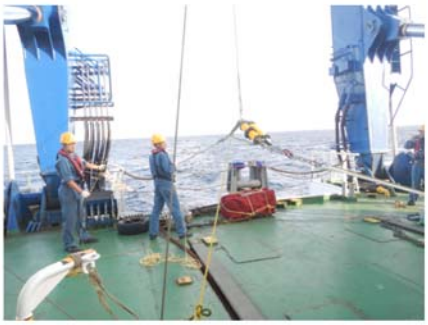
After one day wait / preparation, KEO buoy was successfully re-deployed on 23rd December 2017. Anchor position was determined by using onboard SSBL system. Real time data obtained by KEO buoy mooring is available on NOAA PMEL Kuroshio extension observatory homepage (https://www.pmel.noaa.gov/ocs/). KEO buoy will be turnaround in summer 2018. Working record for re-deployment was as follows:

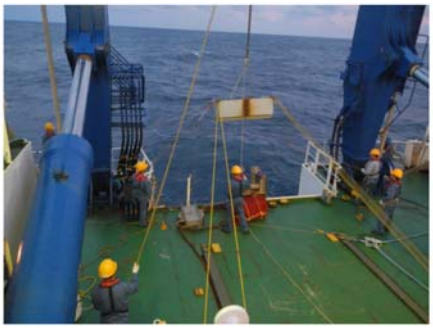
TIME RECORD

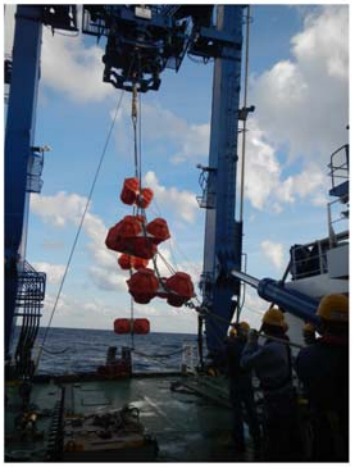
DEPLOYMENT

Cruise:	YK17-E01		Wave Hight:	m	
Start Position:			WIND Direction/Speed	Date(UTC):	23-Dec-17
32-16.1412	N		228deg/ 7.2m/s	Start time(UTC)	23:42
144-50.3467E	E		Crrent Direction/Speed	Finish time(UTC)	09:50
Water Depth:	6,162m		298.4deg/ 0.9m/s	Recorder:	M.Honda
Component	S/N		TIME(UTC)	MEMO	
KEO BUOY	----		23:55		
TP-5m					
AQUADOPP-8.46m					
TC-10m					
TC-15m					
AQUADOPP-16.46m					
T-20m					
Backscatter-23m					
TC-25m					
TC-35m					
AQUADOPP-36.46m					
T-40m					
TCP-50m			23:57		
AQUADOPP-68m			00:05		
TCP-75m			00:09		
TCP-100m			00:18		
Backscatter-103m			00:20		
TCP-125m			00:28		
TCP-150m			00:34	0-150m plastic faring panel	
TCP-175m			00:37		
TCP-225m			00:41		
TCP-275m			00:50	240-340m Plastic fairing panel	
TCP-325m			01:06		
TP-375m			01:16		
TCP-425m			01:23		
TP-475m			01:35		
TCP-525m			01:41	Insulation rock used because of malfunction of attachment	
End of WIRE	----		02:05		
NYLON-10m	----		02:20		
NYLON-380m	----		Connection 02:42, 02:52, 03:03, 03:13, 03:23, 03:33, 03:45		
NYLON-349m	----				
NYLON-342m	----				
NYLON-4941m	----				
POLY-2322m	----		04:04,04:10,04:35	There are some surface scratchs. Repaired by tapes	
GLASS BALL	----		05:38		
A/R	----		05:52		
Anchor Let it GO			07:30		
Calibrated Position					
32-16.6040	N		08:30 visibe inspection→OK		
144-35.2671	E		08:35 certification of sensor condition →OK		
Ancor Depth			09:15 Onboard SSBL system used for positioning instead of Deck set		
5707.01	m				

Redeployment of KEO buoy







3) Recovery of partitioned mooring line

Because of bad weather / sea condition and possibility that buoyancy of glass floats was not enough for glass floats, which connects long pp / nylon rope, to be back to sea surface, NOAA decided that recovery of mooring remnant was cancelled during this cruise.

(3) Cruise log

December 2017

19th 9:00 (JST) Sail (Yokosuka Headquarter pier)

21st 8:00 (JST) - Recovery of drifting KEO buoy

23rd 8:00 (JST) - Redeployment of KEO buoy

25th 9:00 (JST) Port call (Yokosuka Headquarter pier)

(4) Cruise participant

Name	Affiliation	Appointment
Makio Honda (PI)	RCGC, JAMSTEC	Principal Research Scientist
Denise Kester	University of Washington	Research Engineering Technician
Ryan Wells	University of Washington	Research Scientist / Engineer
Satoshi Ozawa	Marine Works Japan Inc.	Marine Technician
Shungo Oshitani	Marine Works Japan Inc.	Marine Technician

3. KEO buoy mooring work

Jennifer Keene (University of Washington)
Meghan Cronin (PMEL, NOAA)
Denise Kester (University of Washington)
Ryan Wells (University of Washington)

3.1 Introduction

The NOAA Ocean Climate Stations Kuroshio Extension Observatory (KEO) surface mooring is located south of the Kuroshio Extension current, at 32.3°N, 144.6°E. It was first deployed in June 2004, as an element of the Kuroshio Extension Systems Study (KESS). KESS was a two-year process study, funded by the National Science Foundation (NSF), to investigate interactions between the Kuroshio Extension and its recirculation gyre. At the conclusion of KESS in February 2007, a NOAA partnership with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC)'s Institute of Observational Research for Global Change (IORGC) was formed, continuing work at the site. The mooring is serviced annually, and was deployed for the 14th year in July 2017.

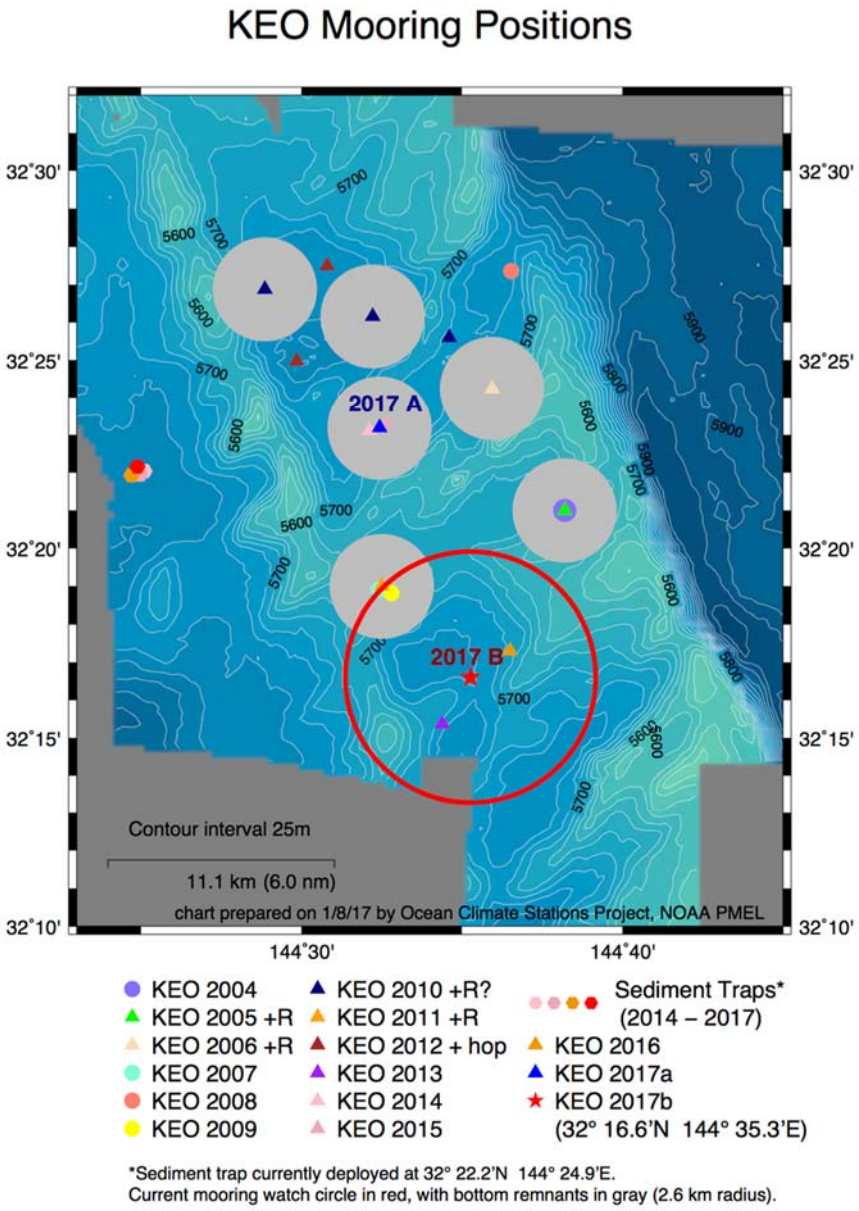


Figure 1: History of mooring deployments at KEO site. Current watch circle shown in red. Gray circles show broken remnants.

The KEO mooring carries a suite of instrumentation to monitor air-sea exchanges of heat, moisture, momentum (wind stress), and carbon dioxide; surface ocean acidification; and upper ocean temperature, salinity and currents. These data, combined with data from the nearby JAMSTEC sediment trap, enable computation of the physical and biological pumps of the carbon cycle in a key region of the North Pacific. As such, it has become a focal point for international climate research. More information about the mooring and KEO site can be found here: https://www.pmel.noaa.gov/ocs/KEO

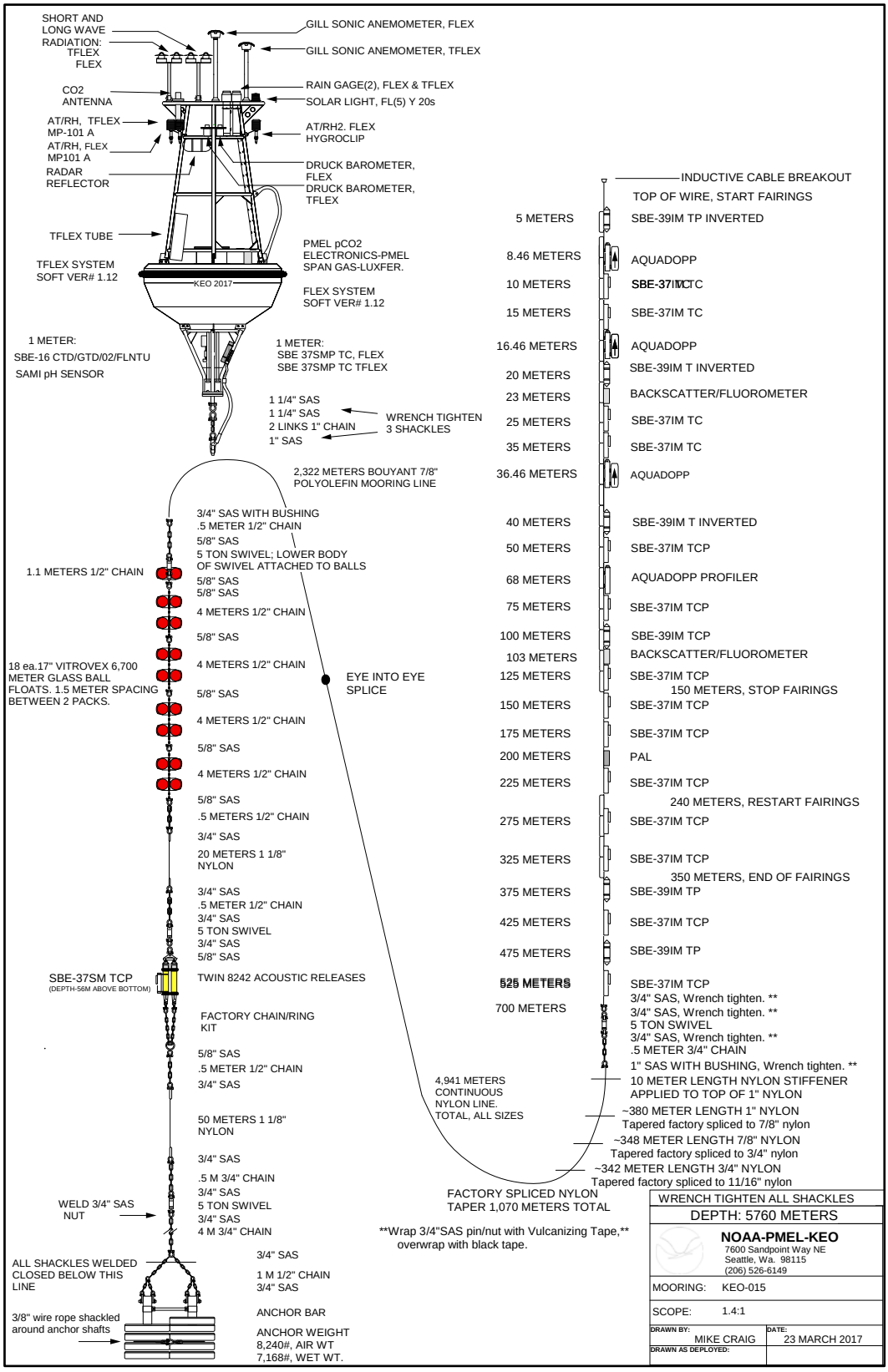


Figure 2: Diagram of NOAA KEO mooring.

On October 19, 2017, the KEO mooring broke from its anchor and began drifting. It initially moved west, toward Japan. Carried by winds and currents, the buoy began to move north, and then east. There was concern that the buoy would get caught in the jet of the Kuroshio Extension current, and be carried into the open ocean. Surprisingly, it stayed in a recirculation gyre of the current. The buoy had almost returned to its original anchor position by the time it was recovered.

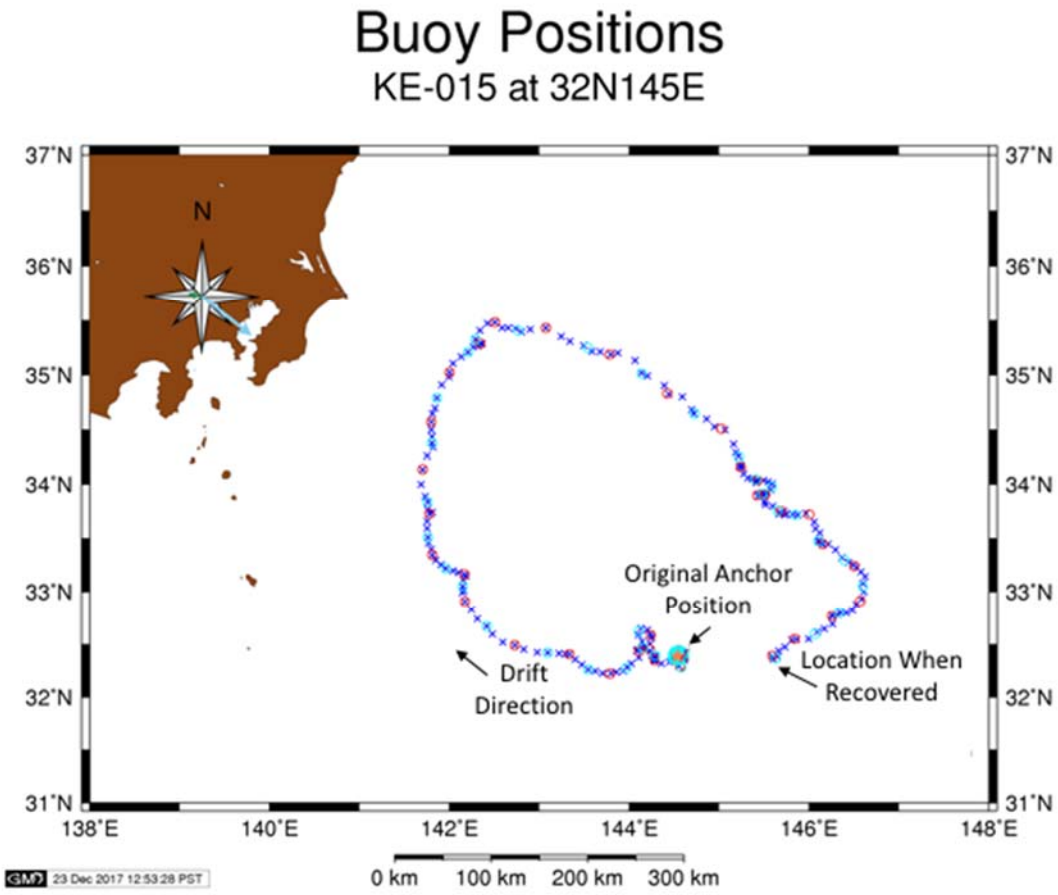


Figure 3: GPS positions recorded by the drifting KEO buoy.

Immediately after the buoy was known to be adrift, the search for a rescue ship began. Personnel at PMEL reached out to NOAA assets, the US Navy, the US Coast Guard, and private US vessel operators. With assistance from Dr. Honda at JAMSTEC, the Japan Coast Guard was contacted, as well as JMA, and three charter companies to try to find any available vessel to rescue the buoy. The search for a rescue ship continued even after the generous offer was made to use the JAMSTEC fleet, in the hope that the rescue mission could be accomplished sooner. At the time, no one expected the buoy to get caught up in the gyre, and there was concern that it would

get too far away from shore to be rescued at all, if the mission was delayed. Fortunately, the buoy turned back west and was easily recovered aboard the *S/V Yokosuka*. NOAA and PMEL are very grateful for the aid provided by JAMSTEC for this mission.

3.2 Mission impossible: Recovery / Redeployment

(1) Recovery of drifting KEO buoy

The ship arrived on site on Thursday, December 21, 2017. By 6:30am (local time), the drifting buoy was spotted at 32°24.264'N, 145°34.402'E. Before operations began, the Chief Officer conducted a safety meeting, and then the small boat was launched with four Japanese crew on board to capture the buoy. Four tag lines were attached to the buoy in addition to the lifting line. Once on deck, the buoy was disconnected and moved out of the way, so that the retrieval of the mooring line and subsurface instruments could begin.

For subsurface instrument recovery, the wire was passed through a block on the A-frame. Instruments were removed at the rail, and then carried inside the sub bay for documentation and cleaning. There was no sign of fishing gear on the mooring line.

Figure 4: Subsurface instrument being removed from the wire.

After about 200m of wire had been recovered, it was already noticeable that the line seemed to be light, with little tension on it. The wire was found to be broken just beneath the

bottom clamp of the 425m instrument. Approximately 12.75m above the 425m sensor, there was a knot in the wire. The instrument deployed at 425m was still attached to the wire, though it looked as if it had slid down about 1” on the cable.

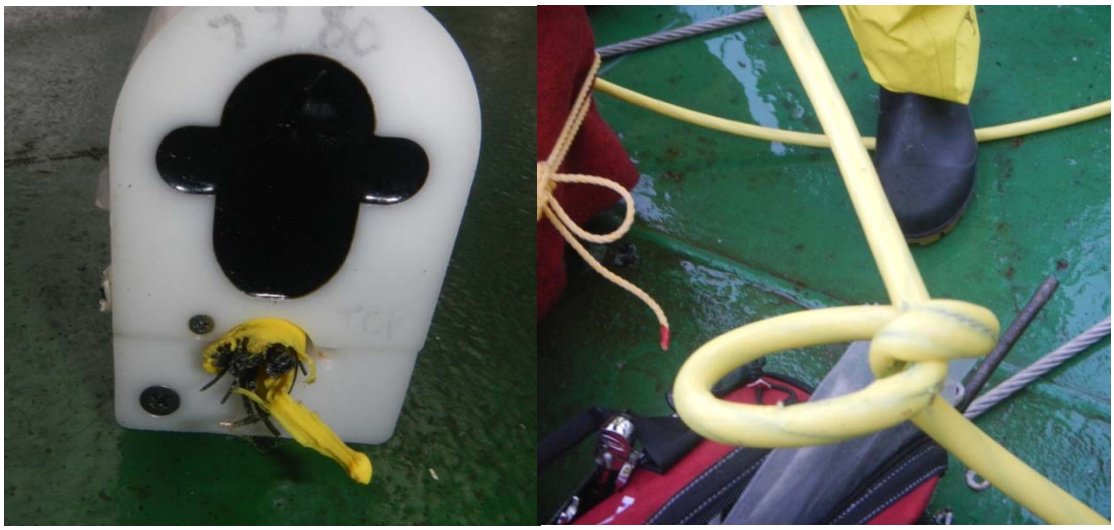


Figure 5: Break (left) and knot (right) in mooring wire.

The broken end of the mooring wire was cut off and sent by air shipment back to PMEL when the ship returned to port. Due to delays in customs clearance, the shipment has not yet left Japan (as of January 12, 2018). When it does reach Seattle, the broken end will be analyzed to try to determine the exact cause of the break. Knots in the wire are unusual, and the cause in this case is unknown. PMEL mooring engineers have never seen a knot or break like this before. Any information learned in the break analysis will be shared with JAMSTEC for future reference.

The specifications of the wire rope are as follows:

Manufacturer: Loos and Co., Inc.

Type: Galvanized steel rope, 3x19 improved plow steel

Diameter: 7/16” diameter (jacketed to 1/2” diameter)

Minimum Break Strength: 18,400 lbs.

The total recovery time from when the small boat contacted the buoy until the last sensor was brought on board was 4 hours and 49 minutes.

(2) Redeployment

Redeployment operations began the morning of December 23, 2017. The first 60m of wire had been laid out on deck, and instruments and fairings were installed in advance. As the buoy was lifted overboard, this top portion of wire was carried and put into the water by hand. The wire was then run through a block on the A-frame, and the remaining subsurface instruments were installed at the rail.

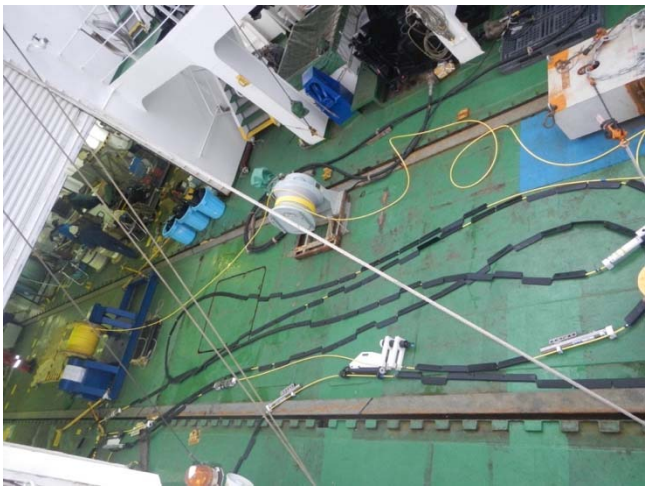


Figure 6: Mooring wire with instruments and fairings installed on deck.

The wire was followed by nylon, and then polyolefin line. Several small snags were noticed in the polyolefin during deployment. These were wrapped with electrical tape for extra precaution. Glass balls were attached and lowered into the water from the A-frame. Another short section of nylon was put in-line, followed by dual acoustic releases. The buoy and mooring line were towed for about two hours, while the anchor was moved into position. (The size and shape of the anchors made this process difficult.) The anchor was deployed through the A-frame.

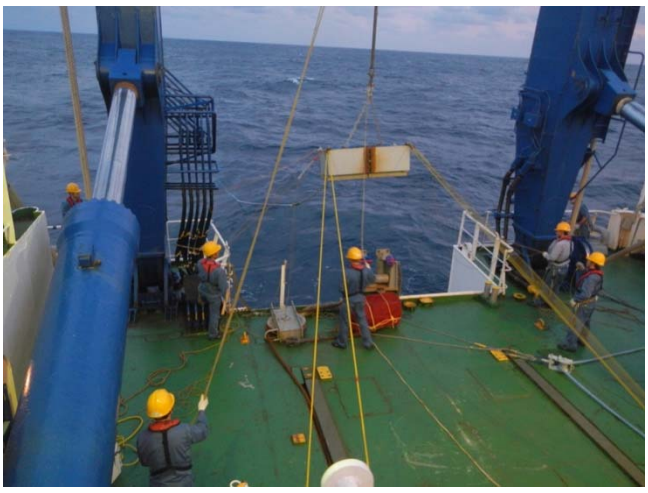


Figure 7: Block anchors deployed through the A-frame.

The final anchor position and water depth were determined by using the ship's SSBL system to range on the acoustic release. The anchor fallback was 231.7m. Water depth was 5,707m, making the final mooring scope 1.435:1.

Final anchor position:

32° 16.604'N, 144° 35.267'W

The total deployment time, from the time the buoy was lifted off the deck until the anchor was dropped was 7 hours and 43 minutes.

(3) Recovery of partitioned mooring system

Though it was hoped that the partitioned mooring remnant at the anchor location could be recovered during this cruise, the decision was made not to attempt recovery. After learning where in the line the mooring broke, there was concern that the glass balls at the bottom of the mooring would not have enough floatation to bring the gear to the surface quickly. The gear could be carried far away from the ship in subsurface currents. Also, with poor weather conditions, it could be difficult to see the gear on the surface. Jennifer Keene at PMEL made the decision not to try to recover the remnant during this cruise.

NOAA PMEL Acknowledgements:

In addition to the acknowledgements below, NOAA PMEL extends special thanks to Dr. Makio Honda for his role in making this mission possible.

Acknowledgment

Captain and ship crew of R/V Yokosuka

Marine technician from Marine Works Japan Inc.

JAMSTEC board members including Director Dr. Asahiko Taira

and JAMSTEC colleagues from

Ship operation department

Research support department

International affair division