

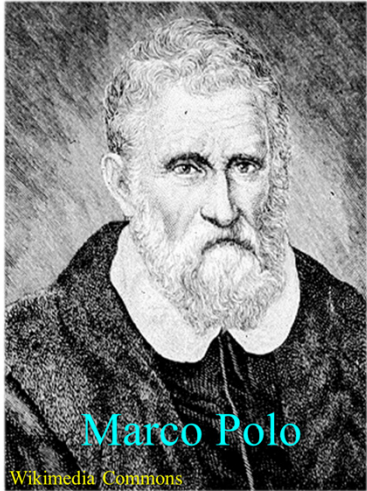
複数AUVと洋上中継器で構成した純無人型 探査ユニットによる海底熱水地帯の潜航調査

Near-Bottom Survey of a Hydrothermal Vent Site by Deploying an
Unmanned Exploration Unit of ASV-Controlled Multiple AUVs

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Zipangu: Land of Gold



"People on the Island of Zipangu (Japan) have tremendous quantities of gold. The King's palace is roofed with pure gold, and his floors are paved in gold two fingers thick." - The Travels of Marco Polo (13th century)

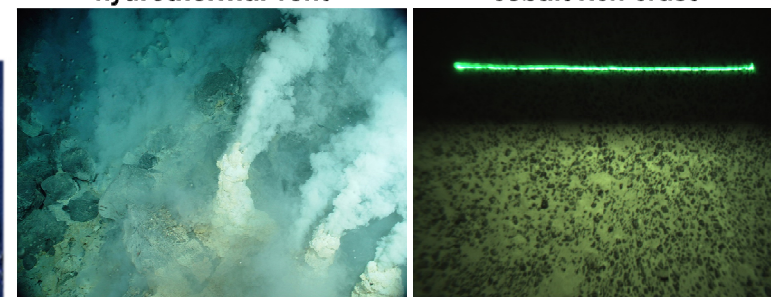


Searching for the Zipangu in the Sea

Seabed Mineral Resources

hydrothermal vent

cobalt-rich crust



rare earth
(aluminum silicate)

- : hydrothermal deposit
- : cobalt-rich crust
- : rare earth

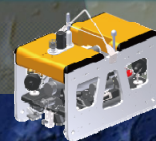
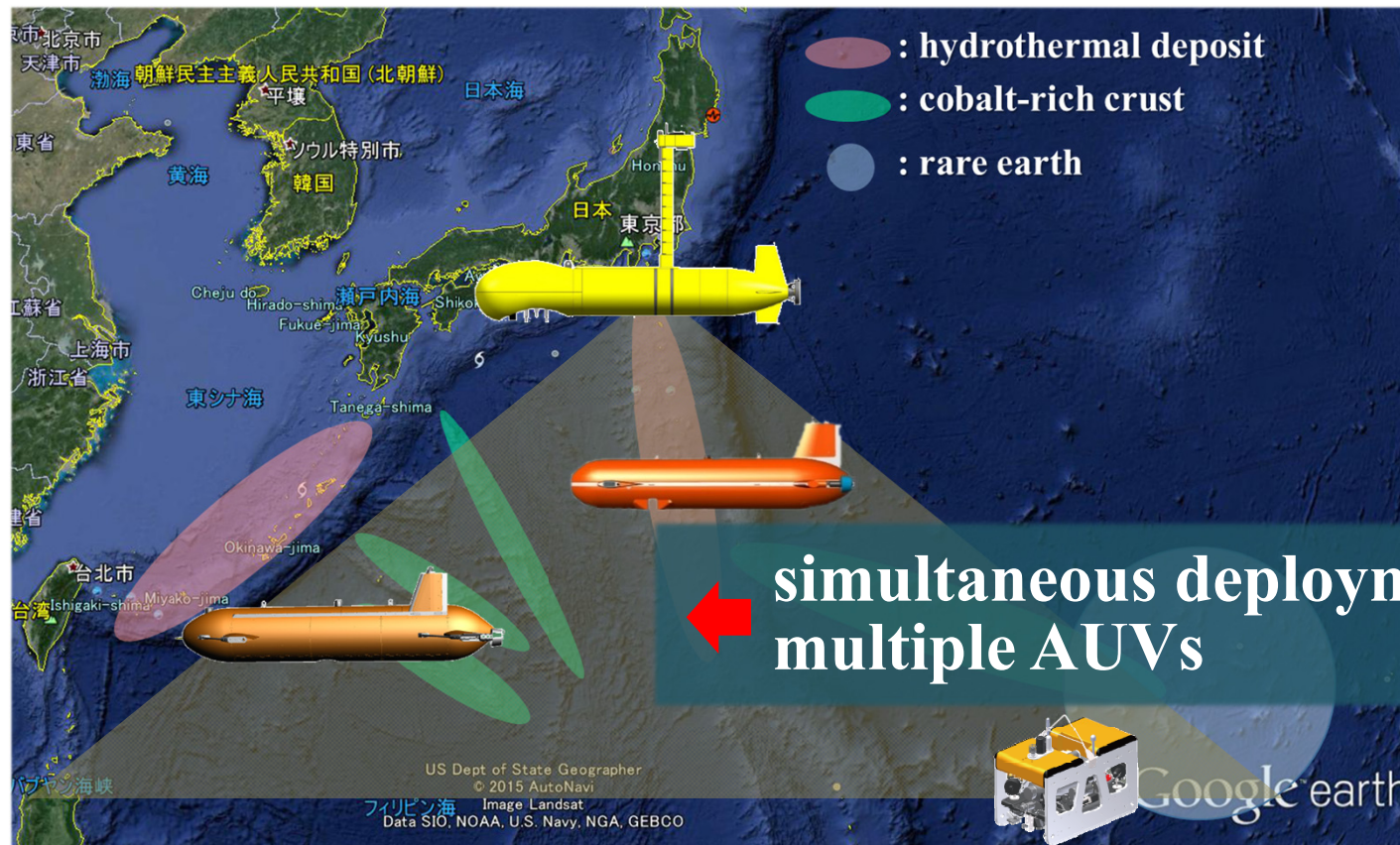
← simultaneous deployment and operation of multiple AUVs



* Source: Japan Project-Industry Council

estimated deposit	available	value	
hydrothermal deposit	750×10 ⁶ ton	450×10 ⁶ ton	0.67 trillion USD
cobalt-rich crust	2.4×10 ⁹ ton	1.1×10 ⁹ ton	0.83 trillion USD

+ cf.) Japan's GDP in 2016: 4.73 trillion USD (IMF)



Google earth

■ The Lineup

● NMRI's AUVs and an ASV

▲ Hobalin

Date of Birth : 19th Nov., 2015

(Scorpio)



▲ C-AUV #01

Date of Birth :

8th Dec., 2015 (Sagittarius)



Sep. 2016

Dec. 2016

Suruga Bay
Launch & Sea Trial

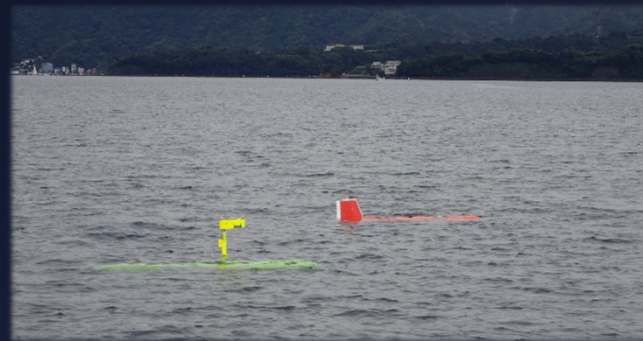
Suruga Bay
Simultaneous Deployment of
2 AUVs + 1 ASV



• *NMRI's AUVs and an ASV*

▲ *C-AUV #02*

Date of Birth :
20th Jul., 2016 (Cancer)



Sep. 2016

Suruga Bay
Simultaneous Deployment of
2 AUVs + 1 ASV

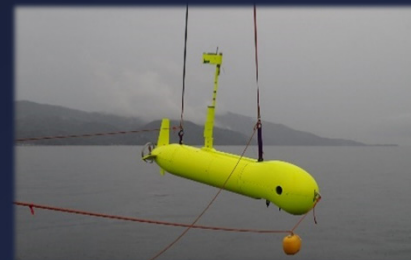


Dec. 2016

Omuro Caldron
Simultaneous Deployment of
3 AUVs + 1 ASV

▲ *ASV for AUV control*

Date of Birth :
12th Sep., 2016 (Virgo)



Sep. 2016

Suruga Bay
Simultaneous Deployment of
2 AUVs + 1 ASV

Dec. 2016



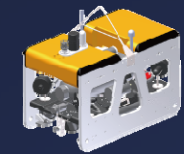
Specifications and Payloads



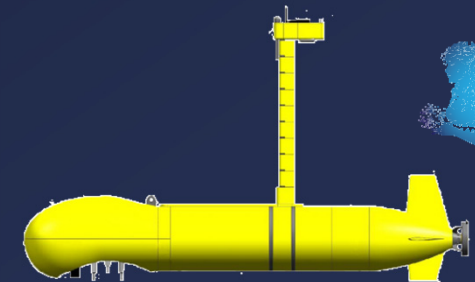
C-AUV #01



C-AUV #02



Hobalin

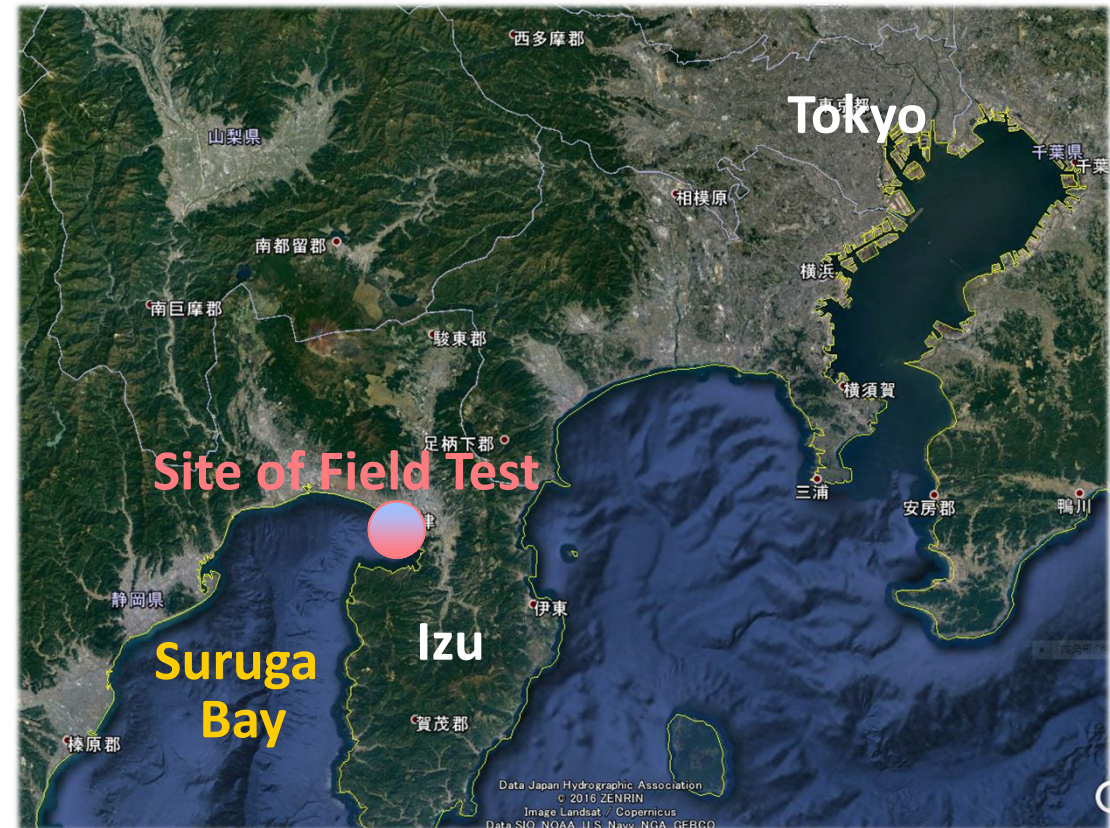
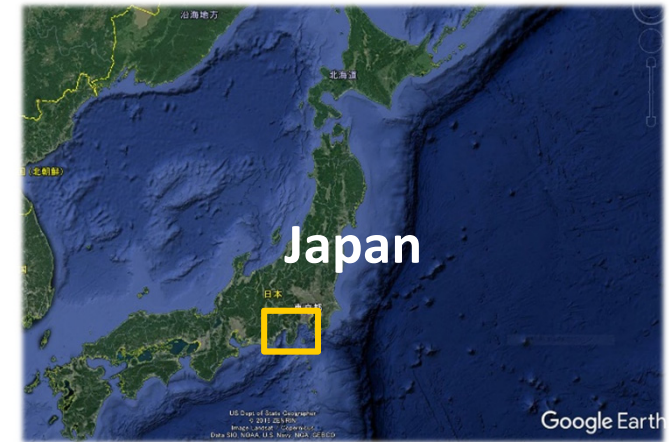
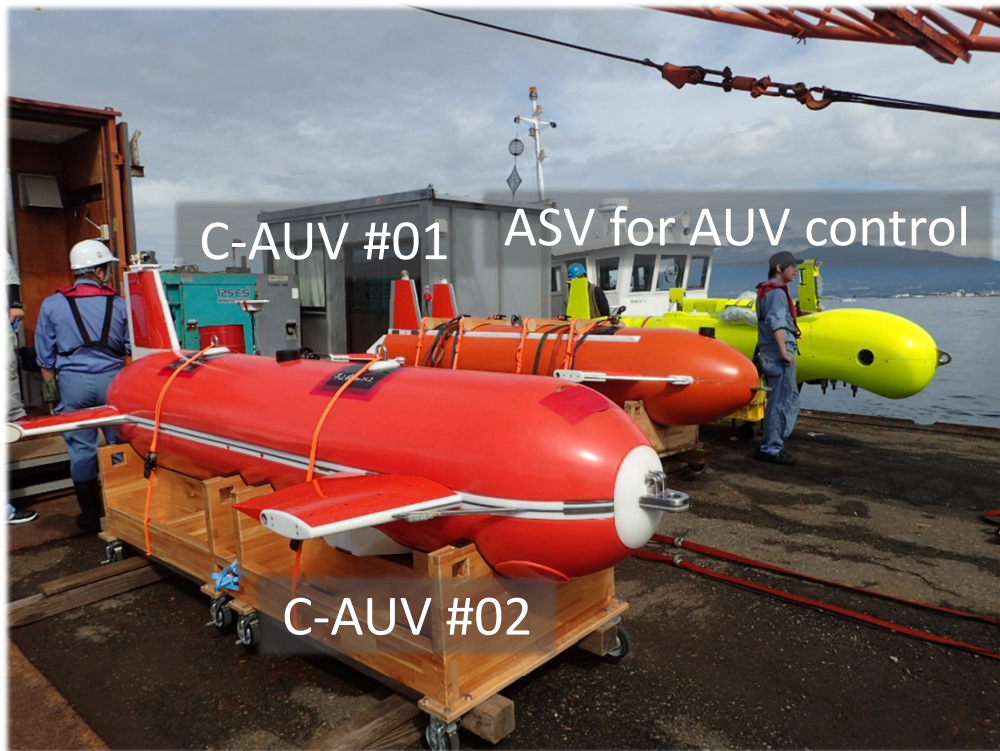


ASV for AUV control

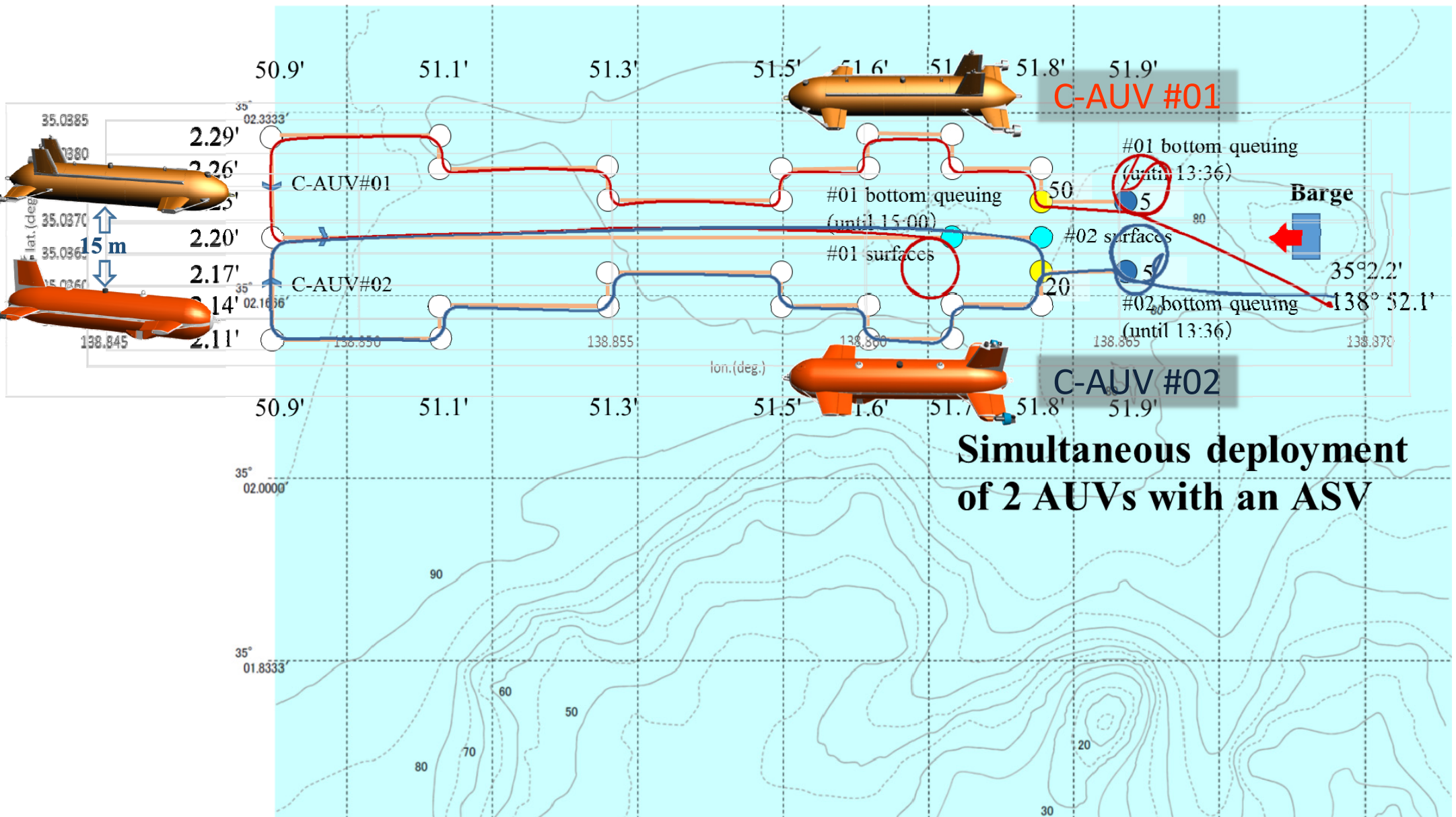
	dimensions (m)	mass (kg)	depth rating (m)	speed (m/s)	main payload
C-AUV #01	3.9×0.65	780	2000	1.5	PSBP
C-AUV #02	3.6×0.6	620	2000	1.5	MBES
Hobalin	1.2×0.7×0.76	270	2000	0.4	camera
ASV for AUV control	4.0×0.58	800	-	1.5	-

Field Test in Suruga Bay

- 2 C-AUVs surveilled by ASV
- A semi-practical bottom survey dive



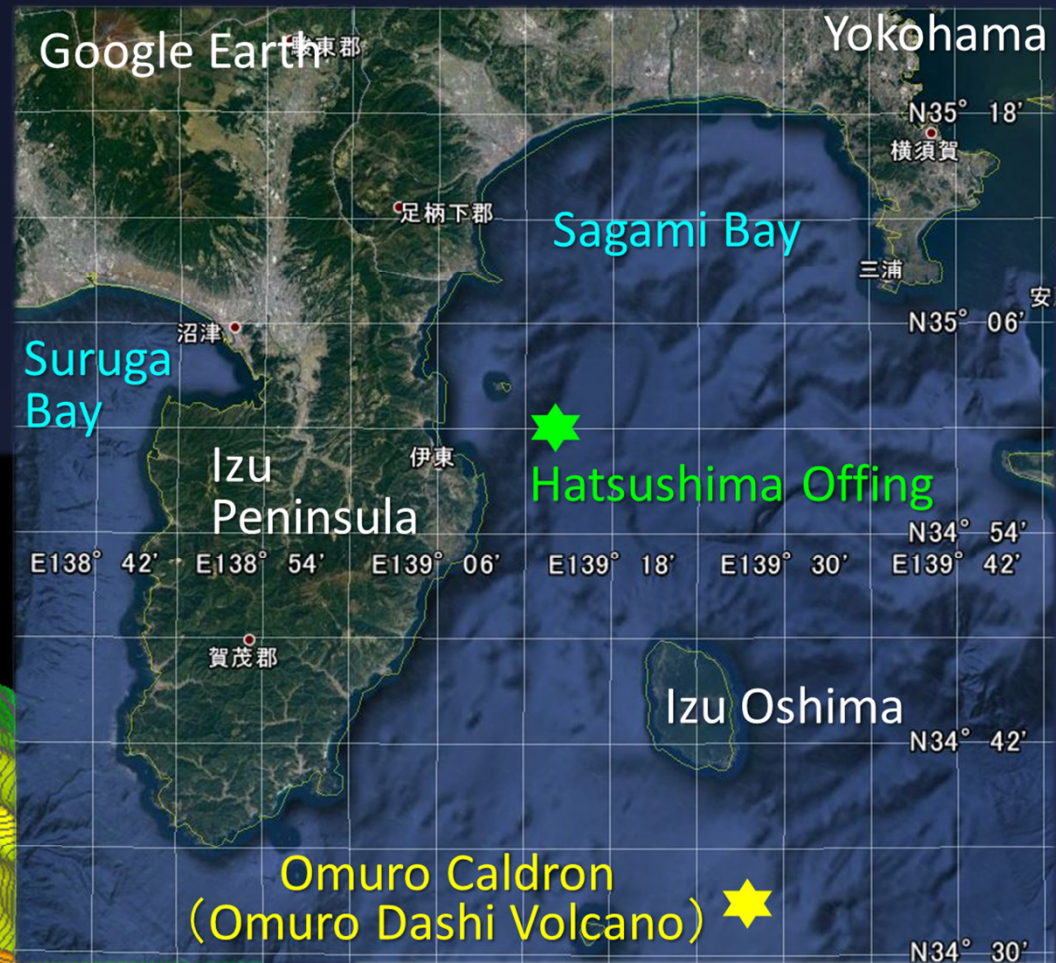
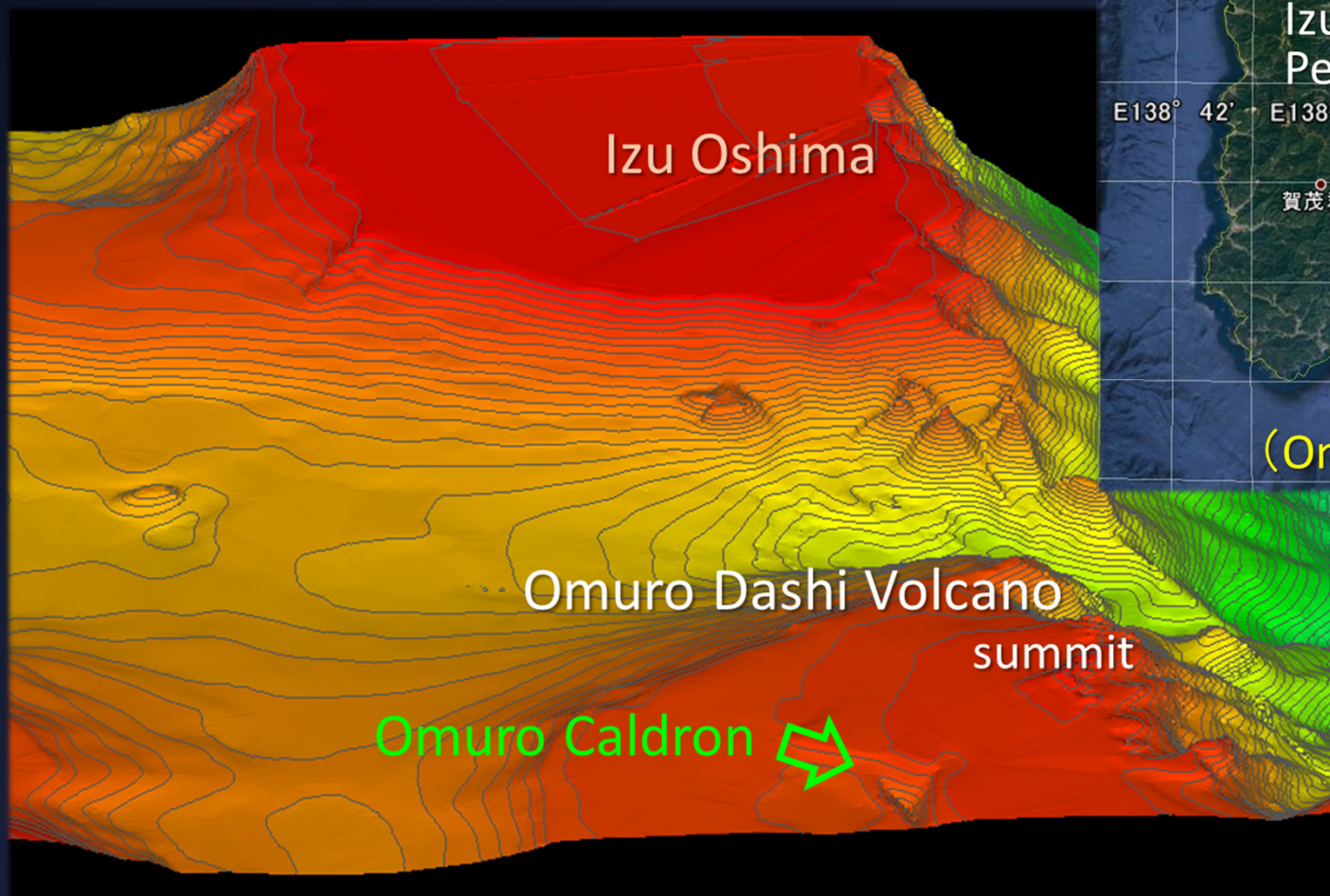
Navigation and Dive Results



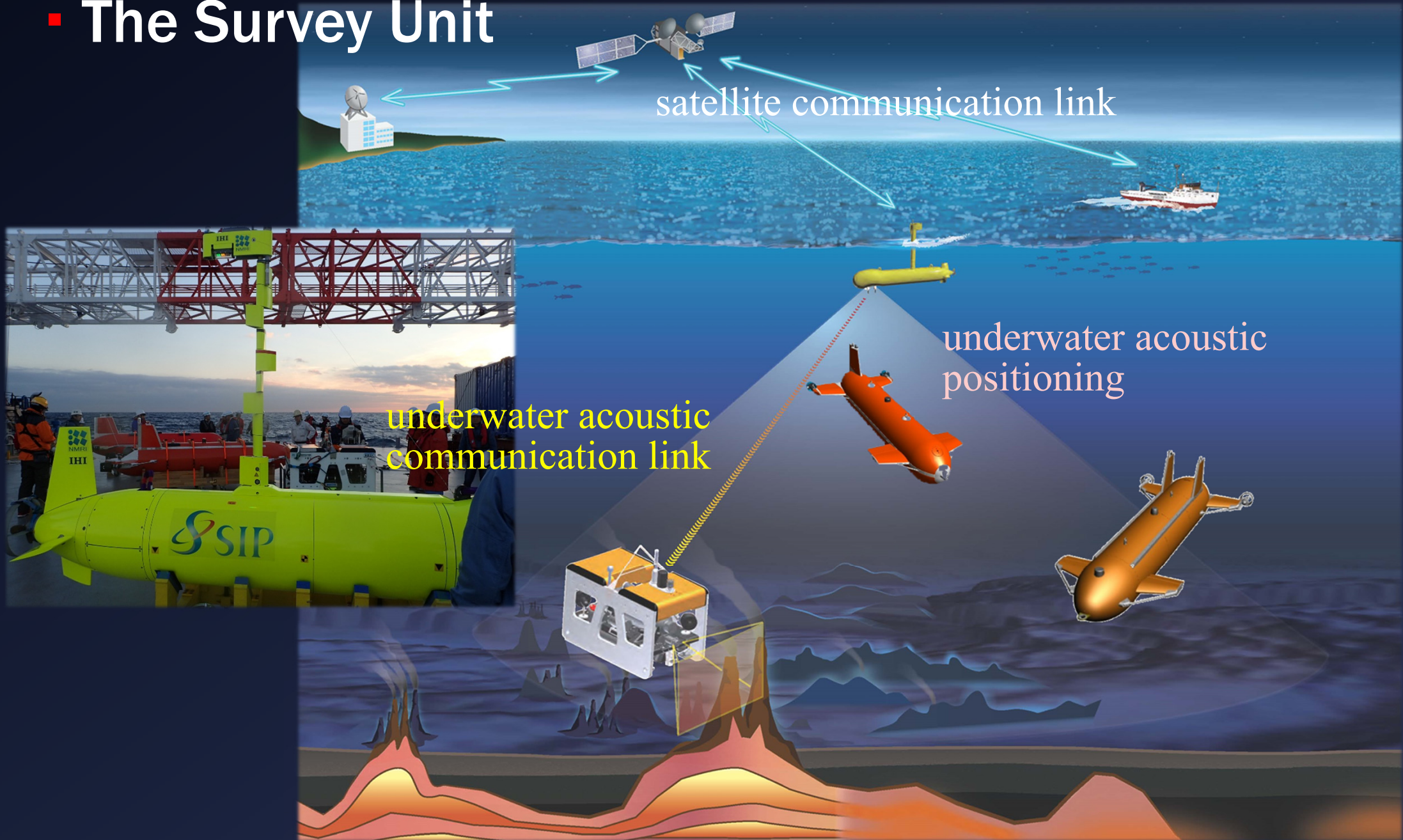
Simultaneous deployment of 2 AUVs with an ASV

Survey Cruise

- AUGUST 1100-16306 Cruise
Hydrothermal Activity Survey in Omuro Calderon
- Nov. 28 - Dec. 4, 2016



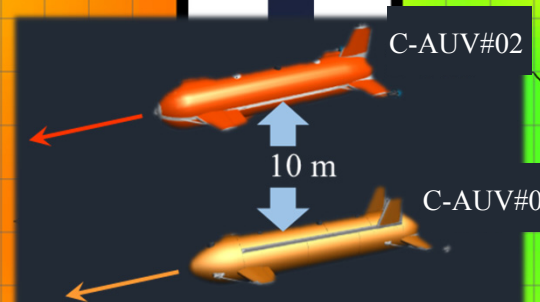
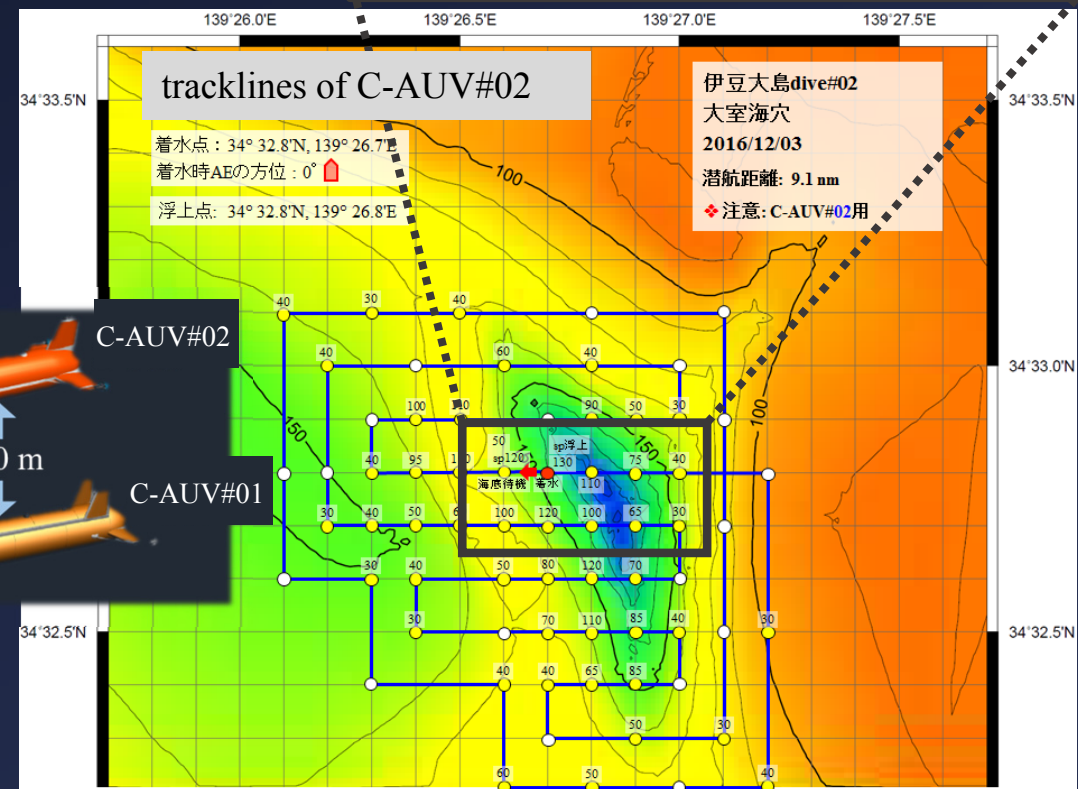
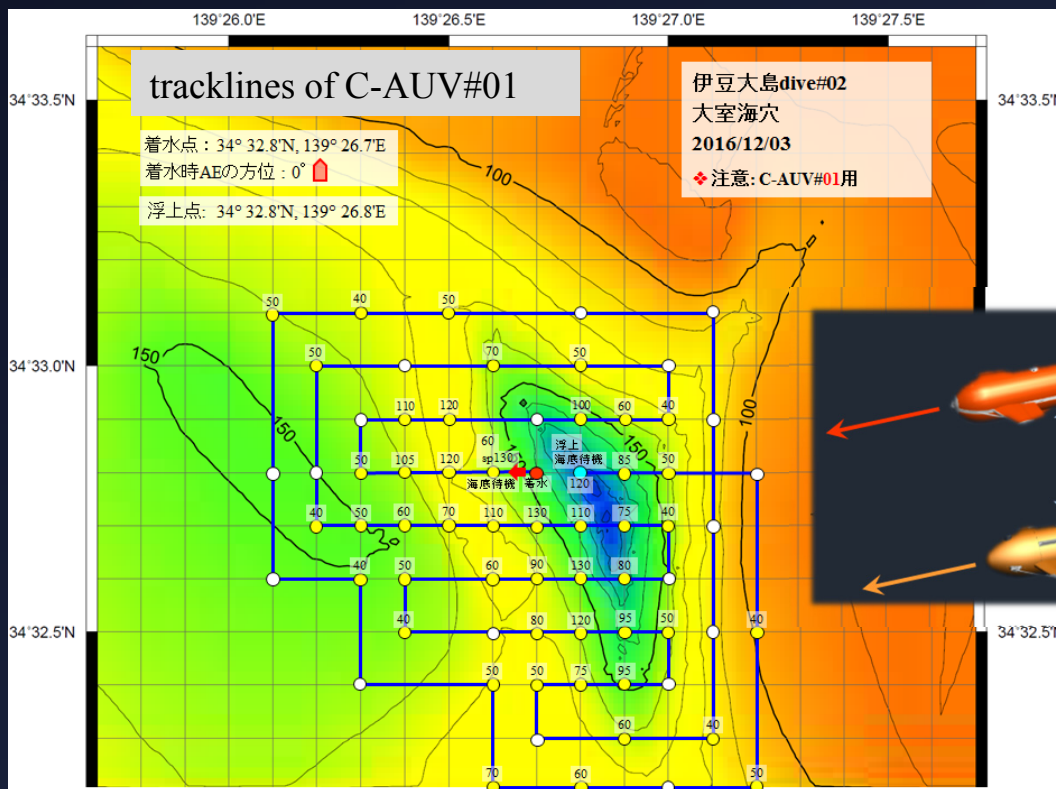
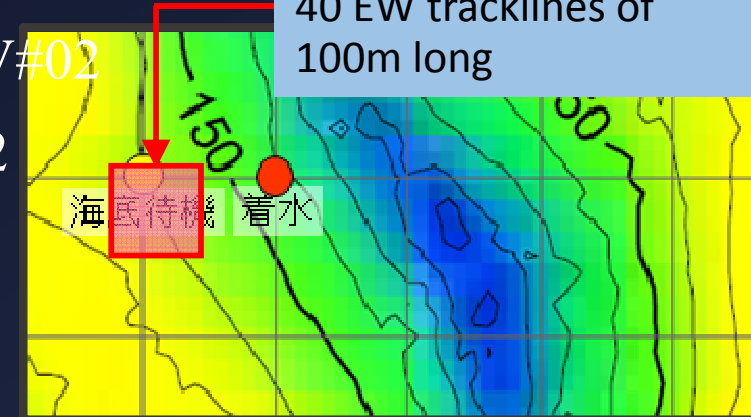
■ The Survey Unit



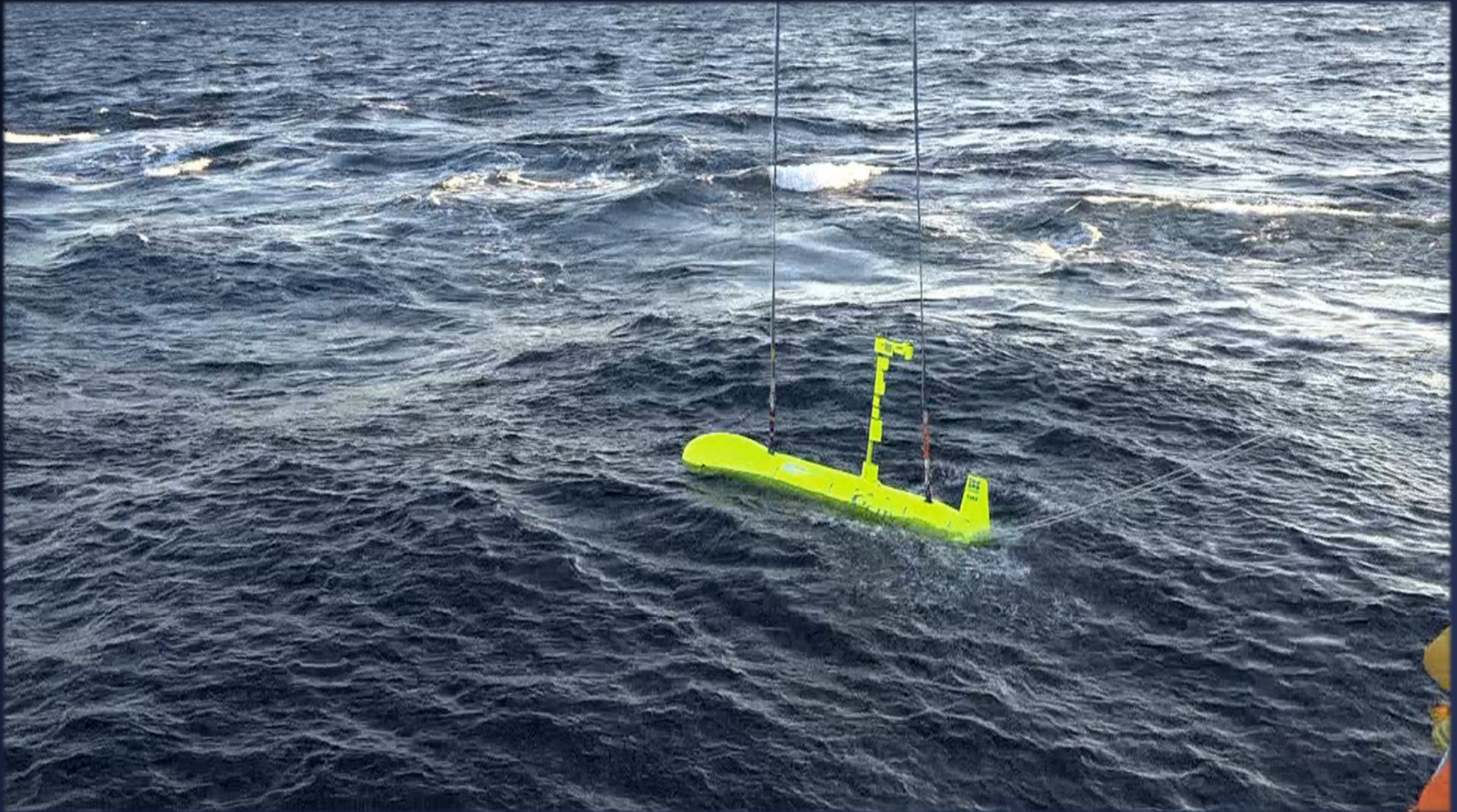
Navigation

- Order of Deployment: ASV, Hobalin, C-AUV#01, C-AUV#02
- **Simultaneous Start** of Bottom Tracking: C-AUV #01 & 02
- **Sequential Surfacing** of 3 AUVs

Dive area of Hobalin:
40 EW tracklines of
100m long

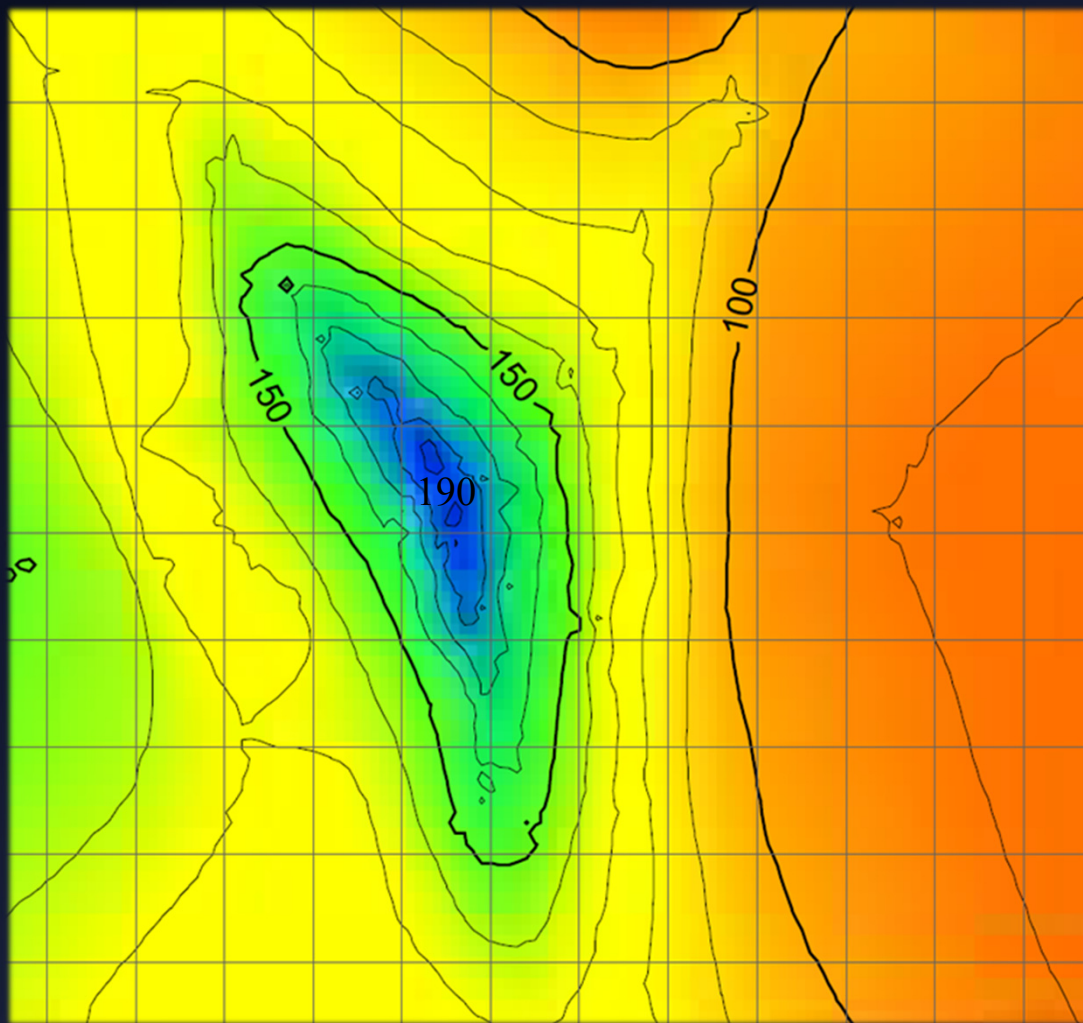


■ Scenes of Survey Works

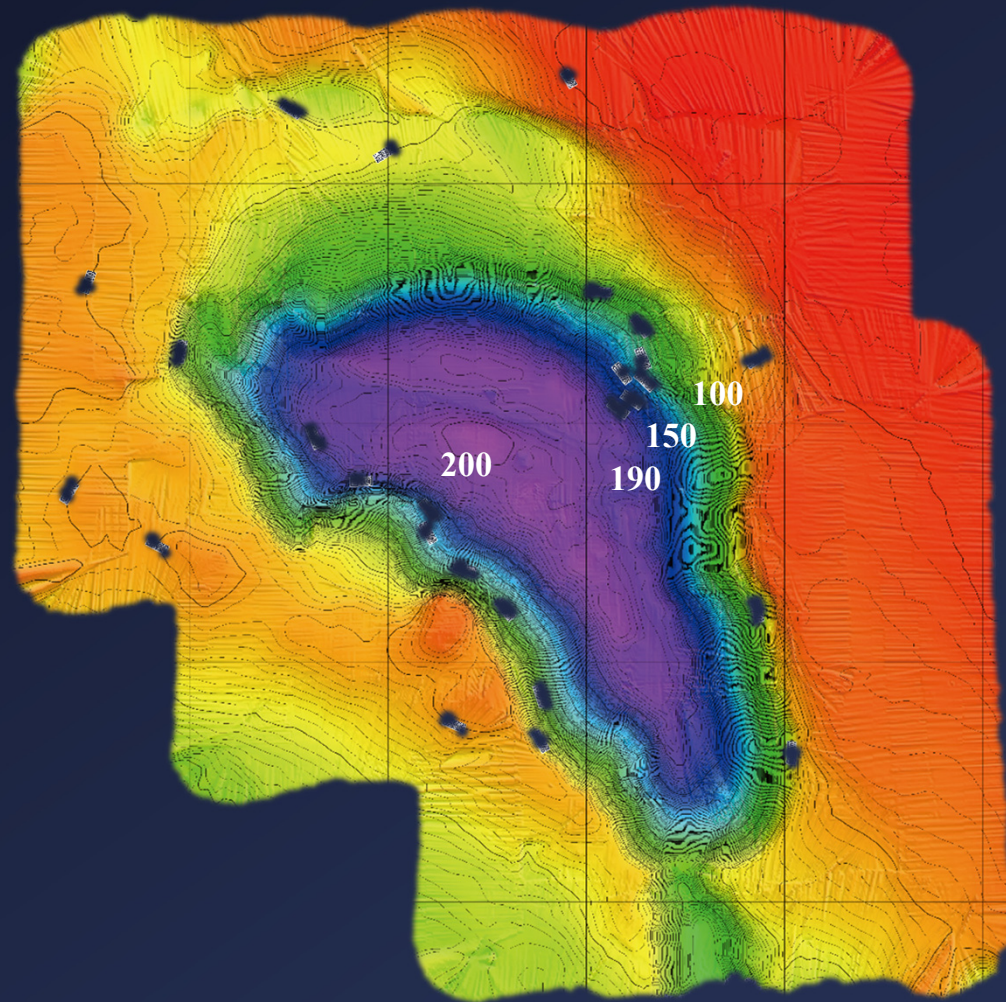


Survey Results

- Bottom Bathymetry

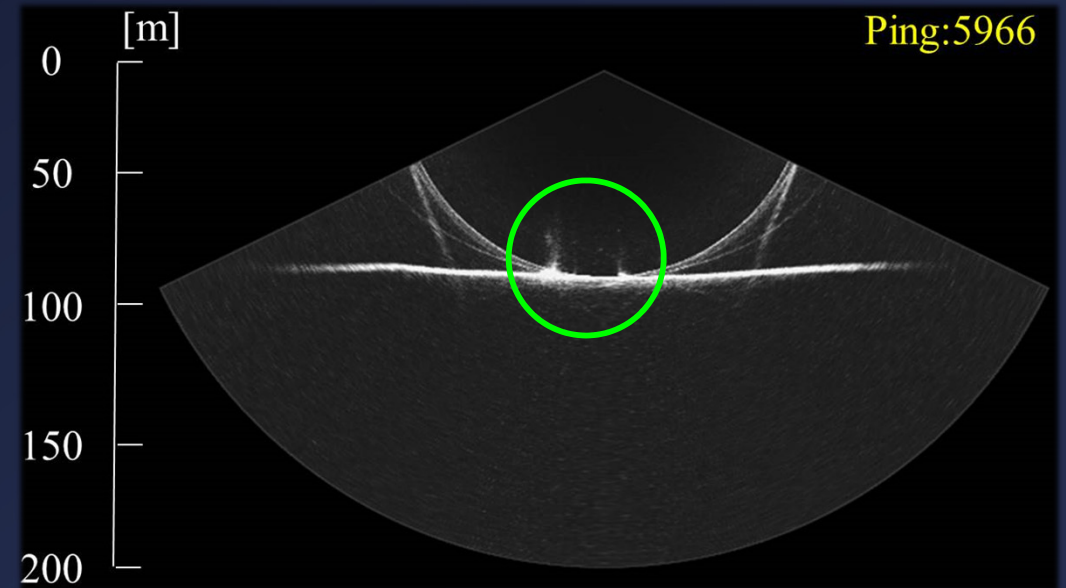
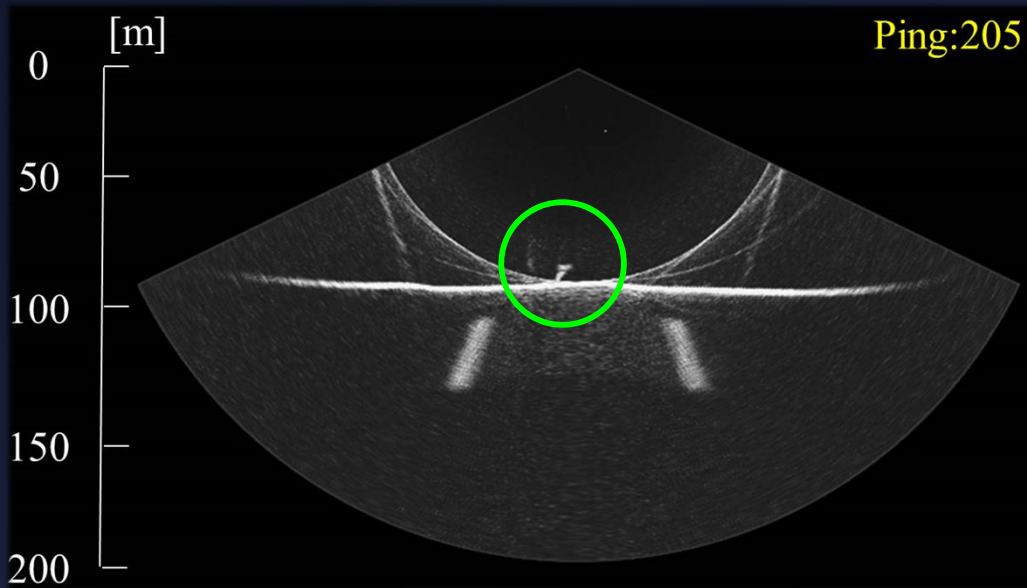
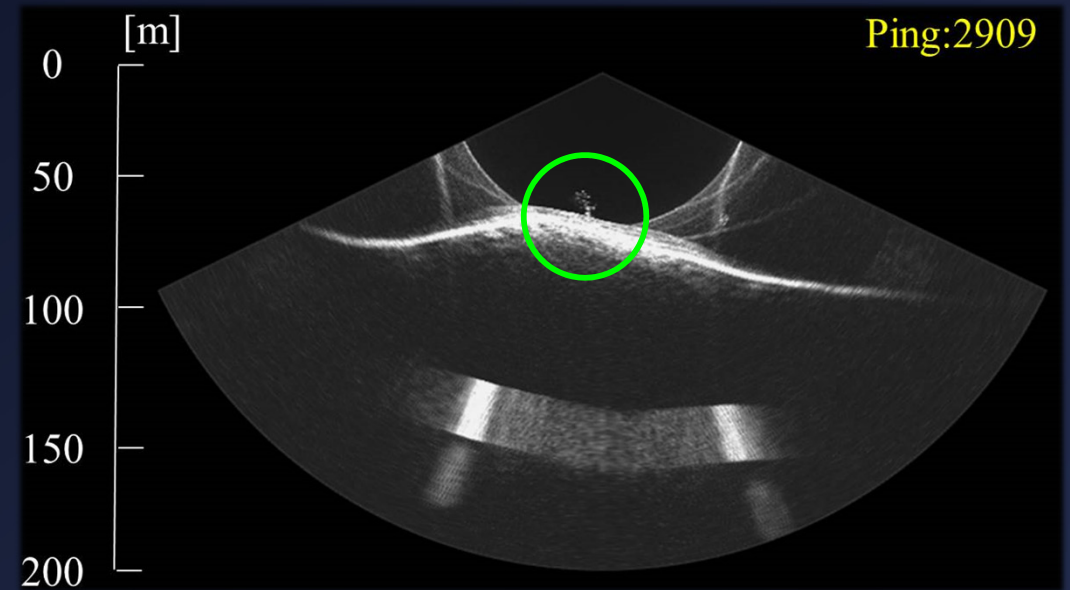
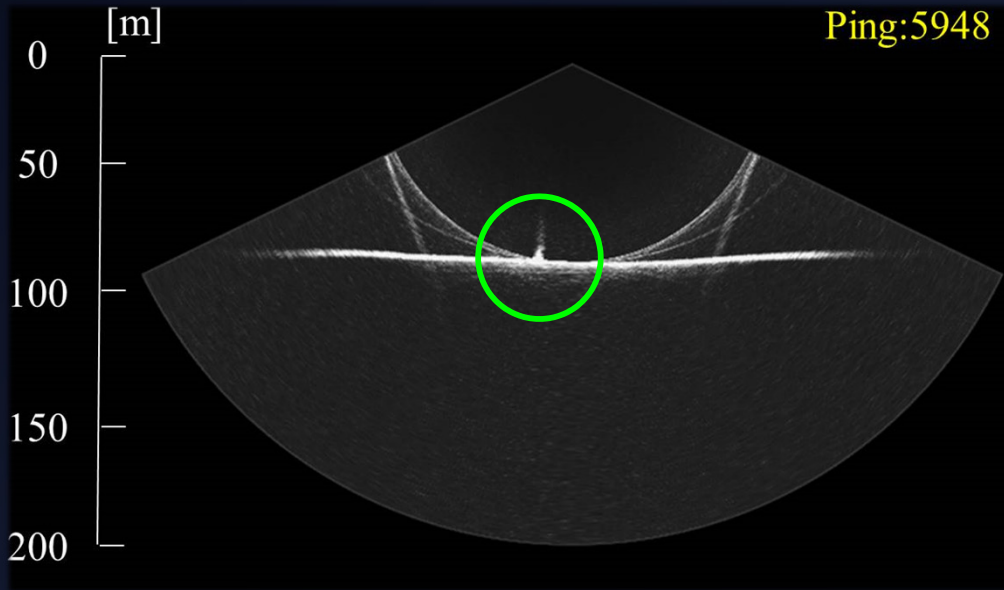


existing: 50 m meshed, surface vessel

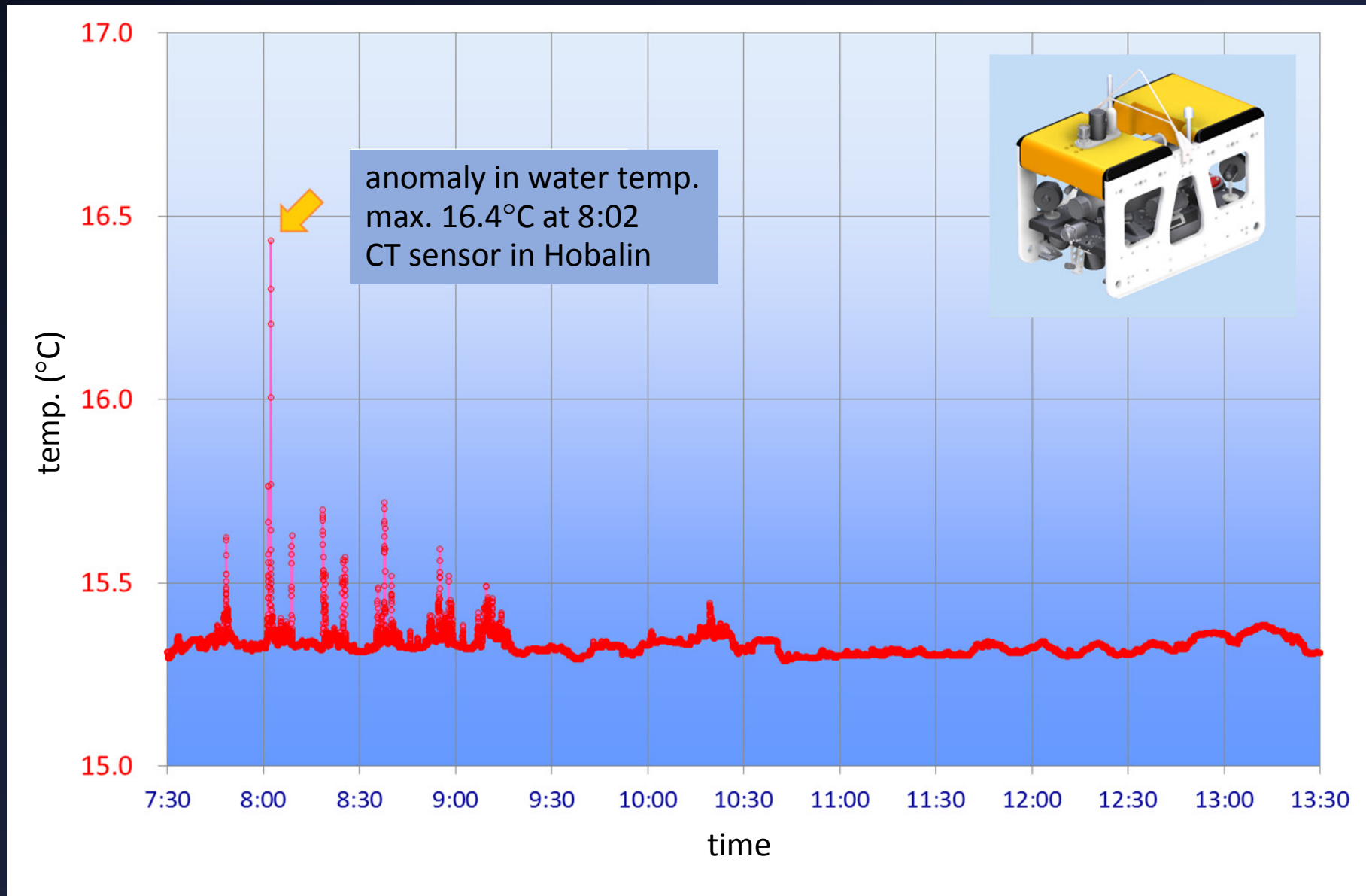


new: 2 m meshed, C-AUV#02

- Sign of Hydrothermal Activity: Plumes in Acoustic Images



Sign of Hydrothermal Activity: Temperature and Photo Images



A Single Shot of Hydrothermal Vent

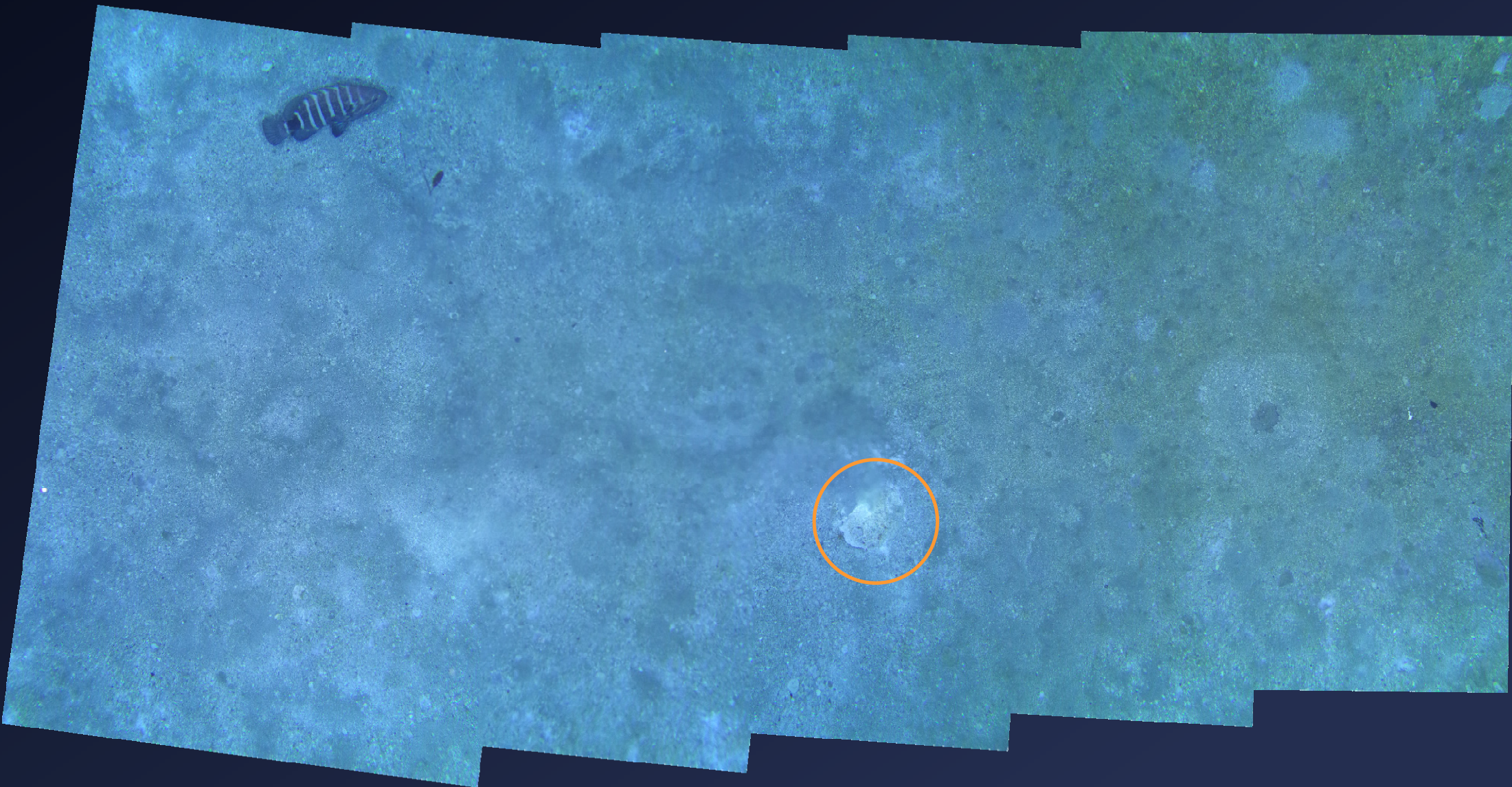


picture taken at 8:02 a.m.

A Single Shot of Hydrothermal Vent (Enlarged)



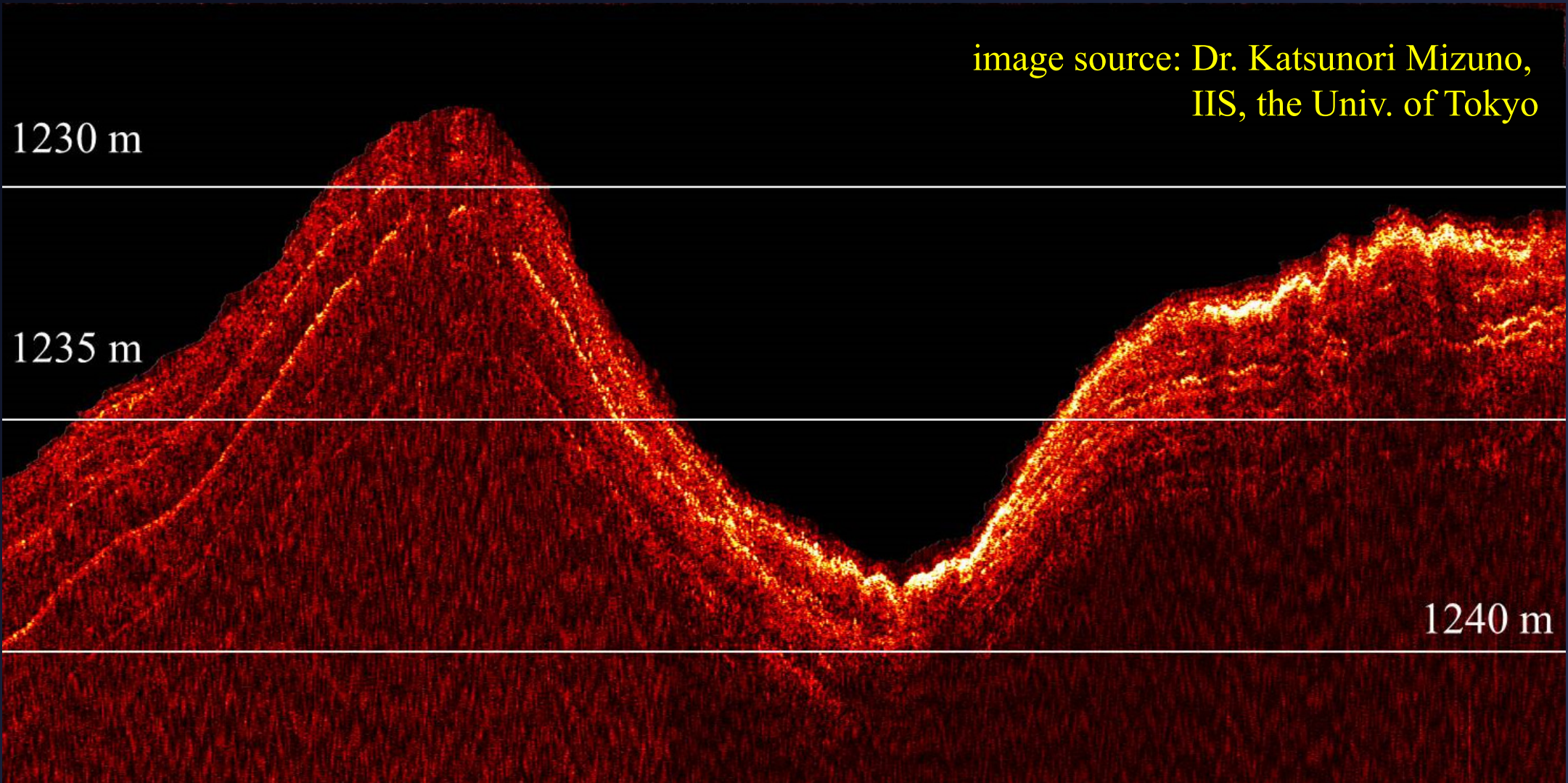
Mosaicked Bottom Image



Sub-Bottom Profiling

- sub-bottom layers of Hatsushima Offing visualized by PSBP(Parametric SBP) installed in C-AUV#01

image source: Dr. Katsunori Mizuno,
IIS, the Univ. of Tokyo



Conclusions and Future Works

- Simultaneous Deployment and Operation of Multiple AUVs

- *2 C-AUVs, 1 H-AUV*
- *controlled by an ASV*
- *surveyed hydrothermal activities*



*Practical Mission
achieved by a Pure
Unmanned Survey Unit*

- Future Works

- Advanced Navigation
- Increased No. of Vehicles: *4 AUVs in 2017*

ACKNOWLEDGMENTS

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