IHO Crowdsourced Bathymetry
Working Group 9 Meeting
29 June – 3 July, 2020

Mathematical Seafloor Geomorphology

JAMSTEC contribution to Nippon Foundation - GEBCO Seabed2030 Project

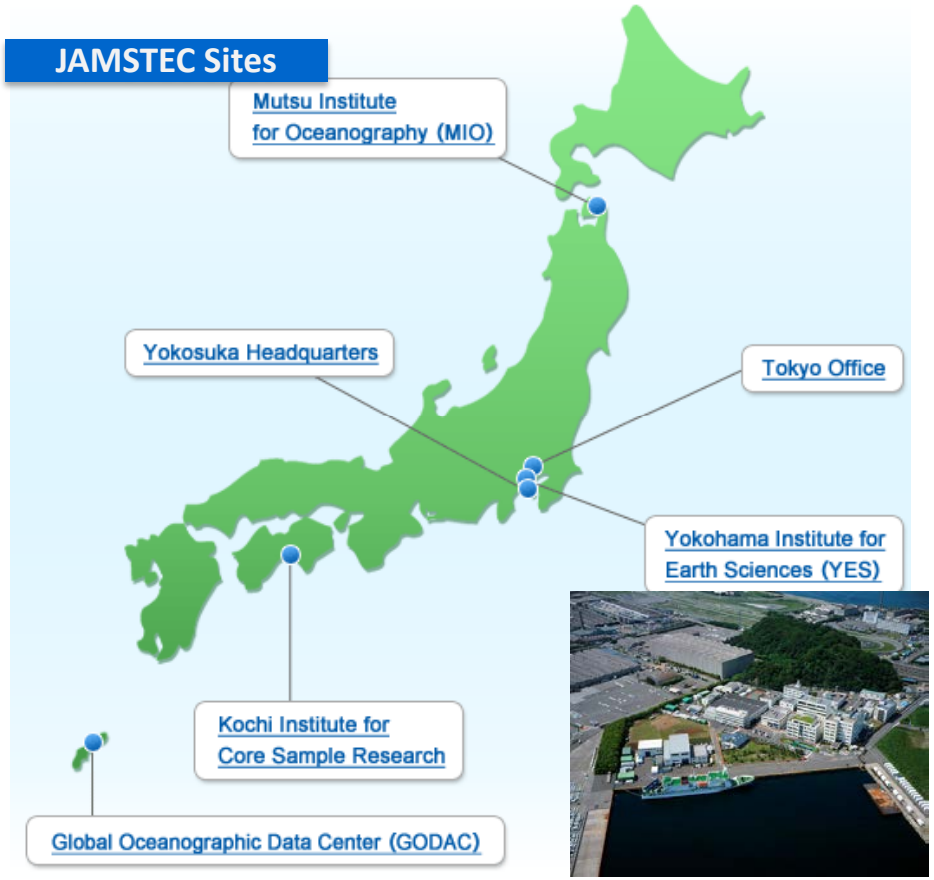
Yukari Kido

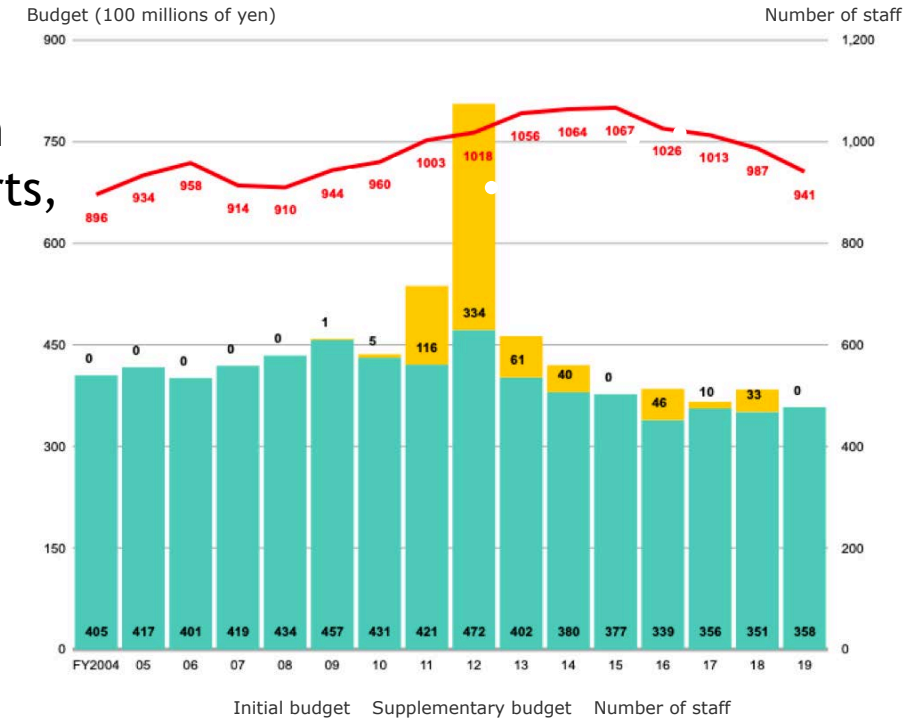
Japan Agency for Marine-Earth Science and Technology

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

Established Oct.1, 1971.

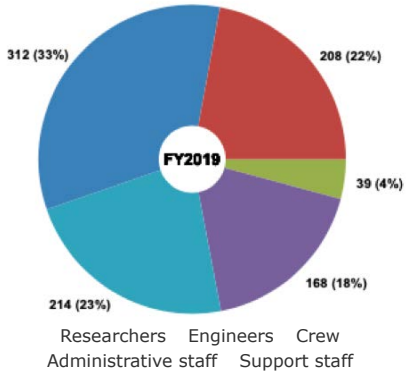
National Research Institute under jurisdiction by MEXT (Ministry of Education, Culture, Sports, Science and Technology)





Full-time staff by category as of April 1, 2019

	Full-time staff
Researchers	312
Engineers	208
Crew	39
Administrative staff	168
Support staff	214
Total	941



Vessels/Manned Submersible

GT: Gross tonnage

R/V *HAKUHOMARU*

GT 3,991 t

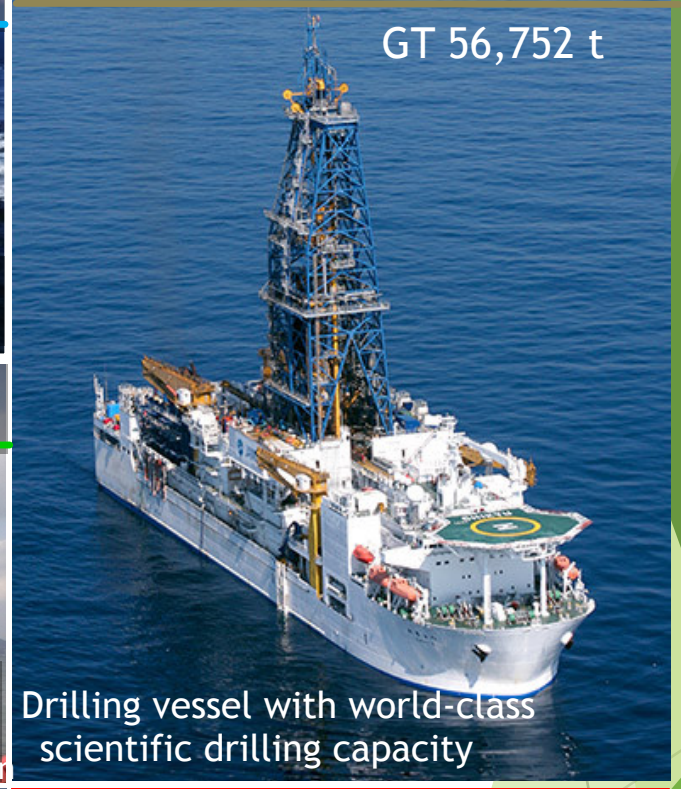
Multipurpose research vessel with long-term cruise

R/V *MIRAI*

GT 8,687 t

Large vessel able to perform observation over wide areas

D/V *CHIKYU*



GT 56,752 t

Drilling vessel with world-class scientific drilling capacity

R/V *YOKOSUKA*

GT 4,439 t

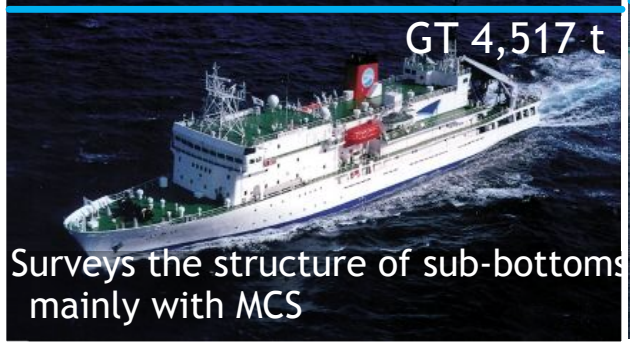
Support vessel for "SHINKAI6500"

R/V *SHINSEIMARU*

GT 1,629 t

Operation from 2013
Multipurpose R/V focusing on the survey off the coast of Tohoku region

R/V *KAIREI*



GT 4,517 t

Surveys the structure of sub-bottoms mainly with MCS

R/V *KAIMEI*

G 5,747t

Multipurpose research vessel for wide-area seabed research

Deep Submergence Vehicle *Shinkai6500*

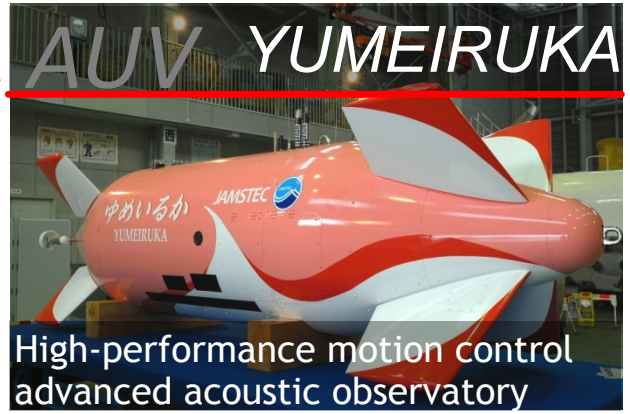
World-class manned submersible

Unmanned Underwater Vehicles/Supercomputers

AUV URASHIMA

Large AUV capable of long-distance dives

AUV YUMEIRUKA



High-performance motion control advanced acoustic observatory

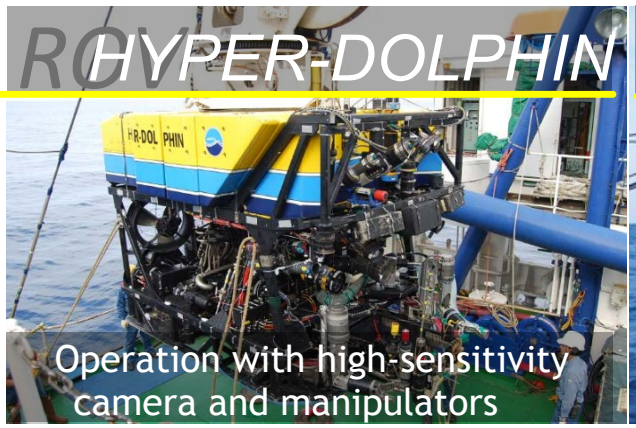
AUV JINBEI

High cruising capability
Equipped with chemical sensors

AUV OTOHIME

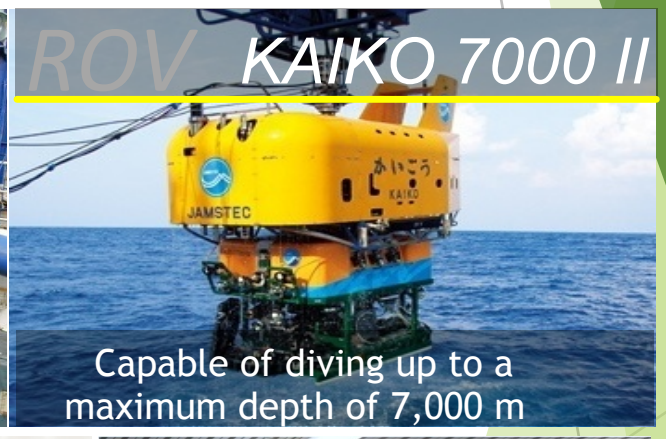
Working AUV equipped with manipulators

ROV HYPER-DOLPHIN



Operation with high-sensitivity camera and manipulators

ROV KAIKO 7000 II



Capable of diving up to a maximum depth of 7,000 m

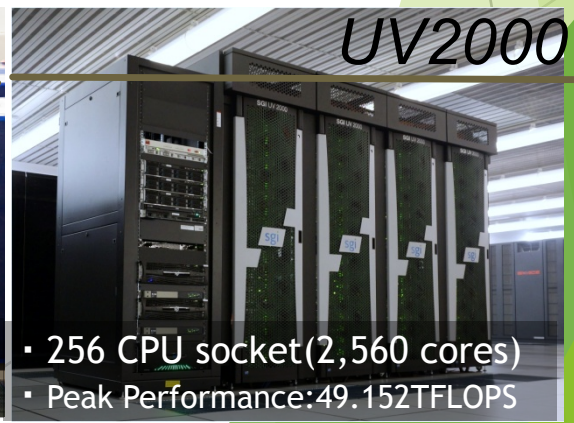
ROV KAIKO Mk-Ⅳ

ROV for heavy-duty work launched in 2013

Earth Simulator

- 5120Processor nodes(20,480cores)
- Peak Performance:1.3PFLOPS

UV2000

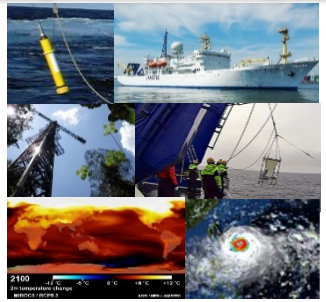


- 256 CPU socket(2,560 cores)
- Peak Performance:49.152TFLOPS

Major Areas of Research & Development

1. Understanding the current status and projecting the future of the global change

To contribute to the resolution of global issues such as climate change, ocean acidification, and plastic pollution, we will lead international projects to conduct integrated research on oceans at all depths and on the close interactions of oceans with the atmosphere and land masses. We will apply the data obtained from this research to formulate both short-term seasonal predictions and mid- to long-term predictions covering centuries.

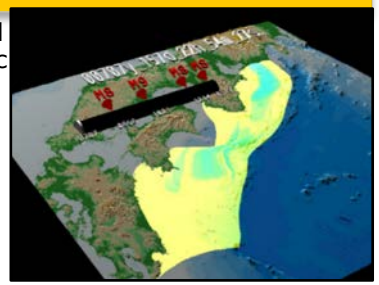


2. Understanding material circulation and origin of marine resources to ensure sustainable use

Our primary goal is to understand the formation processes of marine resources, including organisms, minerals, and energy resources found in the ocean. In addition to conducting the research that contributes to the sustainable use of oceans, we will seek collaborations with other institutions and industries through providing marine samples and sharing data, technologies, and scientific knowledge to accelerate the utility of the ocean.

3. Elucidating the actual conditions of earthquakes and volcanic activity to lead to disaster mitigation

Toward understanding and clarifying the actual conditions of offshore earthquakes and volcanic activity, we conduct marine researches and observation around Japan and the western Pacific region, including the presumed co-seismic rupture area of the forthcoming megathrust earthquake along the Nankai Trough, by using research vessels and various observation equipment in cooperation with related institutes and universities. In order to forecast earthquakes and volcanic activity based on large-scale, high precision numerical simulation by use of data and results obtained from our surveys and observations, we upgrade methods for analyzing such data.



4. Probing unknown causal relationships hidden in Earth systems

To identify interrelationships between changes in Earth systems and human activity, we will develop methodologies for integrating the vast amounts of data generated by JAMSTEC R&D activities, and mathematical analysis methods for efficiently processing the resulting integrated data. We will also support the resolution of policy issues and development of sustainable socioeconomic systems by generating and disseminating information tailored to various needs. We will additionally endeavor to expand this initiative to encompass other relevant organizations both in Japan and overseas so as to build a framework for generating even more advanced and useful information.

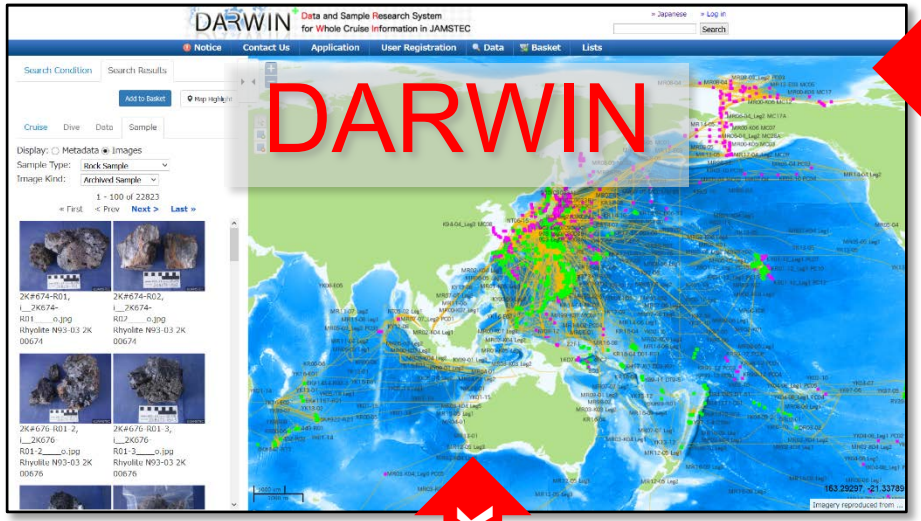
5.1. Exploratory and challenging research and technological development for the future

Our exploratory and challenging research and development on deep-sea extreme environments, or so to be called the Earth's last frontiers, will build a scientific, technological, and intellectual platform which will lead to generating diverse knowledge and innovation to support future Japan as a maritime nation.

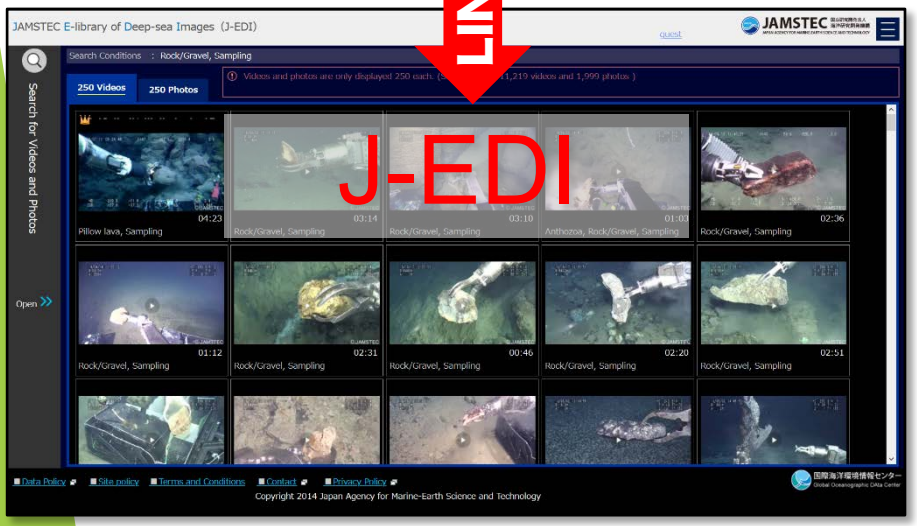
5.2. Advanced technology bringing new insights of the Earth and its oceans

Oceans occupy about 70% of the Earth's surface, and are a significant source of dynamic global change. A wide range of important marine-Earth research targets, including ocean deeps, tectonic subduction zones (with related earthquakes and volcanic eruptions), hydrothermal vents, and the deep sub-seafloor, are the primary targets of our world-leading scientific research and development program. Implementing this, while also supporting Japan's ocean policies, we will maintain and improve our advanced capabilities for investigation and observation of the world ocean and seas.

Online data sites: DARWIN & others



LINK

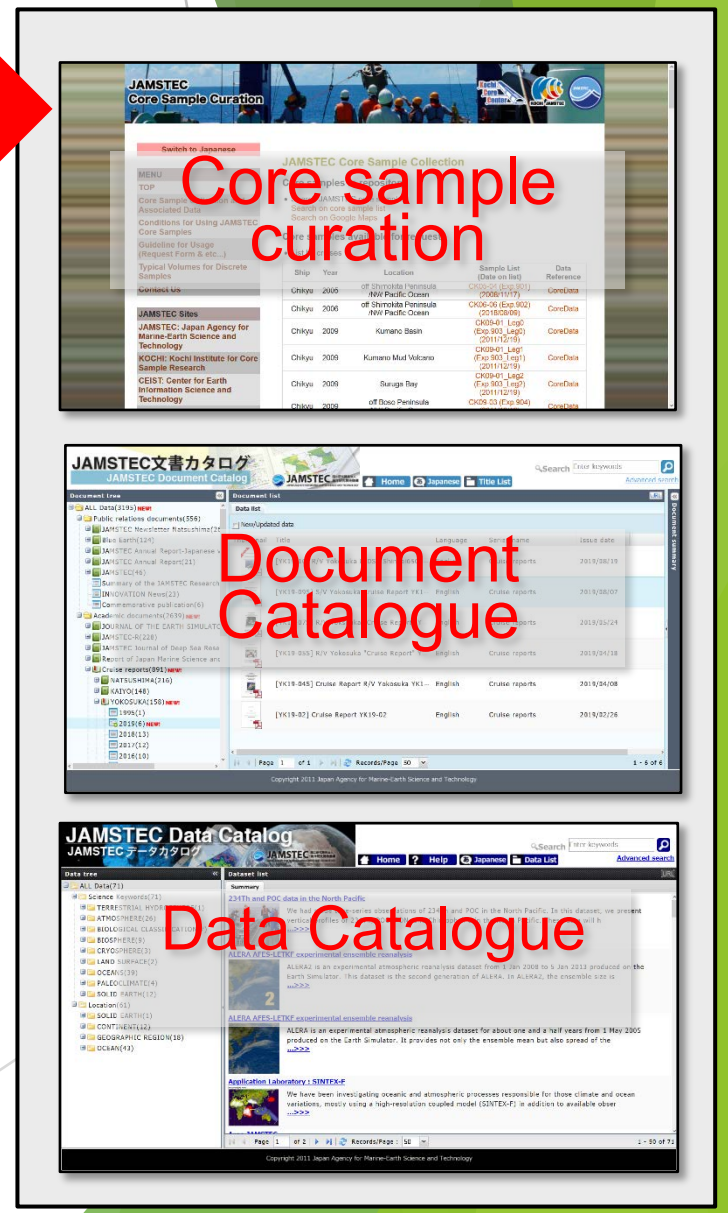


LINK

- Cruise & dive info
- Geophysical observation (bathymetry, gravity, geomagnetics…)

Sample info

- Dive video & photo
- Dive tracks
- Environmental data (salinity, temperature, etc.)

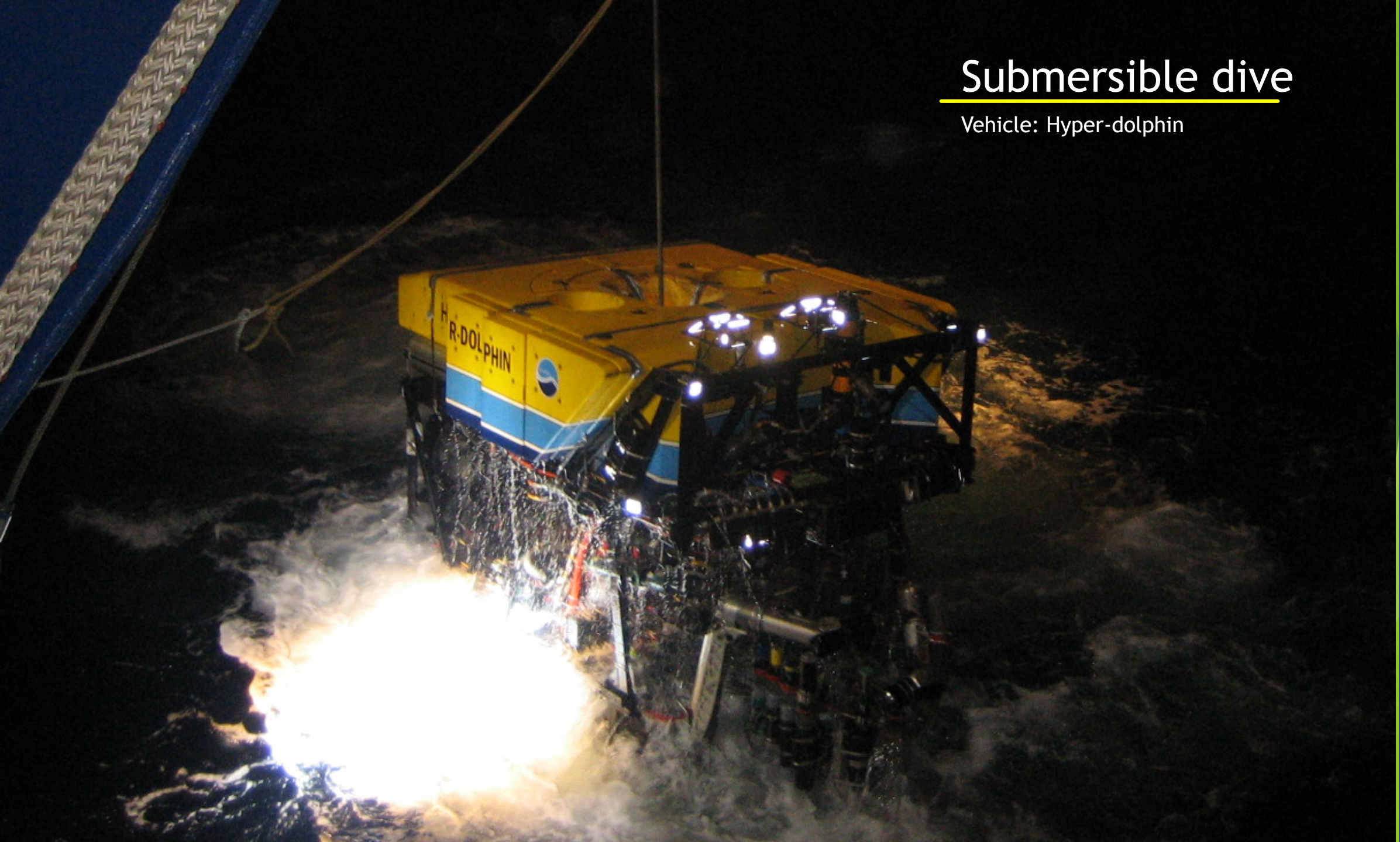


Observation cruise

Ship: R/V Mirai

DARWIN: Cruises, Dives and Observation Data

http://www.godac.jamstec.go.jp/darwin/

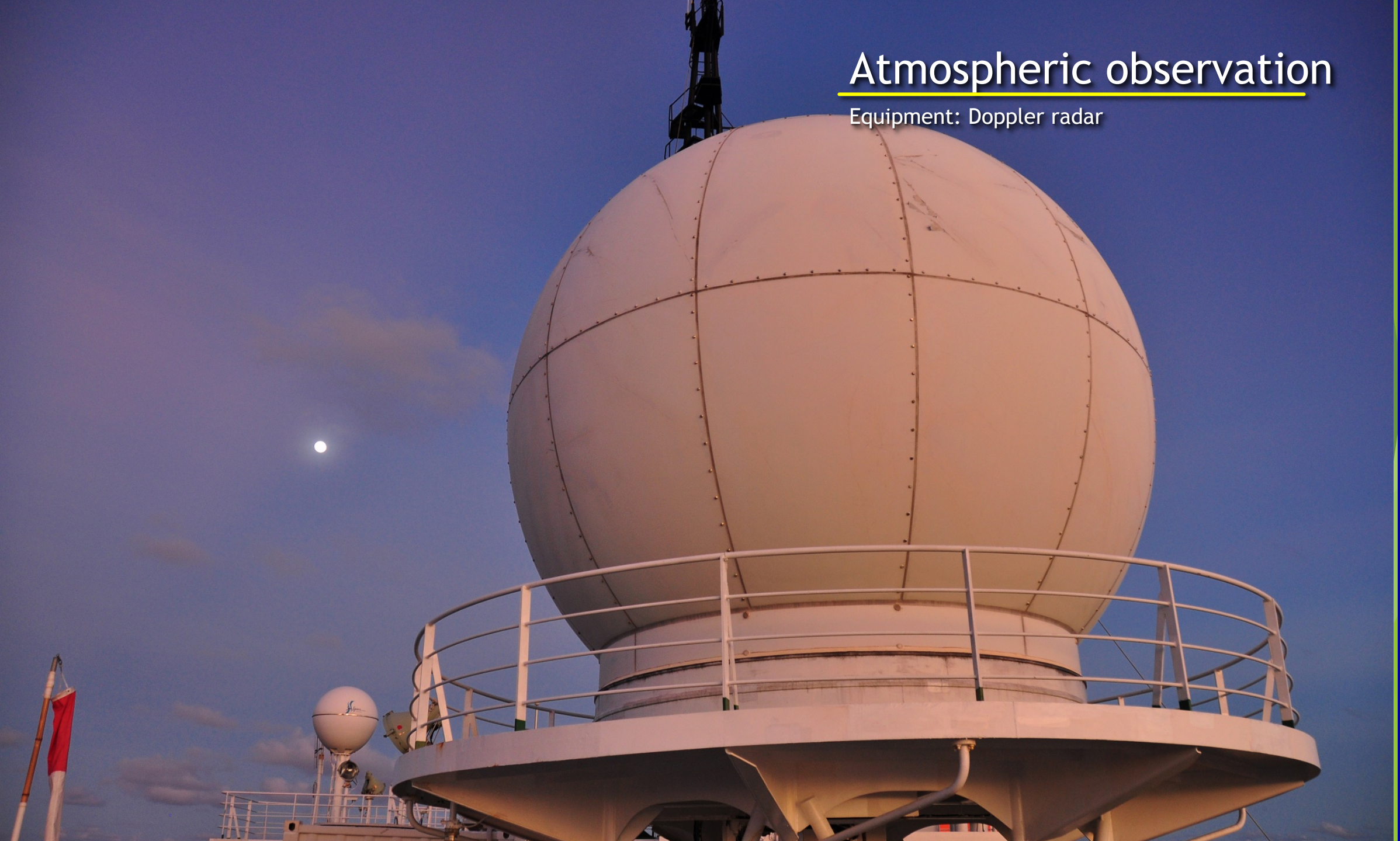


Submersible dive

Vehicle: Hyper-dolphin

DARWIN: Cruises, Dives and Observation Data

http://www.godac.jamstec.go.jp/darwin/

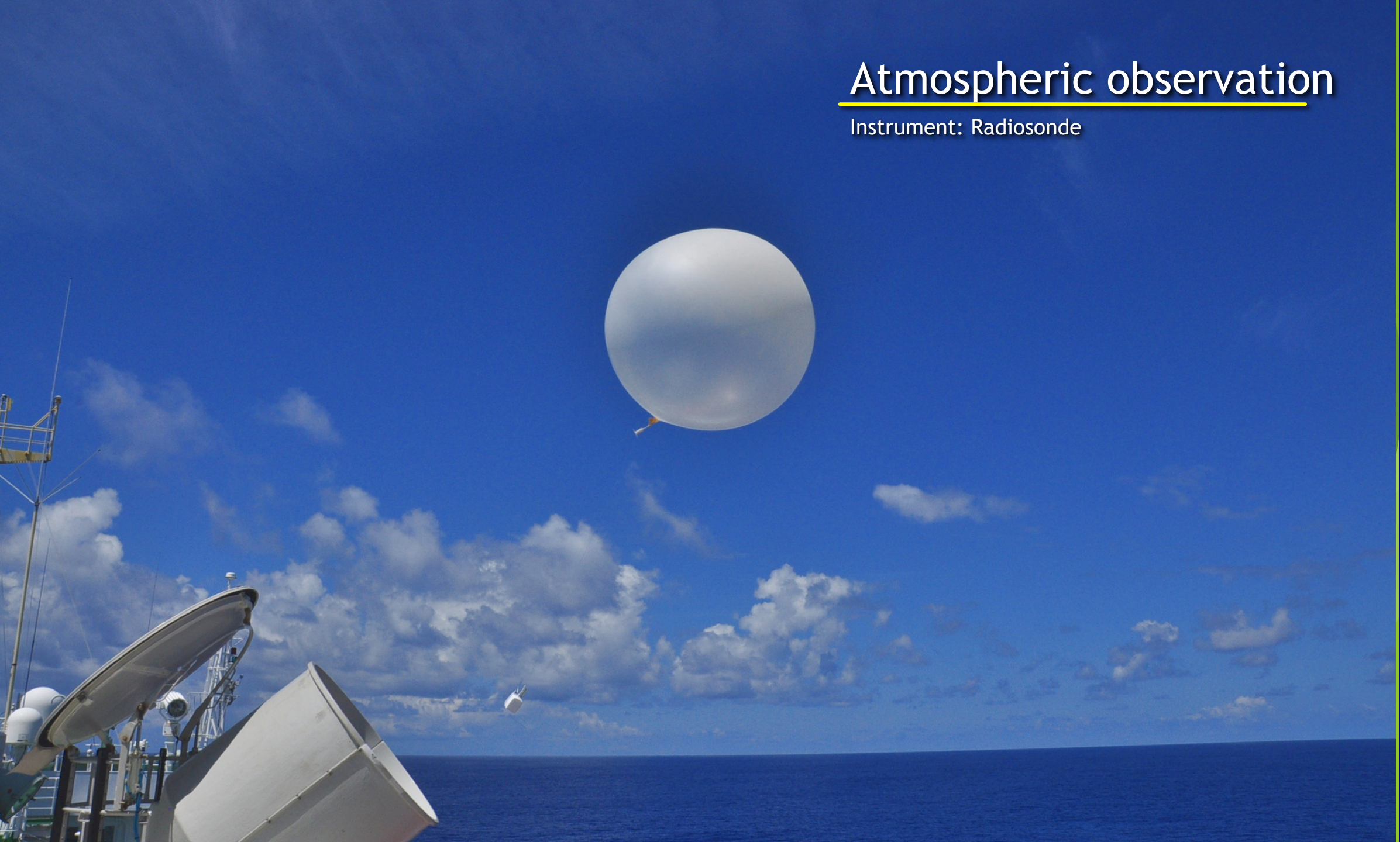


Atmospheric observation

Equipment: Doppler radar

DARWIN: Cruises, Dives and Observation Data

http://www.godac.jamstec.go.jp/darwin/



Atmospheric observation

Instrument: Radiosonde

DARWIN: Cruises, Dives and Observation Data

http://www.godac.jamstec.go.jp/darwin/

Deployment observation

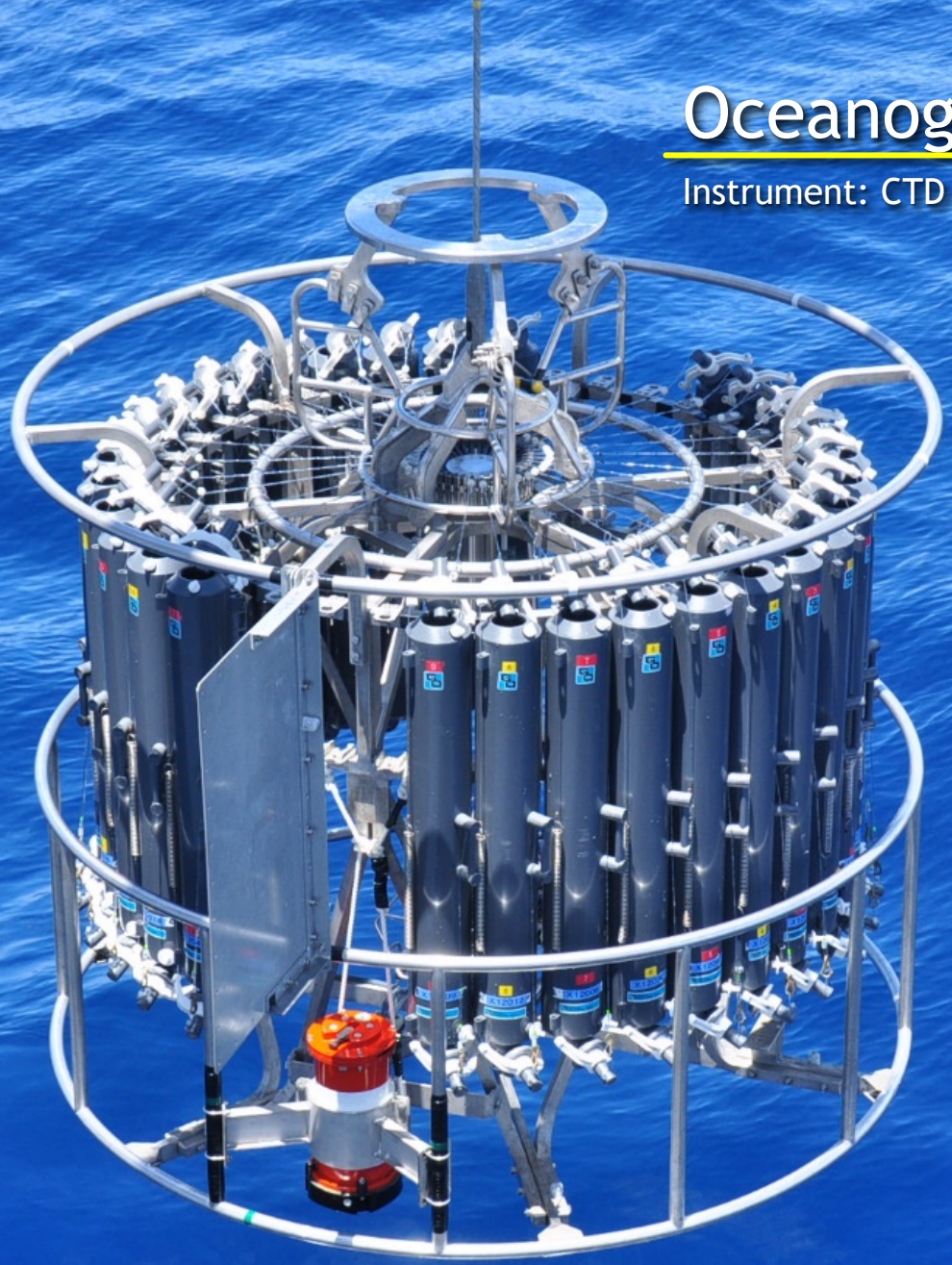
Instrument: TRITON buoy

DARWIN: Cruises, Dives and Observation Data

http://www.godac.jamstec.go.jp/darwin/

Oceanographic observation

Instrument: CTD Rosetta water sampler



DARWIN: Cruises, Dives and Observation Data

http://www.godac.jamstec.go.jp/darwin/

DARWIN: Cruises, Dives and Observation Data

http://www.godac.jamstec.go.jp/darwin/

MIRAI MR13-01 Cruise Data

MR13-01

- Cruise Information
- Data List
- Related Cruises
- Related Publications
- Update History

Related Links

- Information of MIRAI
- Instruments
- Photo Gallery

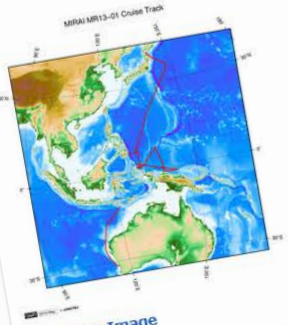
Last Modified

2016-04-07
A cruise information was registered.
Updated data: Shipboard Acoustic Doppler Current Profiler (ADCP), Bathymetry (MBES), Bottle Sampling Water Chemical Analysis, Conductivity-Temperature-Depth Profiler (CTD), Gravity, Marine Meteorology, Navigation, Shipboard Three Component Magnetometer (STCM), Underway Thermosalino Graph, Expendable Conductivity-Temperature-Depth Profiler (XCTD)

Cruise Information

Ship Name	MIRAI
Cruise ID	MR13-01
Period	2013-02-18 – 2013-03-28
Chief Scientist	Yuji Kashino (JAMSTEC)
Project Name	[Tropical Ocean Climate Study (TOCS)]
Cruise Title	Tropical Ocean Climate Study

Cruise Track



Enlarge Image

Ports of call
2013-02-18 02:00 Departure from Fremantle
2013-03-27 00:00 Arrival at Hachinohe
2013-03-27 06:50 Departure from Hachinohe
2013-03-28 00:10 Arrival at Sekinehama

Research area
Western equatorial Pacific and Kuroshio Extension region

Data List

Observation Data	Quality Level
Cruise Summary	Processed (DMO)-QCed
Cruise Report	Processed (DMO)-Basic
Navigation	Processed (DMO)-Corrected
Bathymetry (MBES)	Processed (DMO)-Corrected
Gravity	Processed (DMO)-Corrected
Shipboard Three Component Magnetometer (STCM)	Processed (DMO)-Corrected
Marine Meteorology	Processed (DMO)-Corrected
Shipboard Acoustic Doppler Current Profiler (ADCP)	Processed (DMO)-QCed
Lowered Acoustic Doppler Current Profiler (LADCP)	Processed (DMO)-QCed
Conductivity-Temperature-Depth Profiler (CTD)	Processed (DMO)-QCed
Expendable Conductivity-Temperature-Depth Profiler (XCTD)	Processed (DMO)-QCed
Underway Thermosalino Graph	Processed (DMO)-QCed
Bottle Sampling Water Chemical Analysis	

Add to Basket

R/V Mirai Cruise Report
MR13-01

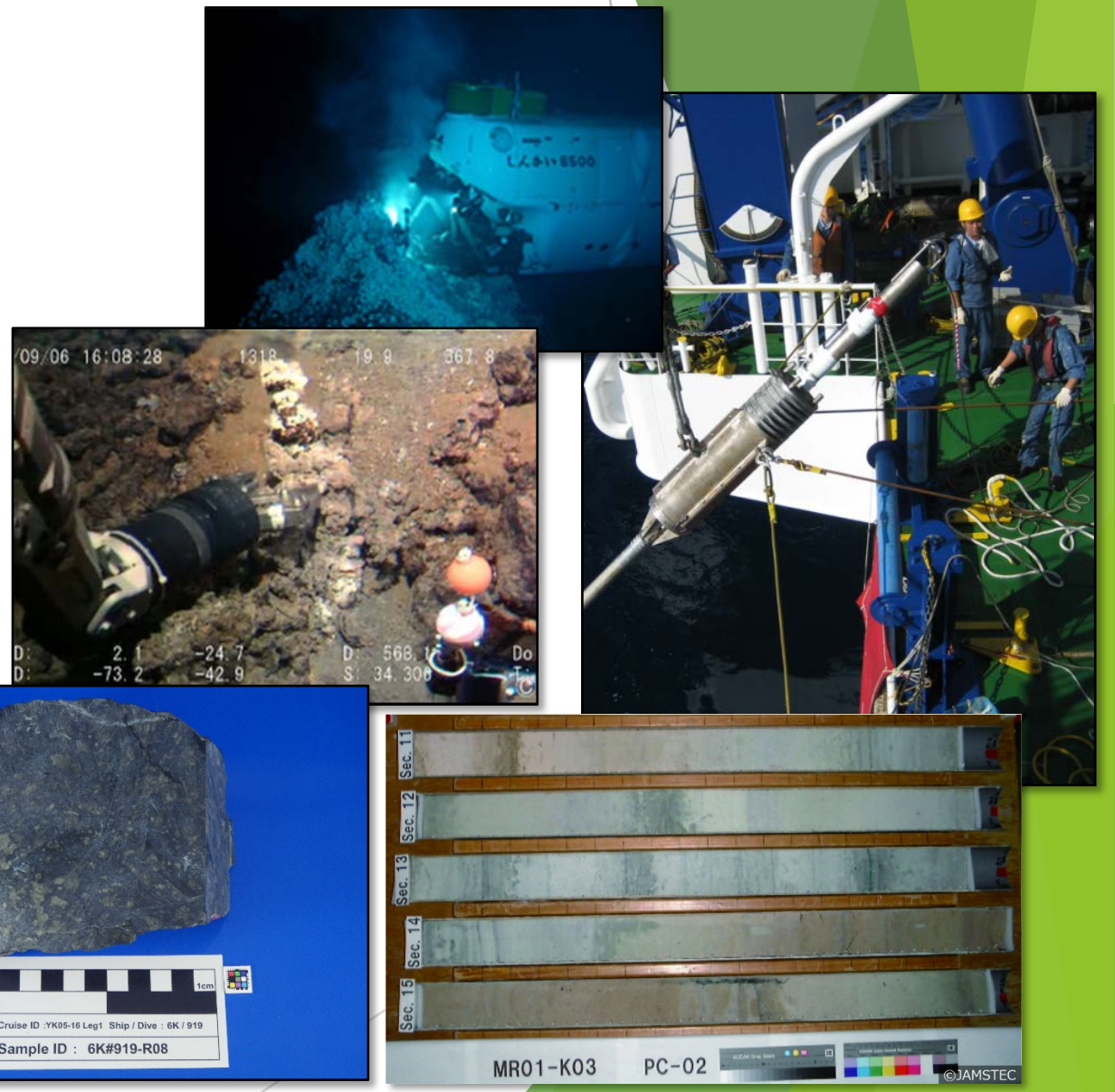
February 18, 2013 – March 28, 2013
Tropical Ocean Climate Study (TOCS)

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

JAMSTEC geosamples

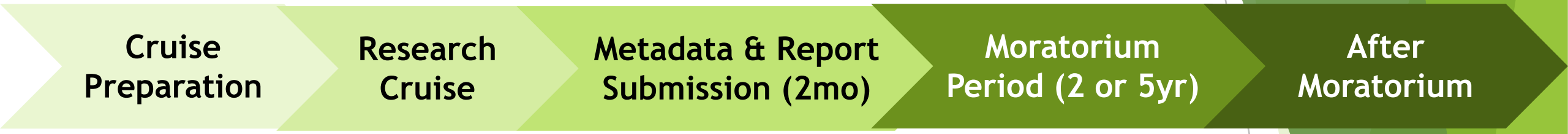
- Samples

Type	Metadata	Archive	Storage
Rock	24249	13523	Yokosuka HQ
Sediment Core	1556	954	Kochi Core Center



- Data/sample handling policies
  - JAMSTEC Data Policy (2008~)
  - JURCAOS-JAMSTEC Cooperative Research Cruise (2019~)

Data & sample handling timeline



Research proposal

Contract & permission

Ship schedule

Onboard operation plan

Routine observation data plan

Operational document acquisition

Raw data

Report & Summary

Metadata

Ports of call log

Scientific data & report acquisition

Processed data

Publication info

Data & Sample Open

Metadata report & summary Open

Public services

Services to request users

Sample handling instruction

Sample logistics plan

Problems & supports

On-shore support

Archive sample submission

Short-term storage

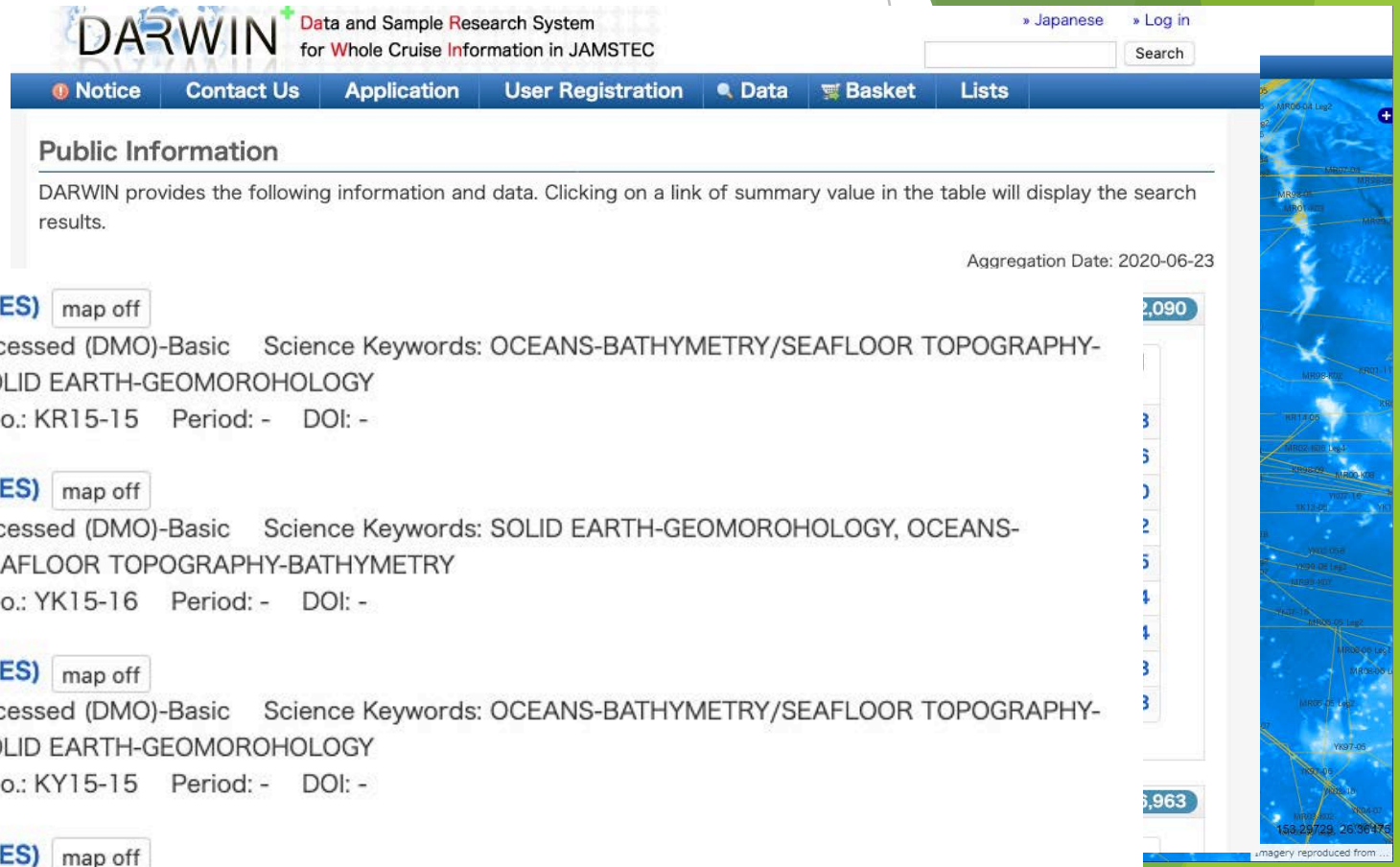
Physical sample handling

Photographing, phys. measurement, description check

Long-term storage

JAMSTEC Database for general public
as of 23 June 2020

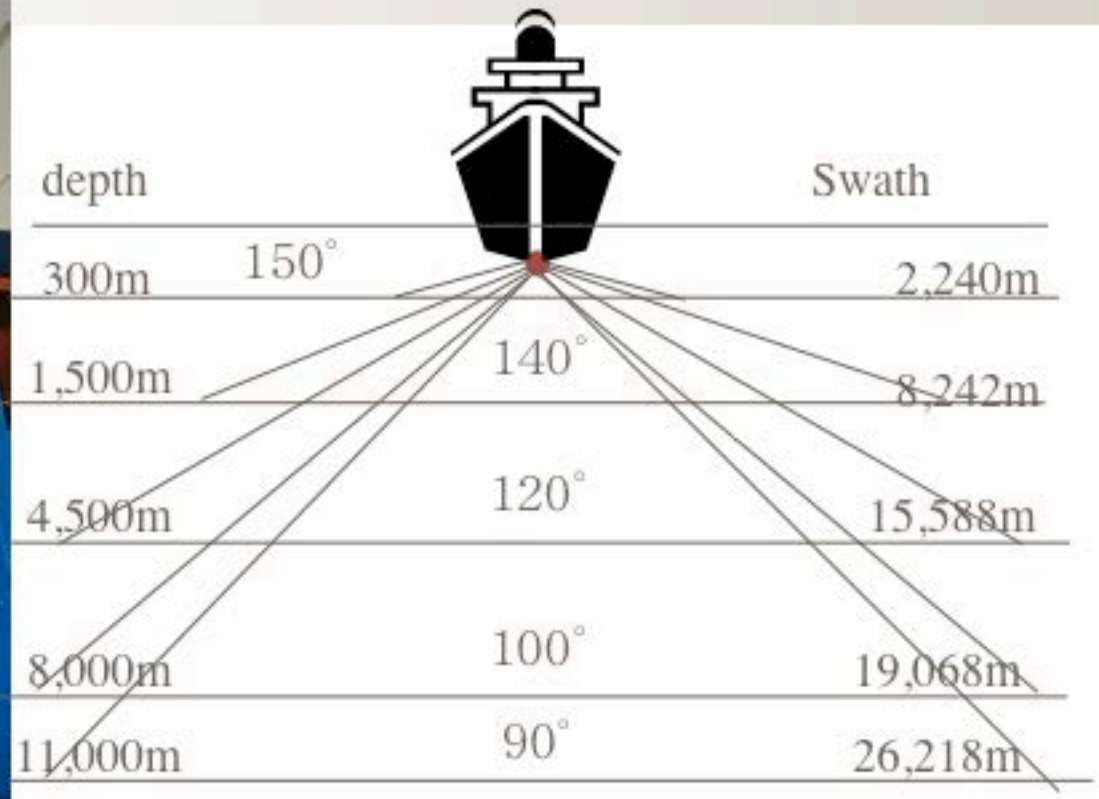
- **Cruises & Dives**
  - 2,090 cruises
  - 6,963 dives
- **Observation data (total**
  - CTD : 209 cruises
  - XBT : 894 cruises
  - Submersible CTD : 2,235
  - ADCP + LADCP : 559 cru
- **Marine Geophysics data**
  - Bathymetry : 1,087 cruis
  - Gravity : 738 cruises
  - Magnetics : 881 cruises

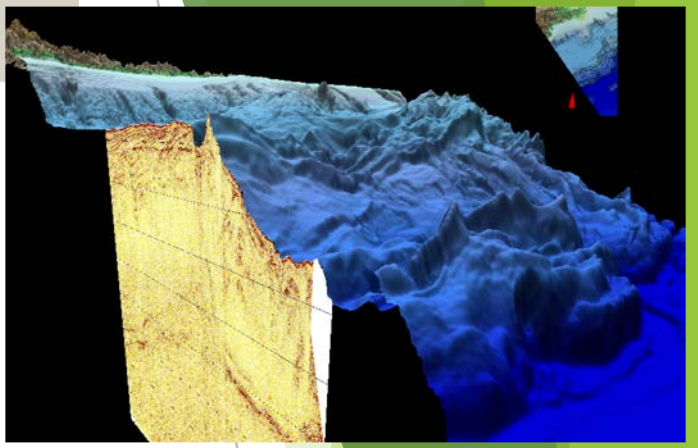


napsearch/

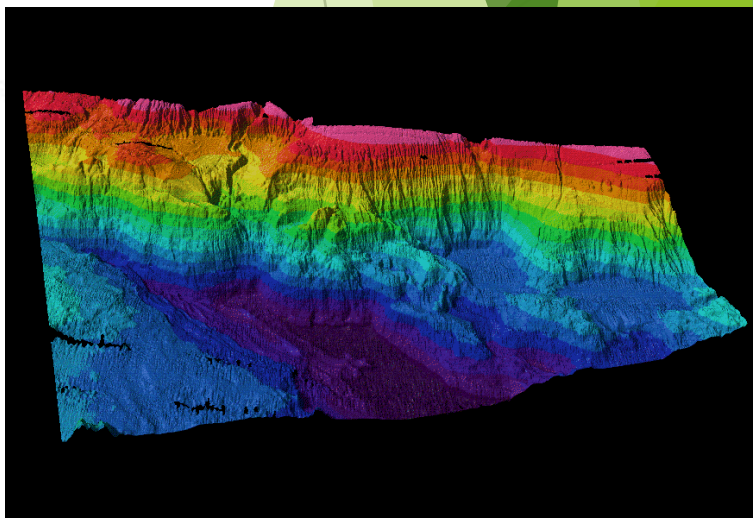
http://www.godac.jamstec.go.jp/darwin/counts/e

Multi-narrow beam bathymetry survey





Interactive Visualization System



Specification

Range: 50 ~ 11000m
Software : CARIS
Swath width: Max 150deg
Frequency: 12 KHz

Range of error:
directly underneath: WD x 0.2%
side: WD x 0.5%

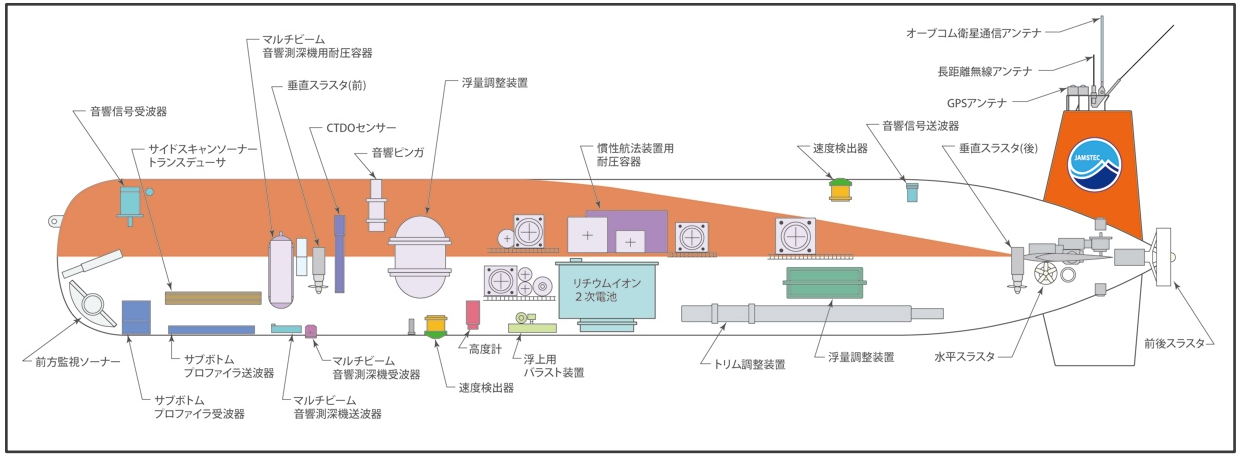
MBES equipped aboard JAMSTEC vessels

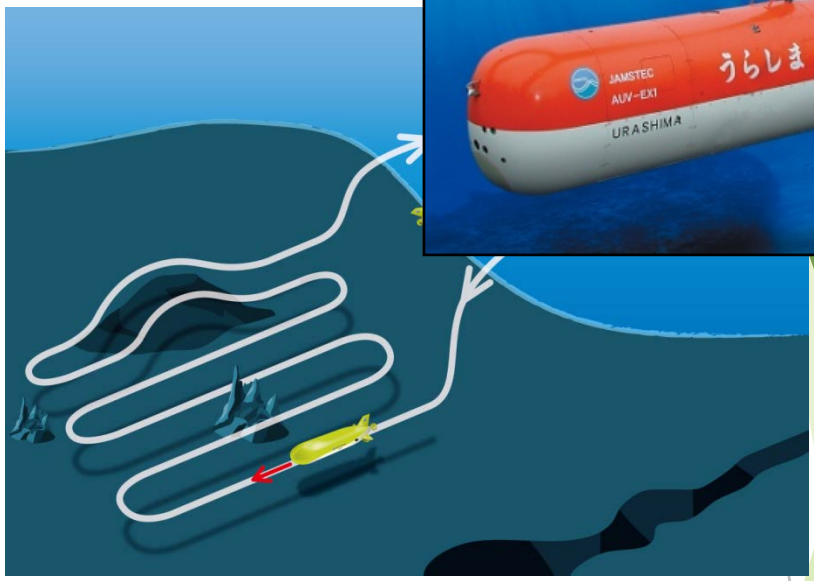
Courtesy of Nippon Marine Enterprise Co. Ltd.

	····· 199X ··· 2000 ···· 2004 ····· 2012	2013	2014～ Present
Natsu-shima	SeaBat 8160 →		Retired in 2015
Kaiyo	Classic SeaBeam → SeaBeam 2112 →		Retired in 2015
Yoksuka	TS-10 → SeaBeam 2112 (1999) →		EM122
Kairei	SeaBeam 2112 (1997) →	SeaBeam 3012 →	
Mirai	SeaBeam 2112 (1997) →	SeaBeam 3012 →	
Kaimei		EM122 →	





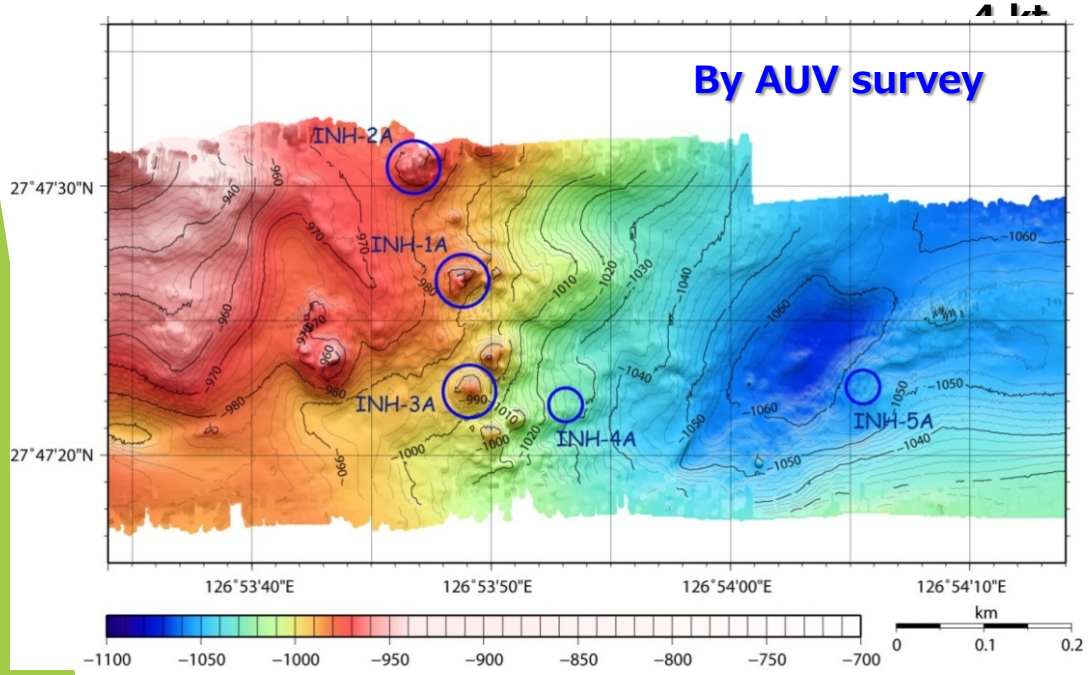




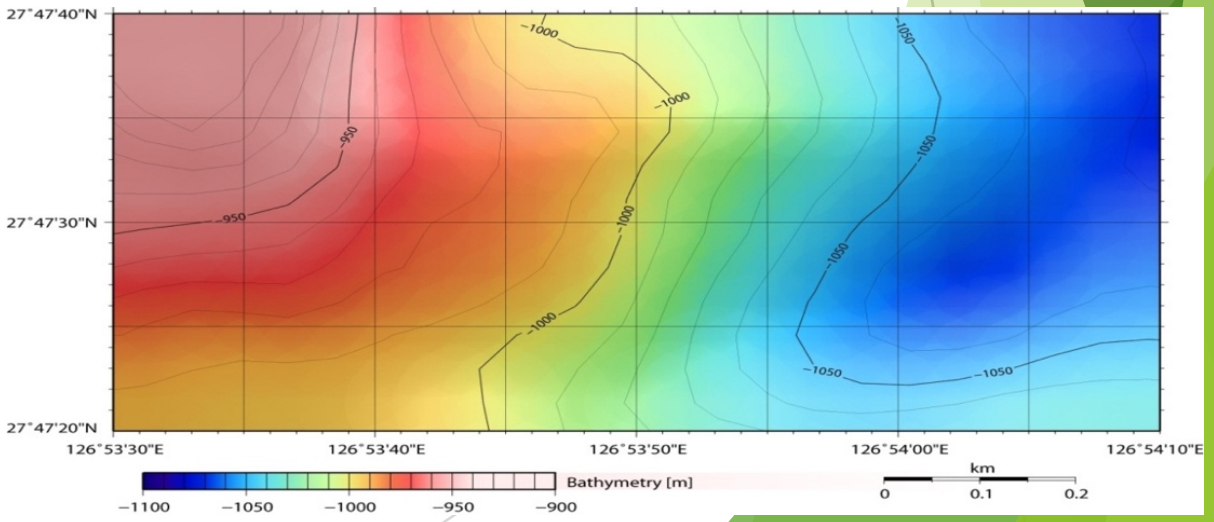
Numbers of dive : 280（2019）

Length	**:**	**10 m**
Weight	**:**	**ca. 10 t**
Max speed	**:**	**4 kt**

By AUV survey



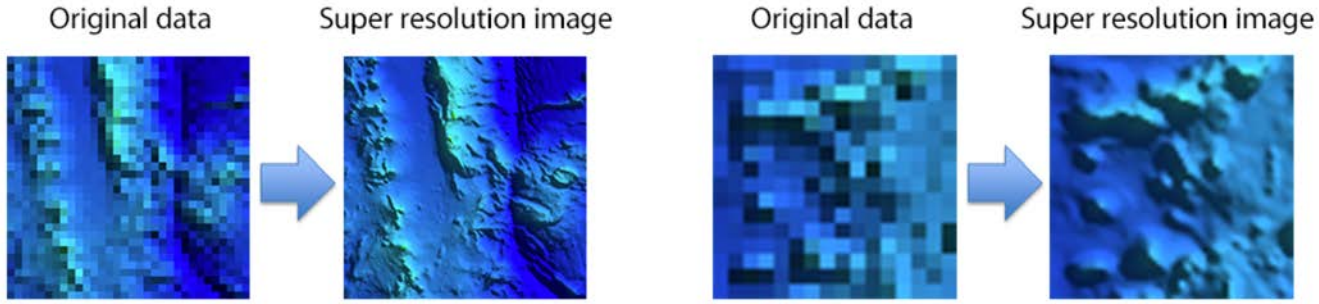
By onboard MBES system



SUPER RESOLUTION FOR GEOGRAPHY USING SPARSE CODING & DEEP LEARNING

- Our Goal -

Establish a methodology that can provide us higher resolution sea floor bathymetric maps from low resolution/low quality maps.



Team1: Sparce Coding

Team2: Deep Learning

Same Data

Feasibility study

- Our Approach -

By applying two different machine learning techniques, Sparce coding and Deep Learning for the same data resources, we attempt to compare the advantages of each method.

(Hidaka, M. et al., 2020)

SUPER RESOLUTION?

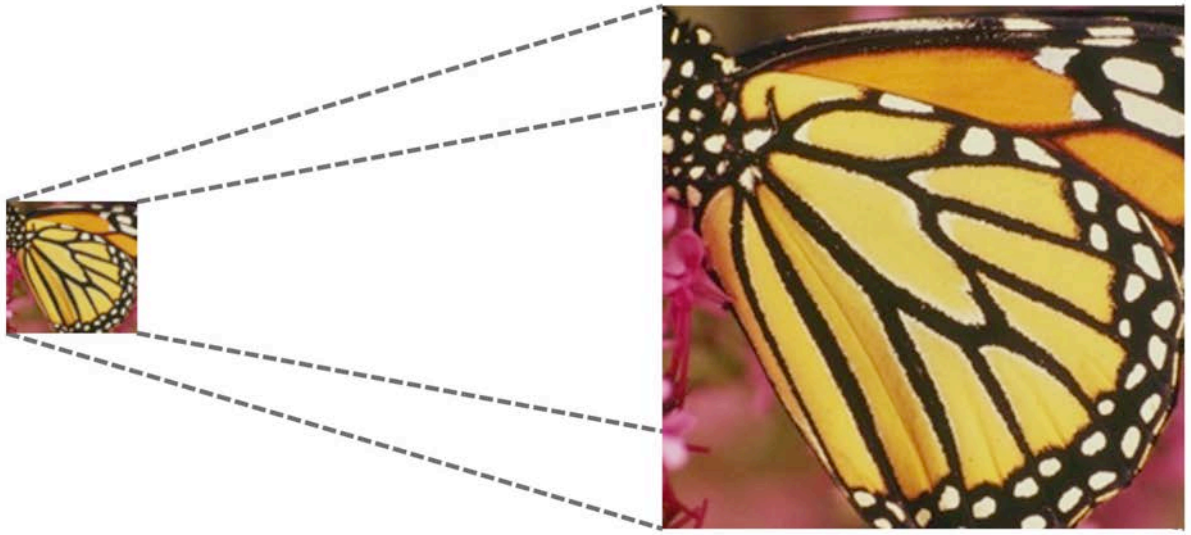
PROVIDE HIGH-RES IMAGE FROM LOW-RES IMAGE

Input

low-resolution image ($\mathbf{I}_{LR}$)

Output

super-resolution image ($\mathbf{I}_{SR}$)



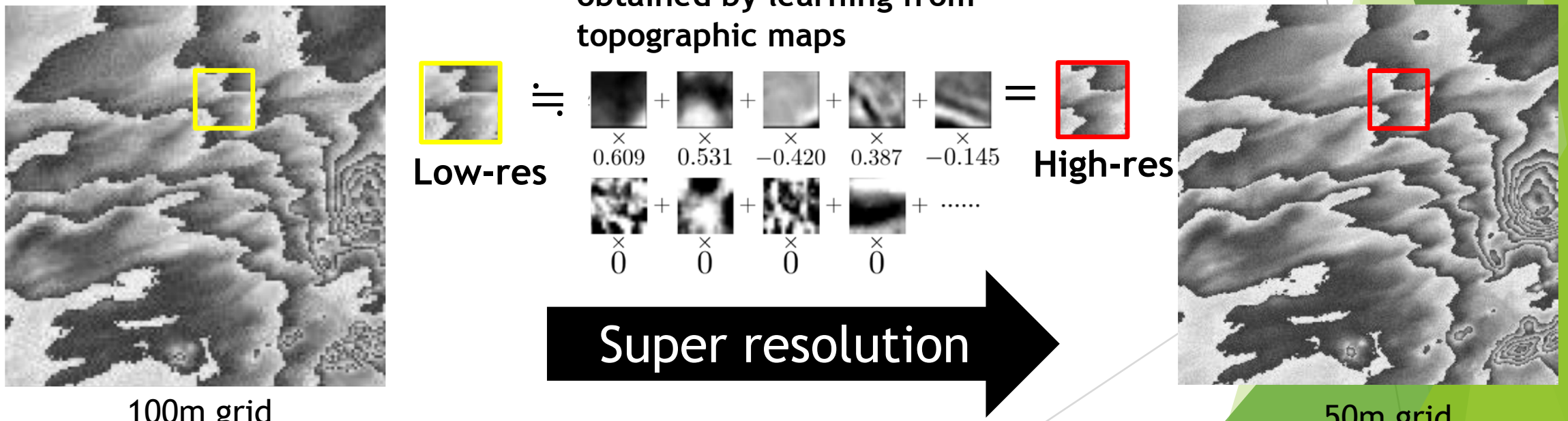
- Interpolation based
  - Bilinear
  - Bicubic
- Dictionary based
  - Sparse coding
- Deep Learning based
  - SRCNN
  - SRGAN

Ill-posed problem, many different approaches have been proposed!

(Hidaka, M. et al., 2020)

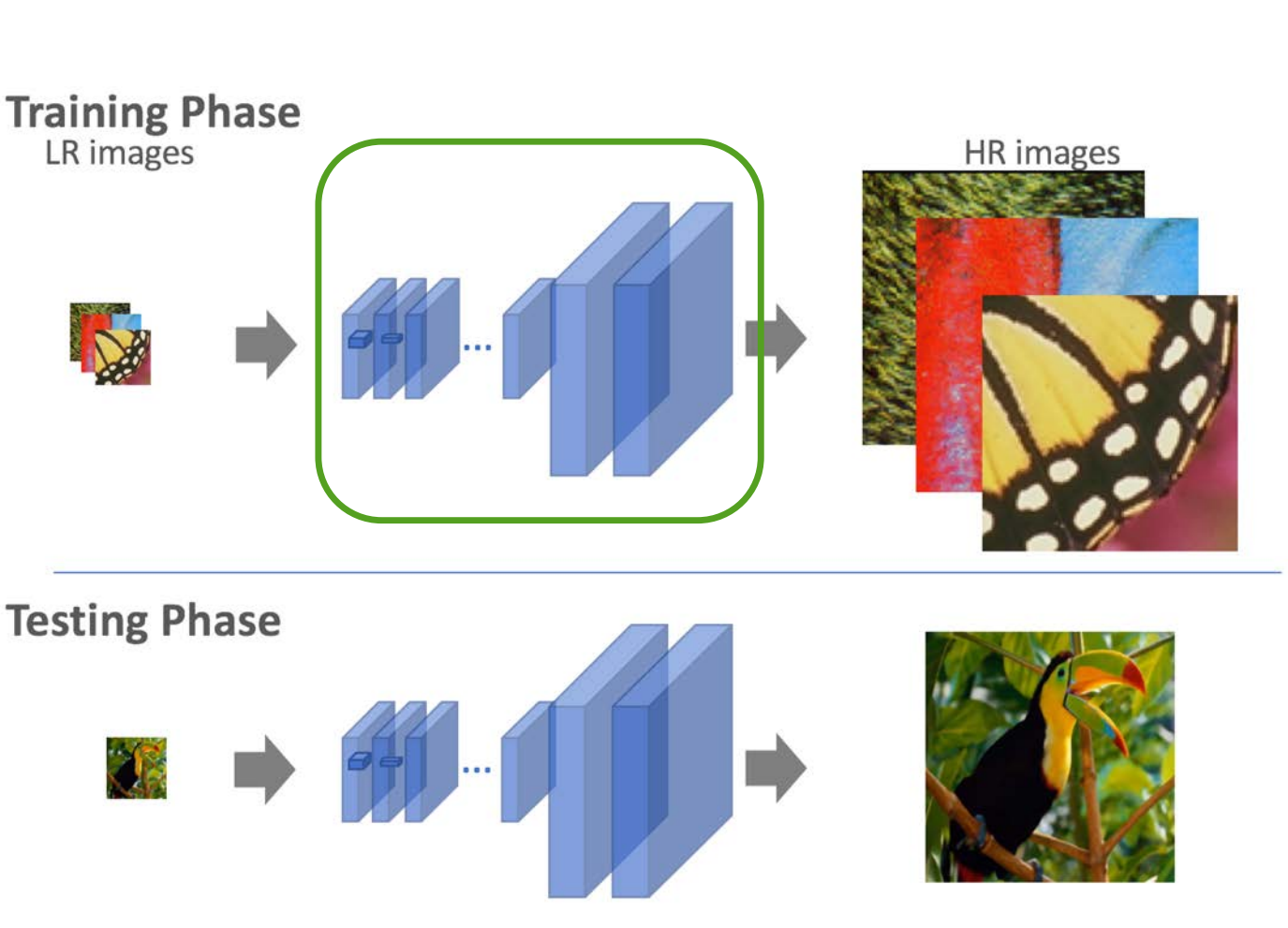
SUPER RESOLUTION BY USING 1. SPARSE CODING

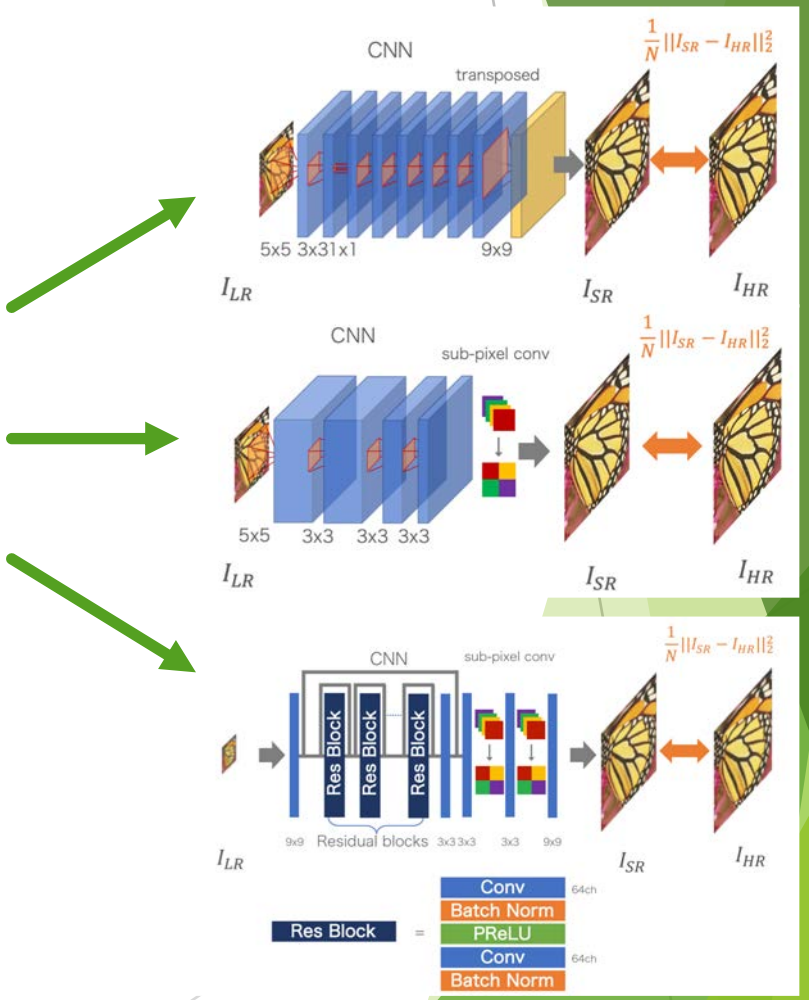
- Sparse coding is the technique which provide an approximate image by the linear combination of a small number of basis vectors (dictionary).
- By using High-res basis vectors, a low-resolution image becomes a super-resolved image.



(Kuwatani, T. et al., 2019; Hidaka, M. et al., 2020)

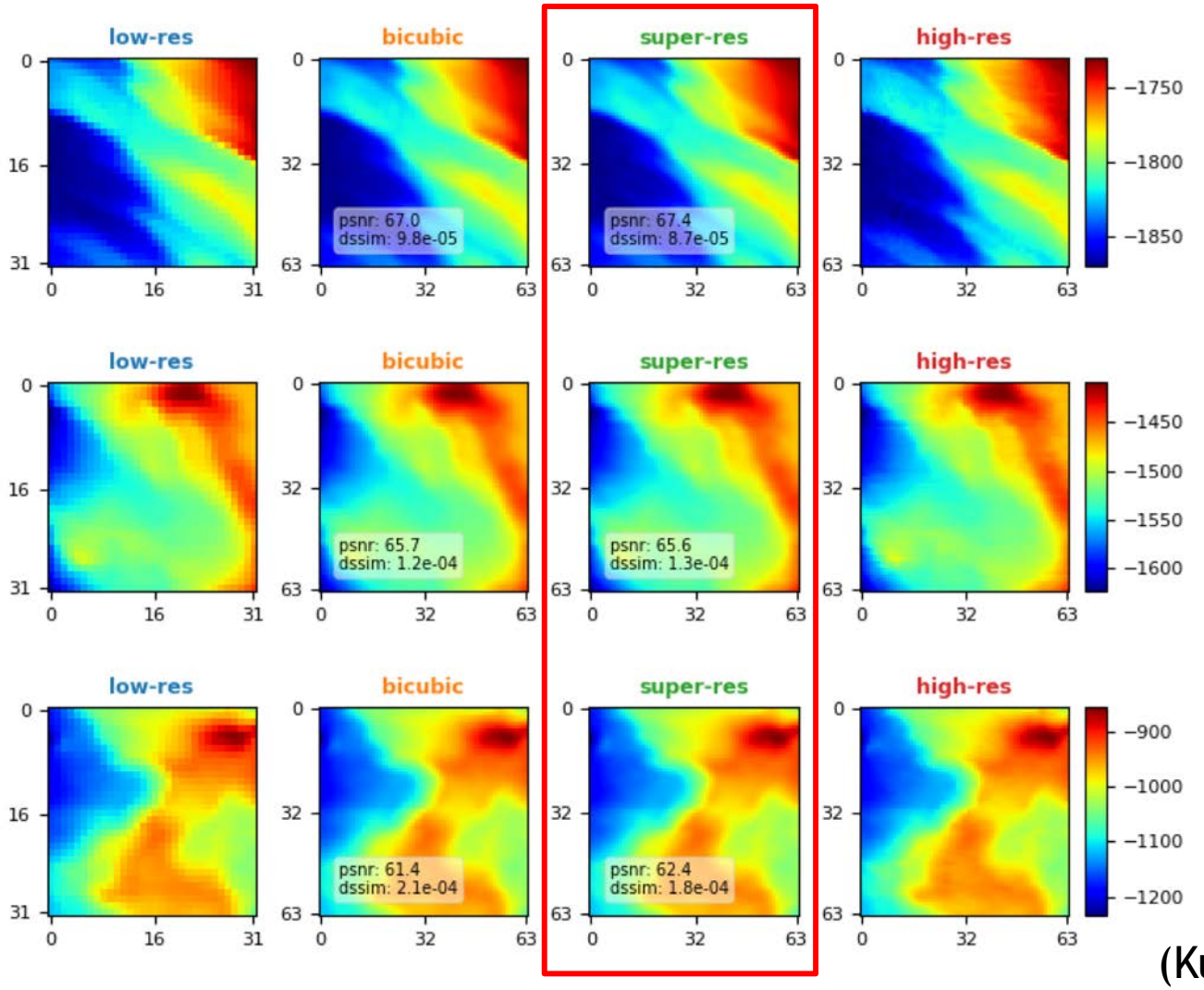
2. DEEP LEARNING FOR SUPER RESOLUTION
CONVOLUTIONAL NEURAL NETWORKS (CNNS)





https://engineer.dena.jp/2019/09/cv-papers-19-single-image-super-resolution-1.html

2. DEEP LEARNING FOR SUPER RESOLUTION
CONVOLUTIONAL NEURAL NETWORKS (CNNS)



Low-res :
Origibnal Low-resolution

Super-Res :
Convolutional Neural Networks (CNN)

PSNR & DSIMM :
Index of the super-resolution quality

Bicubic :
Conventional approach

High-res :
Original High-resolution (destination)

We have applied SRCNN, FSRCNN, ESPCN, SRGAN for our data set…
But, still under consideration.

(Kuwatani, T. et al., 2019; Hidaka, M. et al., 2020)

Mathematical Seafloor Geomorphology team

Activity

- Update and repletion of DARWIN site in the state-of-the-art technology.
- Vessels, fleet and vehicle sounding operation, data QA/QC, new technology of AUV-NEXT.

Related papers

- Matsuoka & Hidaka, in preparation.
- Hidaka, M., et al., submitted to 2020, *JpGU*.
- Kuwatani, T., *Geoinformatics*, in press.
- Kuwatani, T., *Elements*, 2019, https://doi.org/10.2138/gselements.15.4.280
- Kuwatani, T., et al., *Geoinformatics*, 2018, https://doi.org/10.6010/geoinformatics.29.2_49

Future activity

- Keep in contact with key persons in CSB, NIWA, JCG_JHOD_JODC.
- MBES data acquisition system will update and QA/QC will automatically be operation.

Please contact us at seabed2030@jamstec.go.jp