

Regional Training Workshop on Observing the Coastal  
and Marginal Seas in the Western Indian Ocean  
Maputo, Mozambique – June 7 – 9, 2022



# GLOBAL OCEANS

## Annual Indian Ocean Transects (AIOT) Program:

Proposal for a new program to:

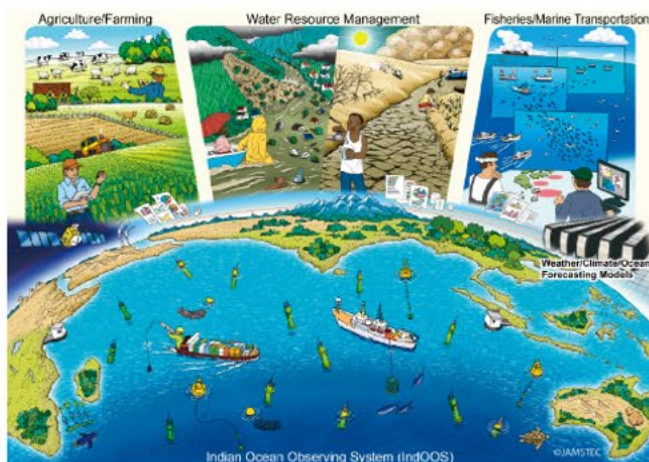
1. Annually replicate selected GO-SHIP hydrographic survey datasets (e.g. Level 1 data), together with newly developed regional transects & datasets that contribute to expanded, sustained observations in the Indian Ocean.
2. Collaboratively develop and host a new at-sea oceanographic training curriculum for regional students and scientists, supported by the AIOT observation program and on-board laboratory facilities.

## Full Report



# IndOOS-2

## A roadmap to sustained observations of the Indian Ocean for 2020-2030



Coordinating lead authors

Lisa M. Beal, Jérôme Vialard, Mathew K. Roxy

December 2019

Sponsored by



## The Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP): A Platform for Integrated Multidisciplinary Ocean Science

### OPEN ACCESS

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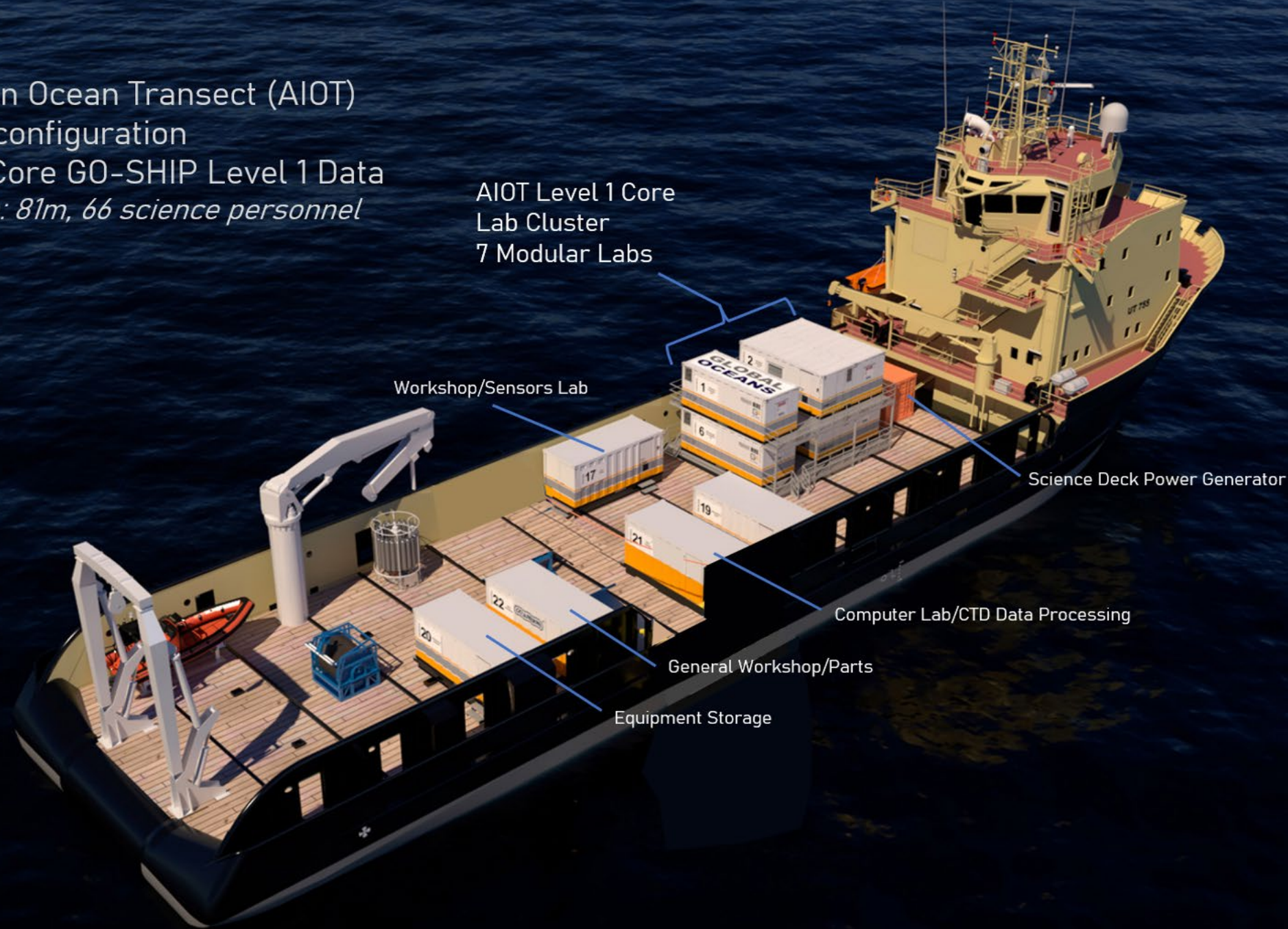
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The Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP) provides a globally coordinated network and oversight of 55 sustained decadal repeat hydrographic reference lines. GO-SHIP is part of the global ocean/climate observing systems (GOOS/GCOS) for study of physical oceanography, the ocean carbon, oxygen and nutrient cycles, and marine biogeochemistry. GO-SHIP enables assessment of the ocean sequestration of heat and carbon, changing ocean circulation and ventilation patterns, and their effects on ocean health and Earth's climate. Rapid quality control and open data release along with incorporation of the GO-SHIP effort in the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) *in situ* Observing Programs Support Center (JCOMMOPS) have increased the profile of, and participation in, the program and led to increased data use for a range of efforts. In addition to scientific discovery, GO-SHIP provides climate quality observations for ongoing calibration of measurements from existing and new autonomous platforms. This includes biogeochemical observations for the nascent array of biogeochemical (BGC)-Argo floats; temperature and salinity for Deep Argo; and salinity for the core



Annual Indian Ocean Transect (AIOT)  
MARV deck configuration  
Supporting Core GO-SHIP Level 1 Data  
*Vessel shown: 81m, 66 science personnel*



AIOT Level 1 Core  
Lab Cluster  
7 Modular Labs

Workshop/Sensors Lab

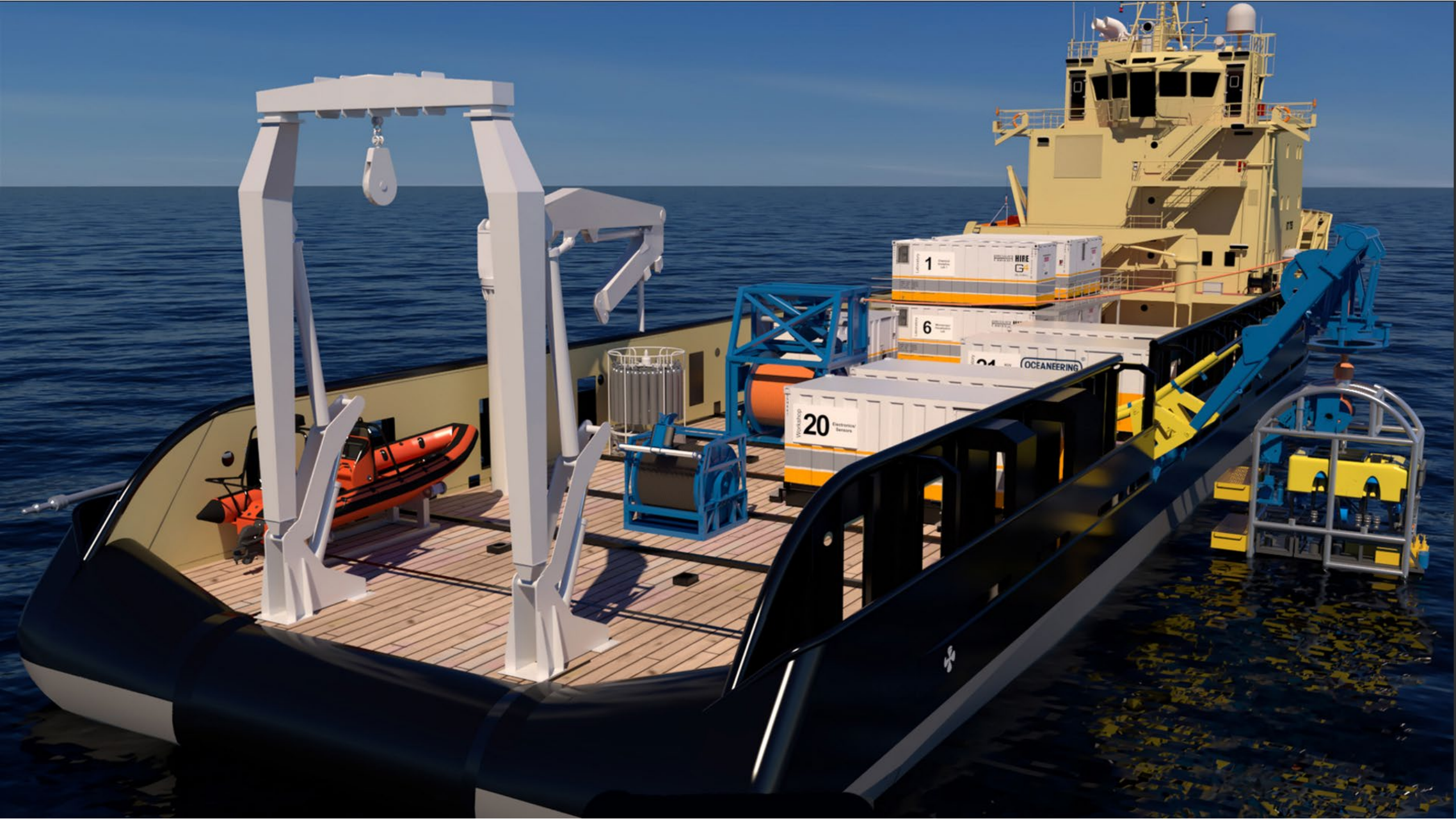
Science Deck Power Generator

Computer Lab/CTD Data Processing

General Workshop/Parts

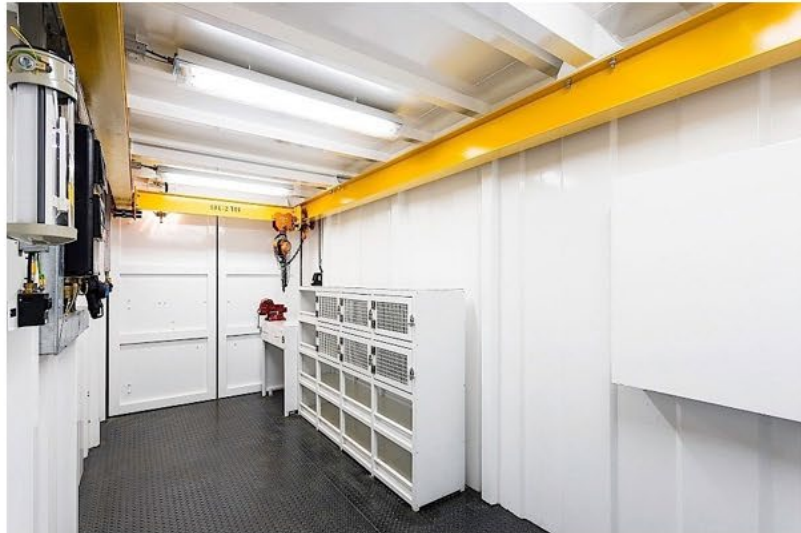
Equipment Storage







# AIOT On-Deck Modular Systems: Laboratories, Workshops, Workspace





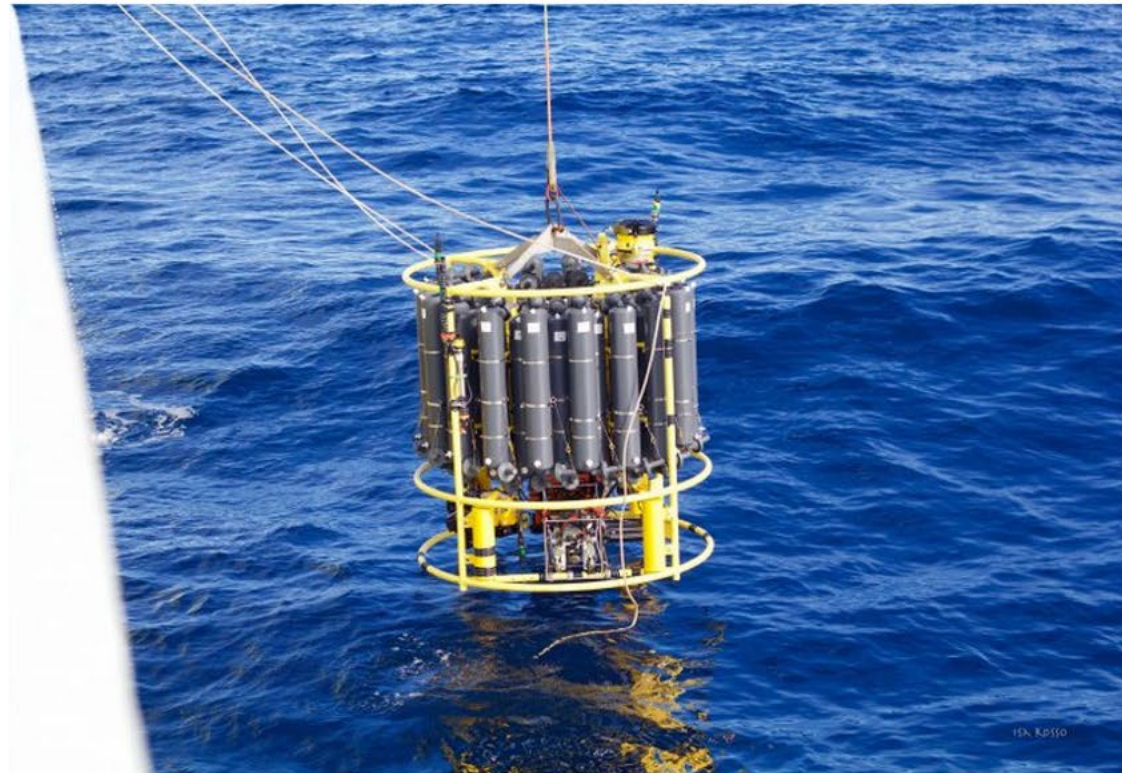
# GO-SHIP

## “Level 1 data”

US GO-SHIP Level 1 measurements are **core measurements**

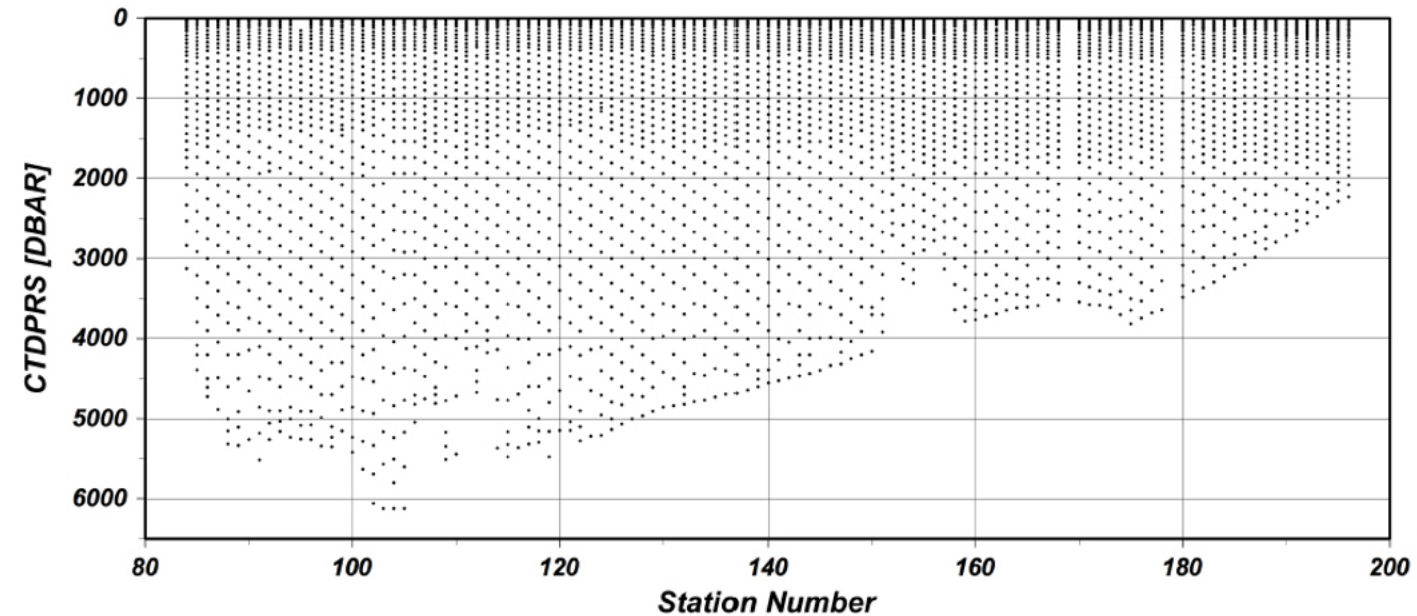
- Dissolved inorganic carbon (DIC)
- Total Alkalinity (TAlk)
- pH
- CTD pressure, temperature, salinity (calculated)
- CTD oxygen (sensor)
- Bottle salinity
- Nutrients by standard auto analyzer (NO<sub>3</sub>/NO<sub>2</sub>, NO<sub>2</sub>, PO<sub>4</sub>, SiO<sub>3</sub>)
- Nitrate NO<sub>3</sub> (calculated)
- Dissolved oxygen
- Chlorofluorocarbons (CFC-11, -12) and SF<sub>6</sub>
- Dissolved organic carbon
- Total dissolved nitrogen
- Surface underway system (T, S, pCO<sub>2</sub>)
- ADCP shipboard
- ADCP lowered
- Underway navigation and bathymetry
- Meteorological

Planned AIOT-dedicated CTD Rosette/sensor.  
Stationed in Singapore.



## GO-SHIP CTD profiles I09N Cruise (2016)

A total of 113 stations were occupied with one CTDO/rosette/LADCP/chipod package. 1 repeat station from the previous section leg I08S station number 83 was the I09N initial station 84. 113 stations 117 CTDO/rosette/LADCP/chipod casts including 1 test cast performed, for the most part, a reoccupation of I09N-2007 and detailed in the following sections. 8 Argo/O<sub>2</sub> floats were deployed on I09N and detailed in the Argo section of the cruise report. 3 trace metal casts were complete from the aft A-frame and detailed in the "Phytoplankton, 15N/13C and Trace Metals" section of the cruise report. 26 successful spectroradiometer (optics) casts were performed through the cruise, also detailed in the "CDOM, Chlorophyll A and Spectroradiometer" section of the cruise report.



CTDO data and water samples were collected on each CTDO, rosette, LADCP and chipod cast, usually with in 10 meters of the bottom. Water samples were measured on board for salinity, dissolved oxygen, nutrients, *DIC*, pH, total alkalinity and *CFCs/SF6*. Additional water samples were collected and stored for shore analyses of  $\delta\text{O}^{18}$ ,  $\delta\text{N}^{15}$  and  $\delta\text{O}^{18}$  in  $\text{NO}^3$ , *DOC/TDN*,  $^{13}\text{C}/^{14}\text{C}$ , *CDOM*, phytoplankton pigments, *POC*, *HPLC*, *AP*, DNA, dPOC/dPON, d  $\text{NO}^3/\text{NO}^3$ , d  $\text{NO}_2^-/\text{NO}_2$ ,  $\text{NH}_4^+$ , cell counts, urea and bacterial abundance.

A sea-going science team assembled from 17 different institutions and participated in the collection and analysis of this data set. The programs, principal investigators, science team, responsibilities, instrumentation, analysis and analytical methods are outlined in the following cruise document.





# AIOT Project Partner: Quantum Analytics

## Analytical Instrumentation & Technical Support

### Elemental Analysis



XRF

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XRD

---

X-Ray Microscopy

---

Organic CHNSO

---

Inorganic CS & ONH

---

TOC & Water Analysis

---

N/Protein Analysis

---

Optical Emission Spectrometry

---

ICP-MS & ICP-OES

### Molecular Spectroscopy



FTIR Microspectroscopy

---

FTIR Spectroscopy

---

Raman Spectroscopy

---

FT-NIR Spectroscopy

---

Process FTIR

### Gas Chromatography



GC

---

GC/MS

---

Pyrolysis

---

Thermal Desorption

### Liquid Chromatography



HPLC

---

LC/MS

+ reagents, gasses, and other consumables & instruments





## AIOT Supplemental Project Data: Identification and Quantification of Microplastics in Seawater using Micro- Furnace Pyrolysis-GC/MS

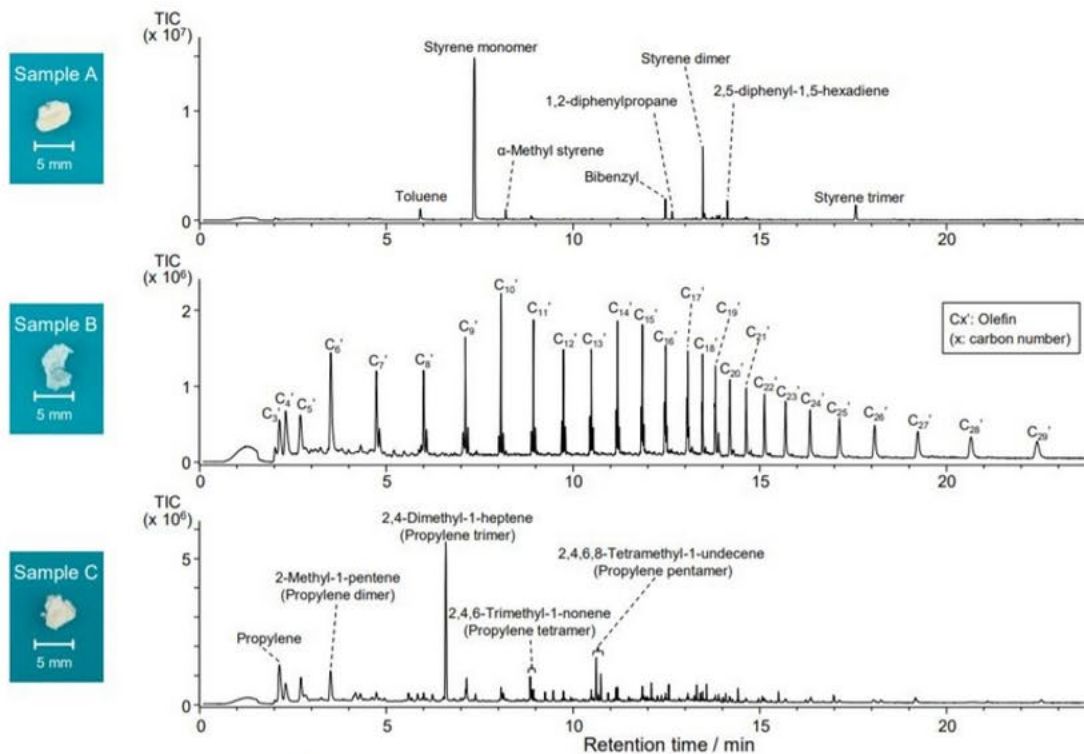


Figure 1. Pyrograms of White Microplastics Samples

Pyrolysis temp.: 600 °C, GC inj. temp.: 300 °C, GC oven temp.: 40 (2 min hold) – 320 °C (20 °C/min, 16 min hold), Split ratio: 1/16 Separation column: UA+ – 5 (5 % diphenyl 95 % dimethylpolysiloxane), L=30 m, id=0.25 mm, df=0.5 μm, Column flow rate: 1 mL/min (He) Scan range: m/z 29 – 350, Scan rate: 4 scan/s, Sample amount: Sample A 35 μg, Sample B 53 μg, Sample C 34 μg. Samples collected from surface water, Osaka Bay, Japan.

**From:** Technical note, Frontier Laboratories Ltd. 4-16-20 Saikon, Koriyama, Fukushima, 963-8862 JAPAN. [www.frontier-lab.com](http://www.frontier-lab.com). Samples courtesy of Professor S Tanaka of Kyoto University. Discussed at <https://www.lqa.com/resource/pyrolysis-gc-ms-for-microplastics/>

# Framework for AIOT Training & Educational Curriculum

**GLOBAL OCEANS**

**OTGA**  
OceanTeacher Global Academy

**UNESCO**  
United Nations  
Educational, Scientific and  
Cultural Organization

**Intergovernmental  
Oceanographic  
Commission**

**ocean best  
practices**

**International Science Council  
SCOR  
Scientific Committee on Oceanic Research**

## **Module A:**

Pre-Expedition Preparation

- Field work preparation
- Analytical instrumentation training/review
- Sampling instrument training/review
- Video library – best practices, equipment preparation/use

## **Module B:**

Expedition/Hands-On Training  
*(Mentor supervised)*

- On-deck/overboard equipment preparation, calibration, sampling.
- Sample collection, processing, storage, documentation.
- Laboratory analysis, instrumentation, methods, calibration/standards, QC process.
- Data processing, documentation.
- *Regional infrastructure support – Buoy servicing (RAMA, OMNI), Argo deployments, etc.*

## **Module C:**

Post-Expedition Data Processing

- Post-expedition data processing, analysis, documentation, archiving.
- Shore-based analysis/methods (eDNA, etc.)
- Data integration with community oceanographic, met/ocean, modeling products.

- Curriculum on the OTGA eLearning Platform + In-Person Classroom
- Learning assessment tools
- Linking AIOT with regional university course offerings & opportunities for field work
- Program assistance with student/scientist visas & travel funding
- Curriculum development: **AIOT Regional Advisory Council**, OTGA, OBPS, Content Providers



# AIOT: Expanding current OTGA training curricula & alignment with existing programs

The screenshot displays the OceanTeacher Global Academy website interface. At the top left, there is a navigation menu with 'Home' and 'Calendar' options. The main header includes the 'OceanTeacher Global Academy' logo and a user status indicator: 'You are currently using guest access (Log in)'. The central content area features the OTGA logo and a descriptive paragraph about the training platform. Below this, eight course categories are presented in a grid, each with an icon, a title, and a brief description of course topics.

**OceanTeacher Global Academy** provides a comprehensive web-based training platform that supports classroom training (face-to-face), blended training (combining classroom and distance learning), and online (distance) learning.

OceanTeacher Global Academy courses cover a range of topics related to the IOC programmes, contributing to the IOC Mandate and the implementation of the IOC Capacity Development Strategy, enabling equitable participation of all IOC Member States and IOC Programmes.

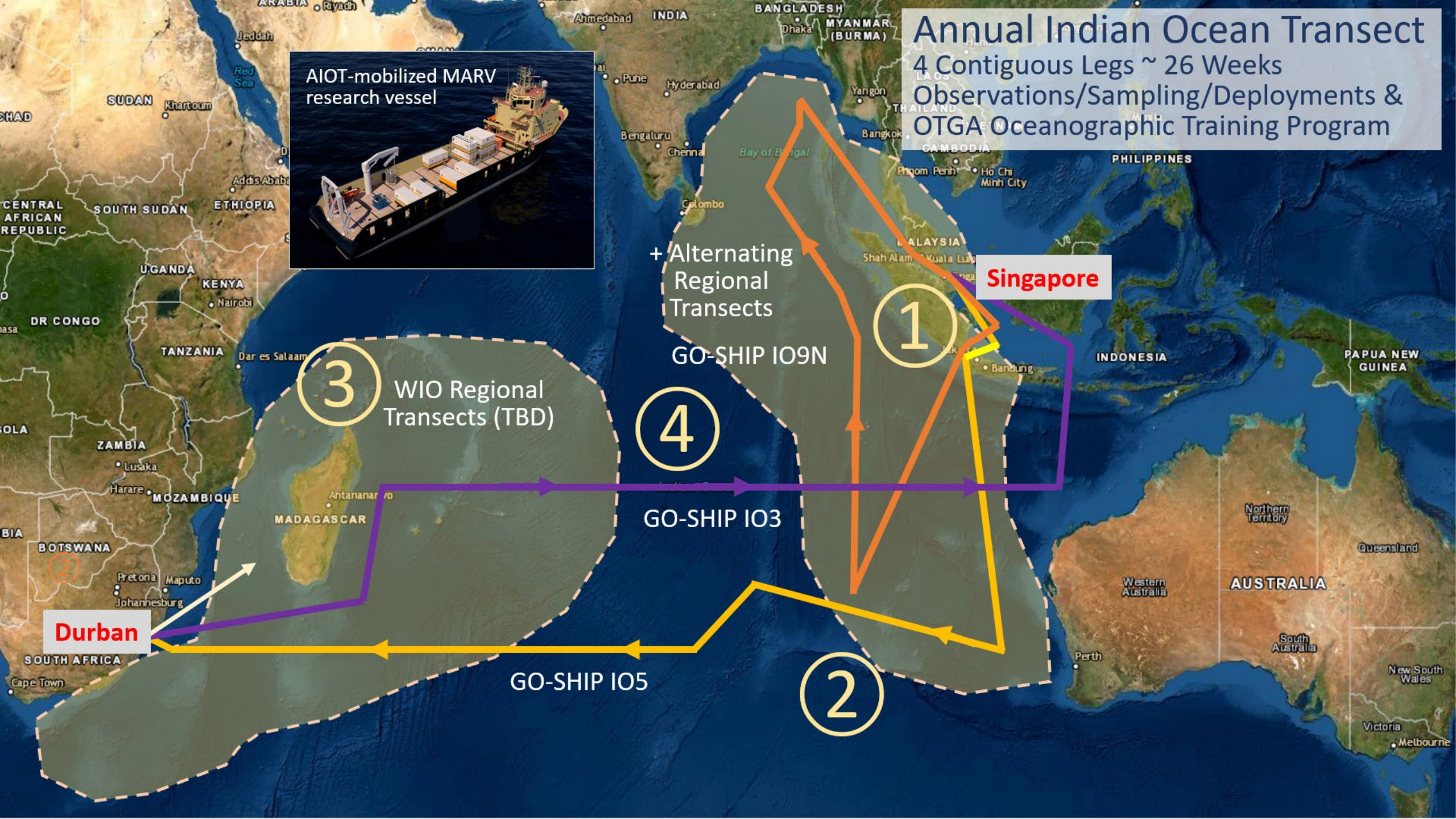
| Course Category                       | Course Topics  |
|---------------------------------------|--|
| Scientific Knowledge and Research     | Course topics include Research data management, OBIS, HAB                    |
| Sustainable Use of Marine Resources   | Course topics include Marine Biodiversity Data Management                    |
| Marine Spatial Planning               | Course topics include Marine spatial planning, GIS applications for ICZM.    |
| Marine and Coastal Ecosystems         | Course topics include Marine GIS applications, Coastal mapping & monitoring. |
| Disaster Risk Reduction               | Course topics include Tsunami awareness, Storm surge forecasting.            |
| Implementing International Marine Law | Course topics include Marine Scientific Research under the UNCLOS.           |
| Ocean Acidification                   | Course topics include Impacts of ocean acidification.                        |
| Marine Pollution                      | Course topics include Prevention and reduction of marine pollution.          |

<https://classroom.oceanteacher.org/>



# Annual Indian Ocean Transect

4 Contiguous Legs ~ 26 Weeks  
Observations/Sampling/Deployments &  
OTGA Oceanographic Training Program



**Singapore**

+ Alternating  
Regional  
Transects

GO-SHIP IO9N

3 WIO Regional  
Transects (TBD)

4

GO-SHIP IO3

**Durban**

GO-SHIP IO5

2

AUSTRALIA

PAPUA NEW  
GUINEA

INDONESIA

1

1

SOUTH AFRICA

MADAGASCAR

MOZAMBIQUE

ZAMBIA

TANZANIA

KENYA

ETHIOPIA

SUDAN

Jeddah

INDIA

MYANMAR  
(BURMA)

BANGLADESH

Dhaka

Yangon

Bangkok

PHILIPPINES

Ho Chi Minh City

Phnom Penh

MALAYSIA

Shah Alam

Kuala Lumpur

Bandung

Colombo

Chennai

Bengaluru

Hyderabad

Pune

Ahmedabad

Riyadh

ARABIA

CHAD

CENTRAL  
AFRICAN  
REPUBLIC

SOUTH SUDAN

ETHIOPIA

DR CONGO

ZAMBIA

BOTSWANA

SOUTH AFRICA

Cape Town

MOZAMBIQUE

ZAMBIA

TANZANIA

KENYA

ETHIOPIA

SUDAN

Jeddah

ARABIA

INDIA

BANGLADESH

MYANMAR  
(BURMA)

PHILIPPINES

INDONESIA

PAPUA NEW  
GUINEA

AUSTRALIA

Northern Territory

Queensland

Western Australia

South Australia

New South Wales

Victoria

Melbourne

Perth

Bandung

Kuala Lumpur

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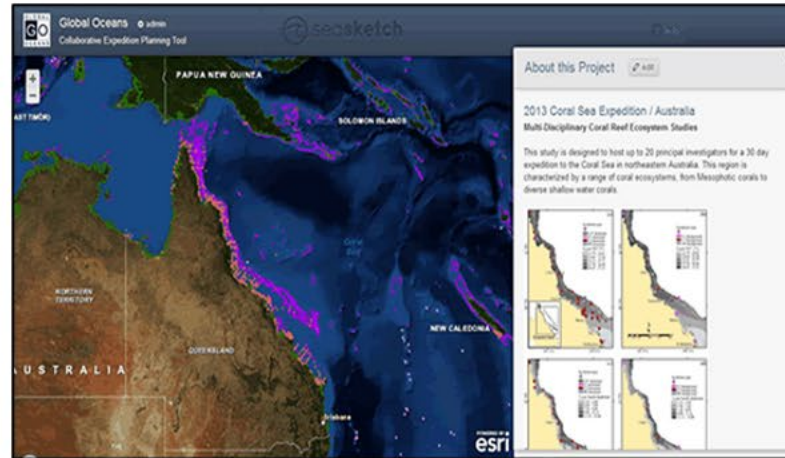
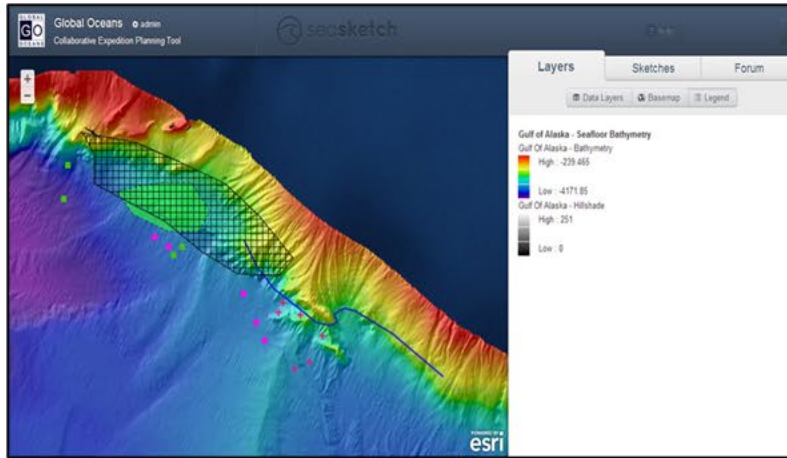
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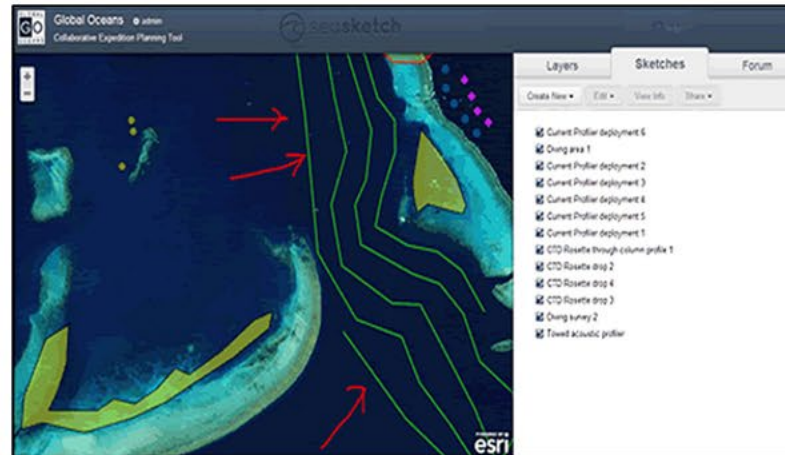


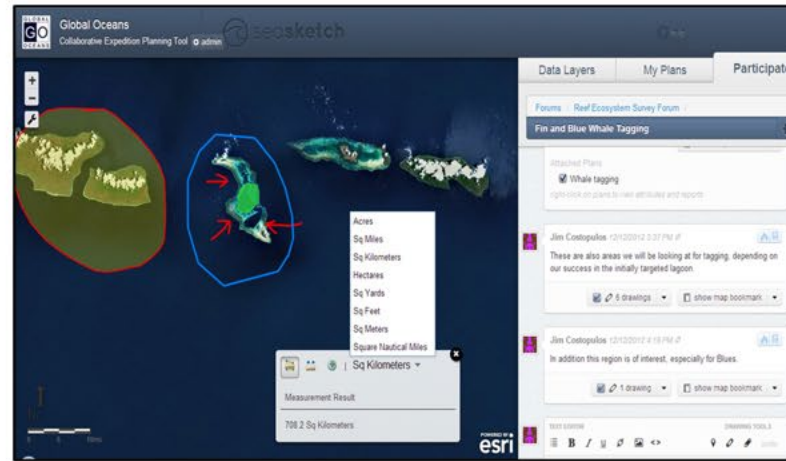
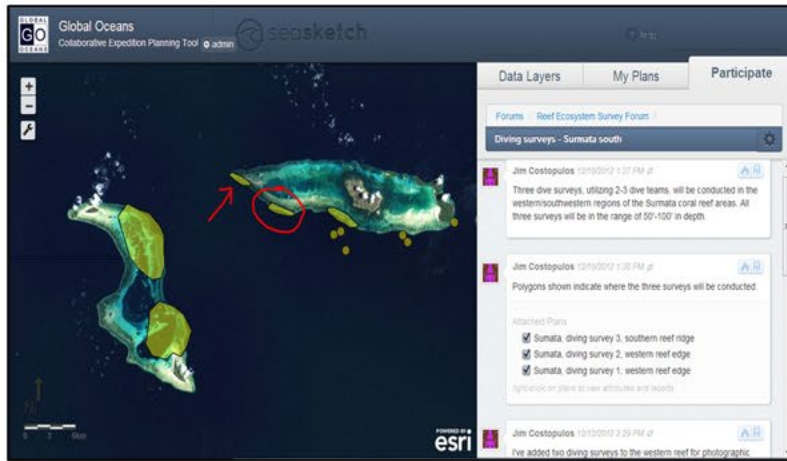
# AIOT: Online Expedition Planning Tool (EPT)

*Project planning and survey modules  
for collaborative project development*

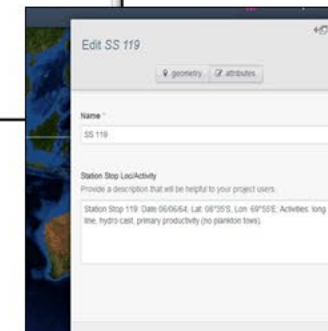
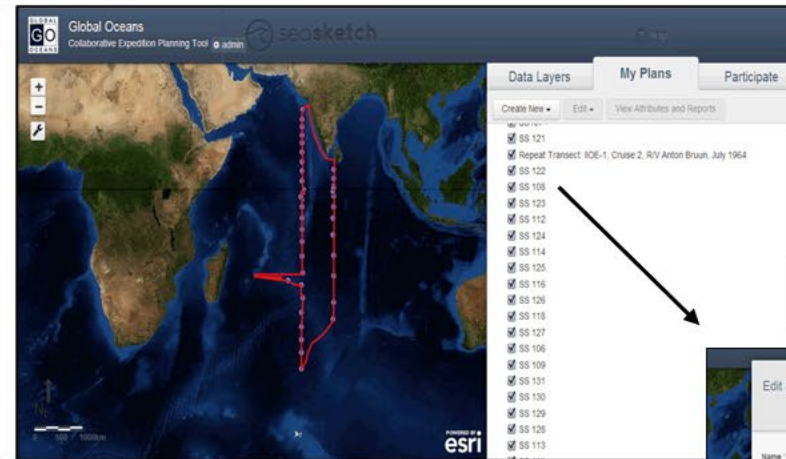
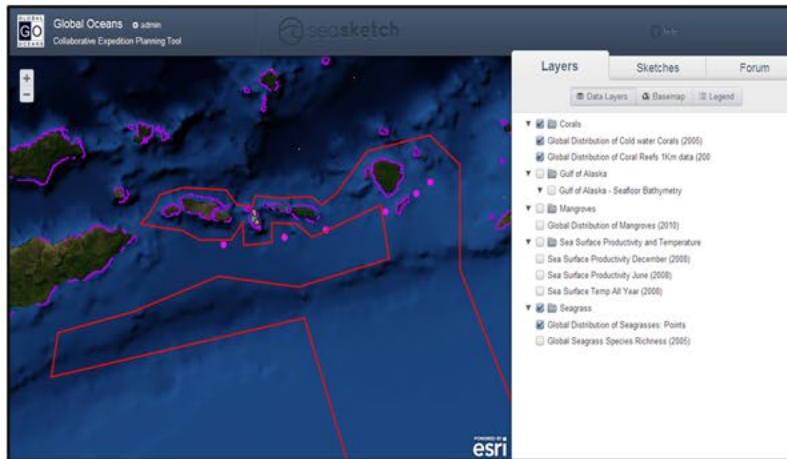


- Secure expedition modules
- Linked to project resources
- Hosting OTGA curriculum resources
- Integrated GIS data layers & libraries





- Transect modeling & activity planning
- User-defined graphics tools & project forums
- Multiple languages





# Annual Indian Ocean Transect

Four contiguous cruise legs on research mobilized MARV vessel

Projected start: 2023/24

GLOBAL  
OCEANS



**Project mobilization:** Singapore

**Leg 1 – Eastern IO Transect**, replicating GOSHIP **IO9N Line** “Level 1” observations + alternating regional priority transects TBD.  
**New OTGA/OBP oceanographic training program integrated with Leg 1 observations/research – 10-12 regional students.**  
International science team: 15-20. **Cruise transit: Singapore to Singapore ~ 35-40 days.**

**Ship Replenishment & Team change:** Singapore

**Leg 2 – E/W Transit to WIO** – along GOSHIP **IO5 Line**, with selected observations/sampling/deployments (TBD).  
International science team: 10-15. **Cruise transit: Singapore to Durban, South Africa ~ 20 days**

**Ship Replenishment & Team onboarding:** Durban

**Leg 3 – Western IO Transect**, Regional transect & observations  
**New OTGA/OBP oceanographic training program integrated with Leg 4 observations/research – 10-12 regional students.**  
International science team: 15-20. **Cruise transit: Durban to Durban ~ 35-40 days**

**Ship Replenishment & Team change:** Durban

**Leg 4 – W/E transit to EIO/Return** – along GOSHIP **IO3 Line**, with selected observations/sampling/deployments (TBD).  
Scientific team 10-15. **Cruise transit: Durban to Singapore ~ 20 days**

**Project demobilization:** Singapore

**GLOBAL  
OCEANS**

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