

# From the Indian Ocean to the World Ocean and back in 50 years

By

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Marine Research Institute

# From the Indian Ocean to the World Ocean and back in 50 years

Dedicated to the memory of Dr NK Pannikar: 1913 – 1977

## Founder of Oceanography in India

Educated in Kerala, Madras and Plymouth UK

- 1962 – 1965 Leader: India's IIOE programme,

- 1966-1973 Founding Director:

National Institute of Oceanography, Goa,

- 1974 – 1977 Vice-chancellor: Kochi University, Kerala

- Recipient of many national and international honours and medals.

I am also greatly honoured to follow my good friend and colleague Dr Shubha Sathyendranath as recipient of the NK Pannikar medal



## Scientific Committee on Oceanic Research



From report from 1957 SCOR Annual Meeting:

*“With such adequate preparation it would be possible for the next one or two years, provided sufficient funds and ship time become available, for as many as 16 vessels from many countries to make **‘a combined assault on the largest unknown area on earth, the deep waters and seabed of the Indian Ocean’**.*

*In this area the seasonal reversals in wind direction, unknown elsewhere, will provide opportunities for investigating the general productivity of the oceans ..... In addition to scientists from the northern hemisphere, **scientists and students from the countries bordering the Indian Ocean should participate**, thus encouraging and developing the marine sciences and fisheries in those countries.”*

Anon. 1958. Report of a Meeting. *Deep-Sea Research* 5:75-78

Thanks: Ed Urban, SCOR



# Introduction



Scientific Committee on Oceanic Research

John H Day, my PhD supervisor



Planning the IIOE  
Washington , DC

Discussing IIOE 2  
New Zealand



# Introduction

## The International Indian Ocean Expedition (IIOE) 1962-1965

\* SCOR formed in 1957 as result of International Geophysical Year (IGY)  
- Indian Ocean Identified as seriously under-sampled and it became the first focus of 5 SCOR working groups and then IIOE SCOR's first large programme



\* Intergovernmental Oceanographic Commission (IOC) formed in 1960 and took over management of IIOE as its first co-ordination activity



# Introduction

## Phases of Development and Management of the IIOE

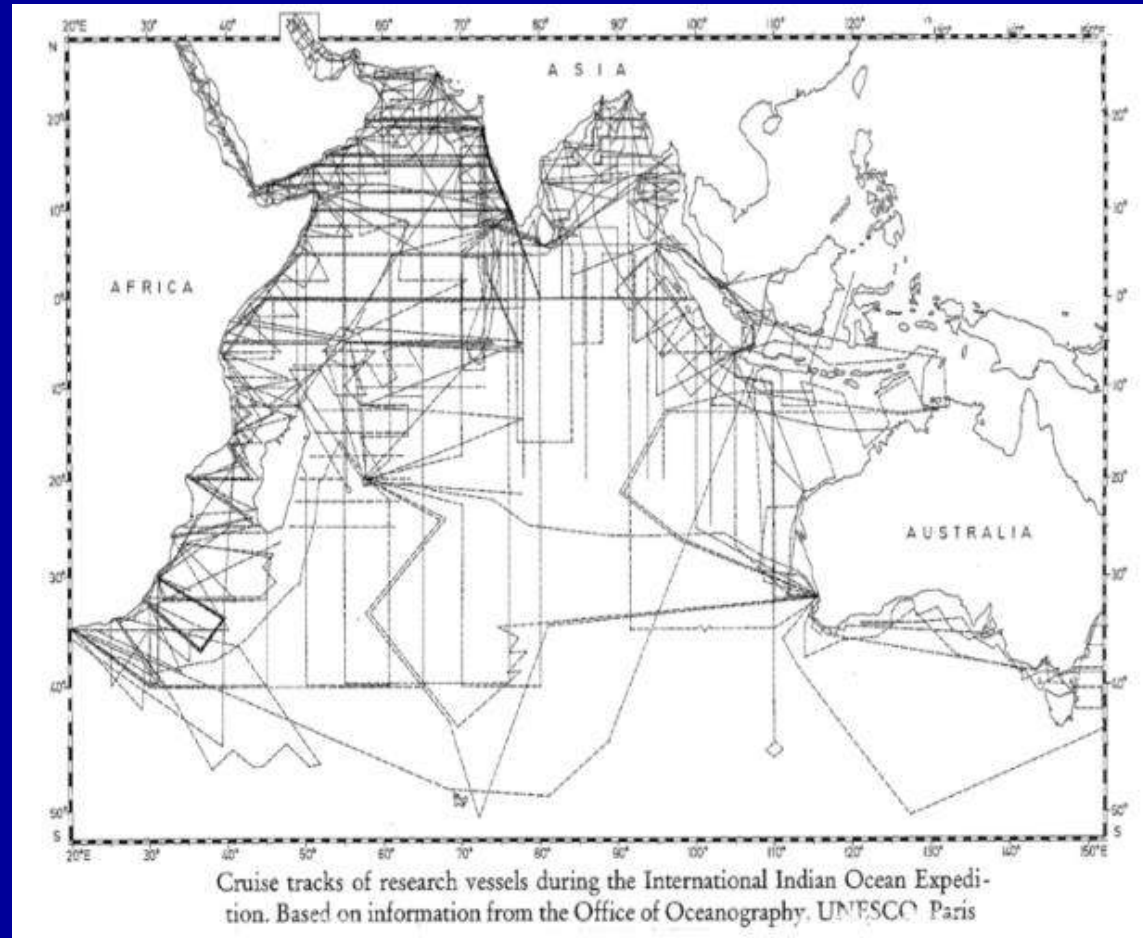
- I. Development of Idea by SCOR: 1957-1959
- II. Start-up and Management by Robert Snider on behalf of SCOR: 1959-1962
- III. Transfer of Management to IOC and Completion of Project: 1963-1965



Thanks: Ed Urban, SCOR

# Introduction

## The International Indian Ocean Expedition (IIOE) 1962-1965

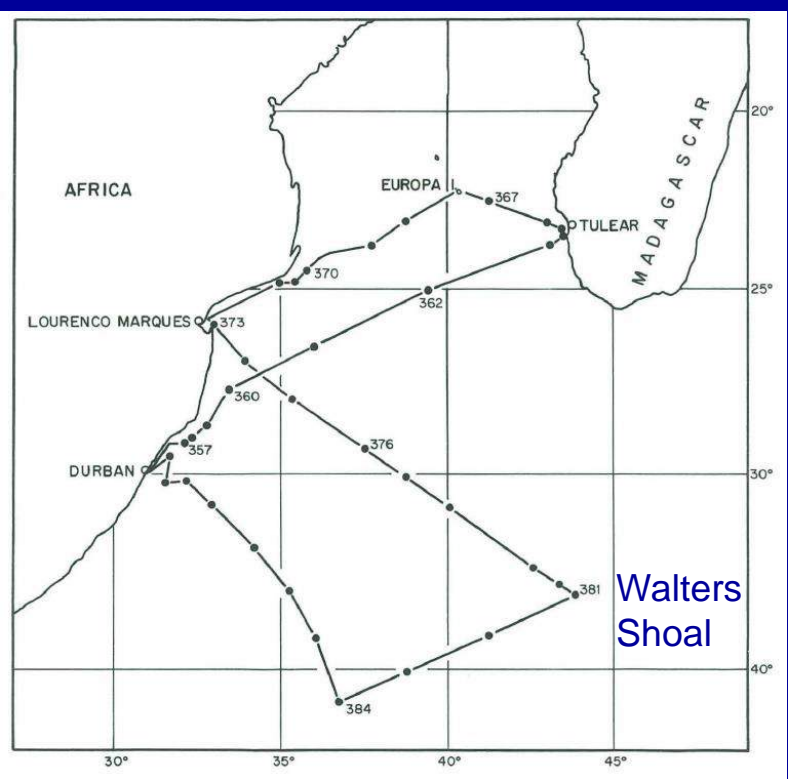


Note the extensive coastal sampling around the rim of the Indian Ocean, I will return to this later



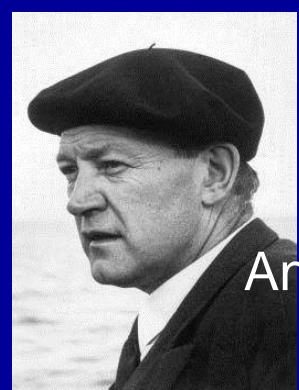
# Part 1

## My experience of The International Indian Ocean Expedition



R/V Anton Bruun

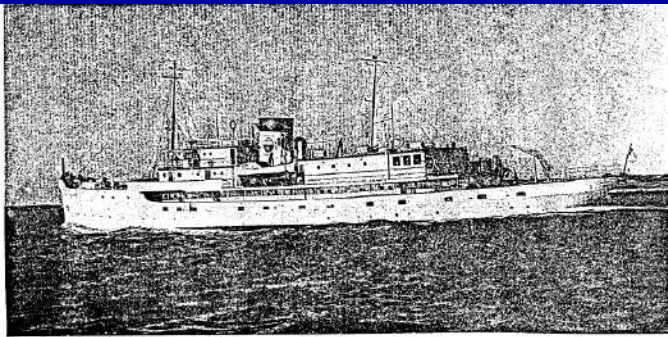
Cruise 7 track R/V Anton Bruun



Anton Bruun



# Part 1: My experience of IIOE



The R.V. "ANTON BRUUN" photographed during the International Indian Ocean Expedition cruises (photograph courtesy of Dr. John H. RYHIER and the Woods Hole Oceanographic Institution).

## Sampling on deck

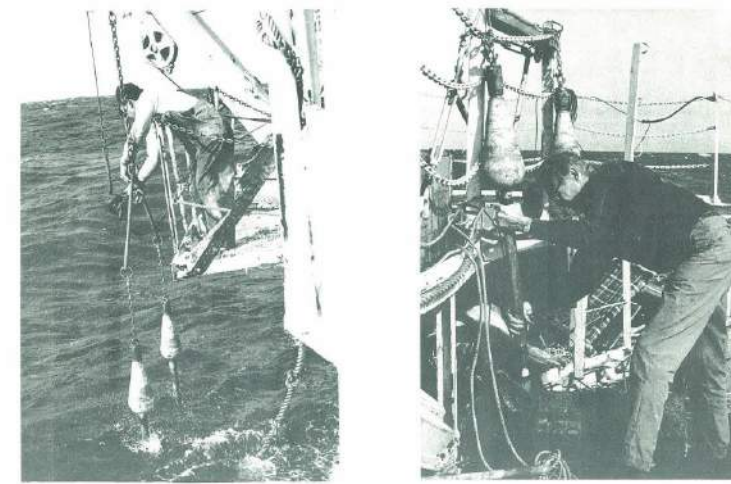
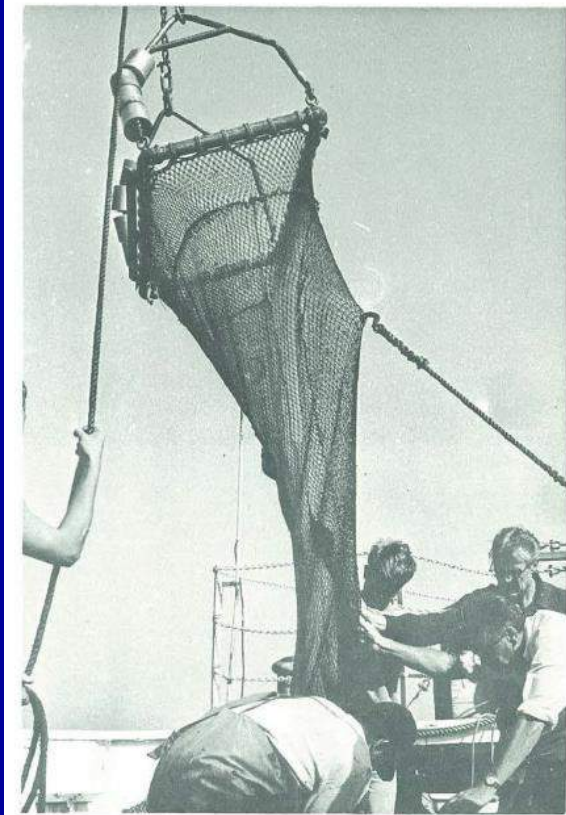
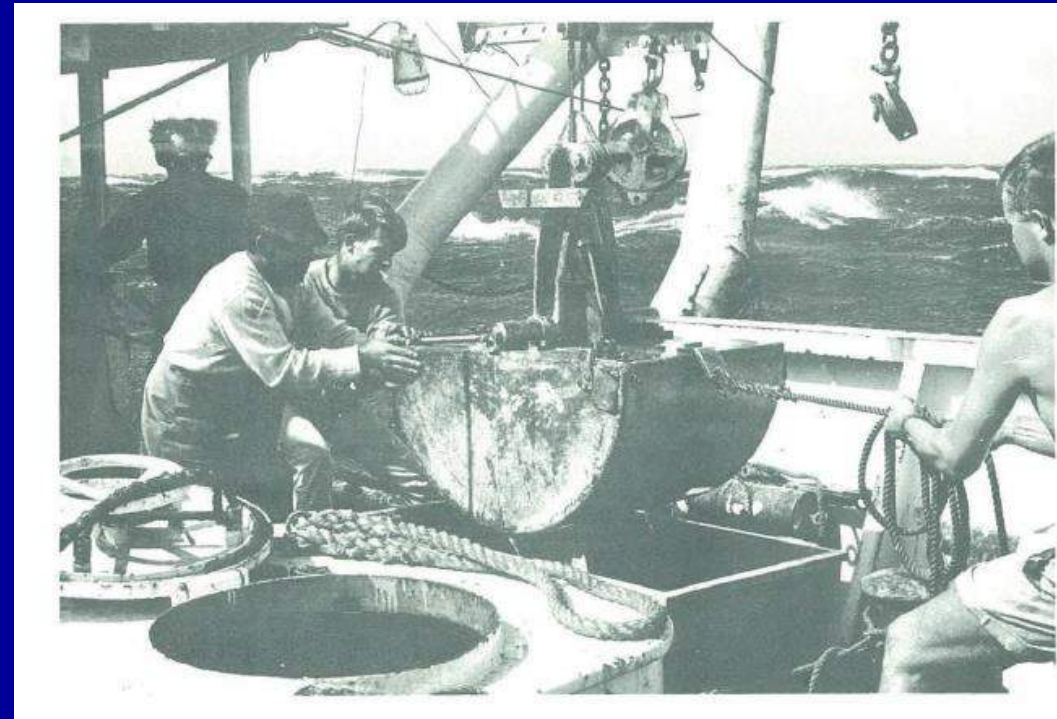


Figure 4 Lowering twin gravity corers (left). Dr. Sandy extracting corer liner (right).

## Geological cores



## Benthic Agassiz dredge



## Benthic Grab

# Part 1: My experience of IIOE

## Sampling on deck

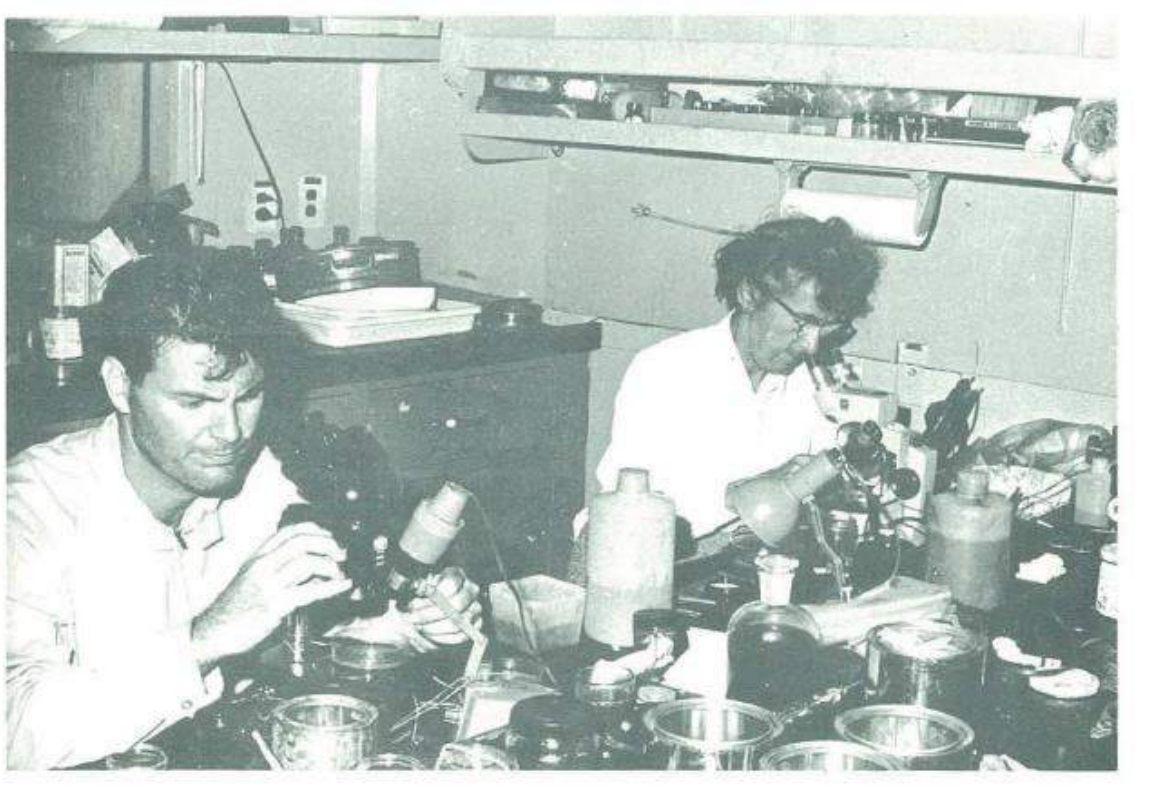


Benthic sampling: pulling grab aboard

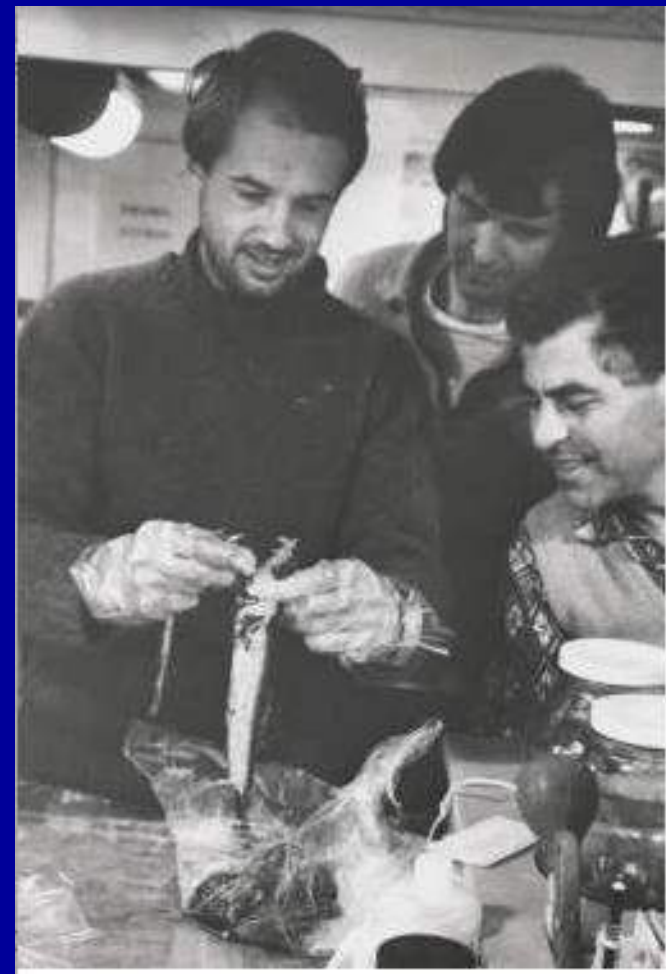
Note: no helmets or boots!

Sieving grab sample

## In the ship's laboratory



Drs Dick Benson and Olga Hartmann



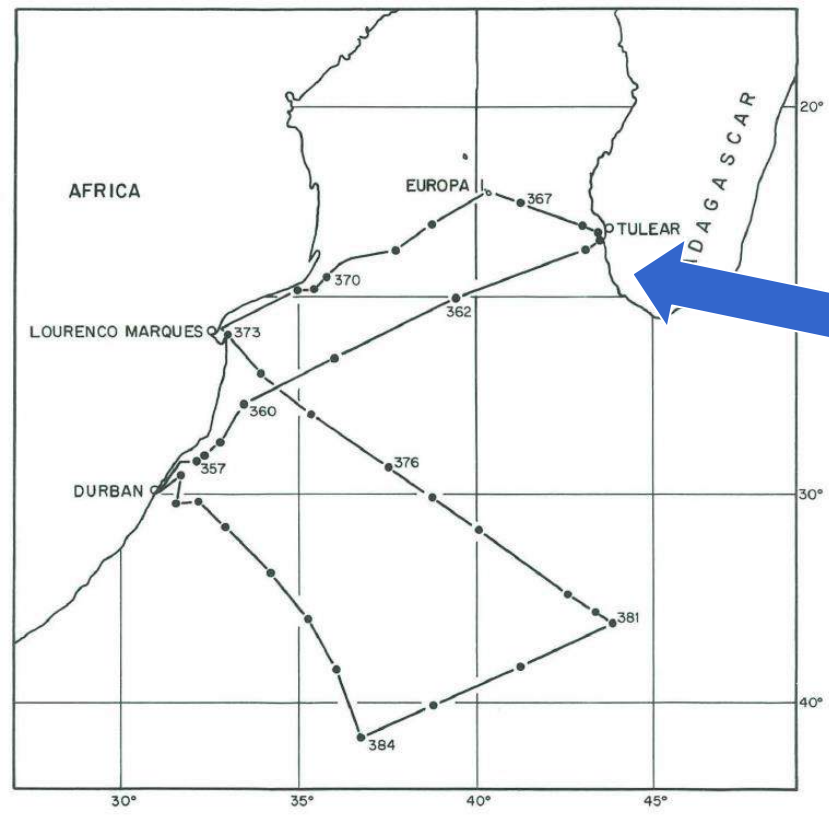
Prof Karl Banse and student

Dick Benson introduced me to Numerical Taxonomy (changing my life) and Olga Hartmann to polychaete worm taxonomy

# My experience of The IIOE



R/V Anton Bruun at anchor, Tular  
Tular



Cruise 7 track R/V Anton Bruun



ORVILLE L. BANDY  
(1917-1973)

Chief scientist and mutineer



My experience of The IIOE



Anton Bruun Tulear, August 1964



Tulear market 1964



C<sup>14</sup>  
Incubation  
expt.

Fishing at  
Walters Shoal

# My experience of The IIOE



IIOE Provided a fantastic opportunity for young graduate students:

1. Betty Mitchell-Innes – phytoplankton studies  
-> PhD at University of Rhode Island

2. My introduction to Numerical Taxonomy

Led to "Numerical Methods in Marine Ecology" and my PhD and a highly cited paper:  
Field, Clarke and Warwick 1982



 ROSENSTIEL  
SCHOOL of MARINE &  
ATMOSPHERIC SCIENCE

3. Another young scientist employed as a technician became Dr Andrew Bakun,



## Part 2: LEGACY OF THE IIOE



“The experience of organising and carrying out the International Indian Ocean Expedition suggests some lessons for the development of **future cooperative ventures**:

1. The participation of **international organizations**, both non-governmental and intergovernmental, can be of great benefit, by **stimulating** both local and international interest and support, and **by focusing external resources** (funds, equipment, scientific personnel) on the cooperation...”

Wooster, W.S. 1984. International studies of the Indian Ocean, 1959-1965. *Deep-Sea Research* 31:589-598.

# LEGACY OF THE IIOE

## 2. Awareness of the need to standardise

e.g. **Indian Ocean Standard Plankton Net**: Samples were collected by a vertical haul, from 200 m to the surface, at a speed of 1 m/s. This net is still sold commercially and used for surveys (see Currie, R.I. 1963. The Indian Ocean Standard Net. *Deep-Sea Research* 10:27)

IOSN SAMPLES RECEIVED BY IOBC  
(February 1966)

Country	No. of Samples	Country	No. of Samples
Australia	206	South Africa	360
France	0	Thailand	0
India	436	U.K.	206
Indonesia	0	U.S.A.	457
Japan	180	U.S.S.R.	79
Pakistan	22	West Germany	122
Portugal	0		
		Total	2,068



From Highley, E. 1968. *The International Indian Ocean Expedition. Australia's Contribution*



## 3. Formation of the National Institute of Oceanography, Goa (NIO)

## 4. Formation of a series of international co-operative programmes:

e.g. WOCE, TOGA, JGOFS, GLOBEC, IMBER, SOLAS, GEOHAB, GEOTRACES .... etc

- Most jointly sponsored by SCOR and other international bodies such as

- Intergovernmental Oceanographic Commission of UNESCO (IOC),

- International Geosphere Biosphere Program (IGBP), and

- World Climate Research Program (WCRP)

# Forward 35 years from 1965 – 2000 Part 3: The World Ocean



# The vision to 2020

This book reviews trends and exciting discoveries in the 21st century, particularly about the future. We have no crystal ball to guess completely new discoveries and extrapolates developments forwards for the next 20 years.

“Making predictions is difficult, particularly about the future.”  
Nils Bohm



# Oceans 2020 review shows clearly that



- Technology leads scientific ideas
- Computer power doubles every 2 years
- Miniaturization will lead to microchips the size of dust particles
- We will be able to deploy sensors wherever needed by 2020

# The Information revolution

- The internet has revolutionized scientific communication
- Data sharing in Global research programmes

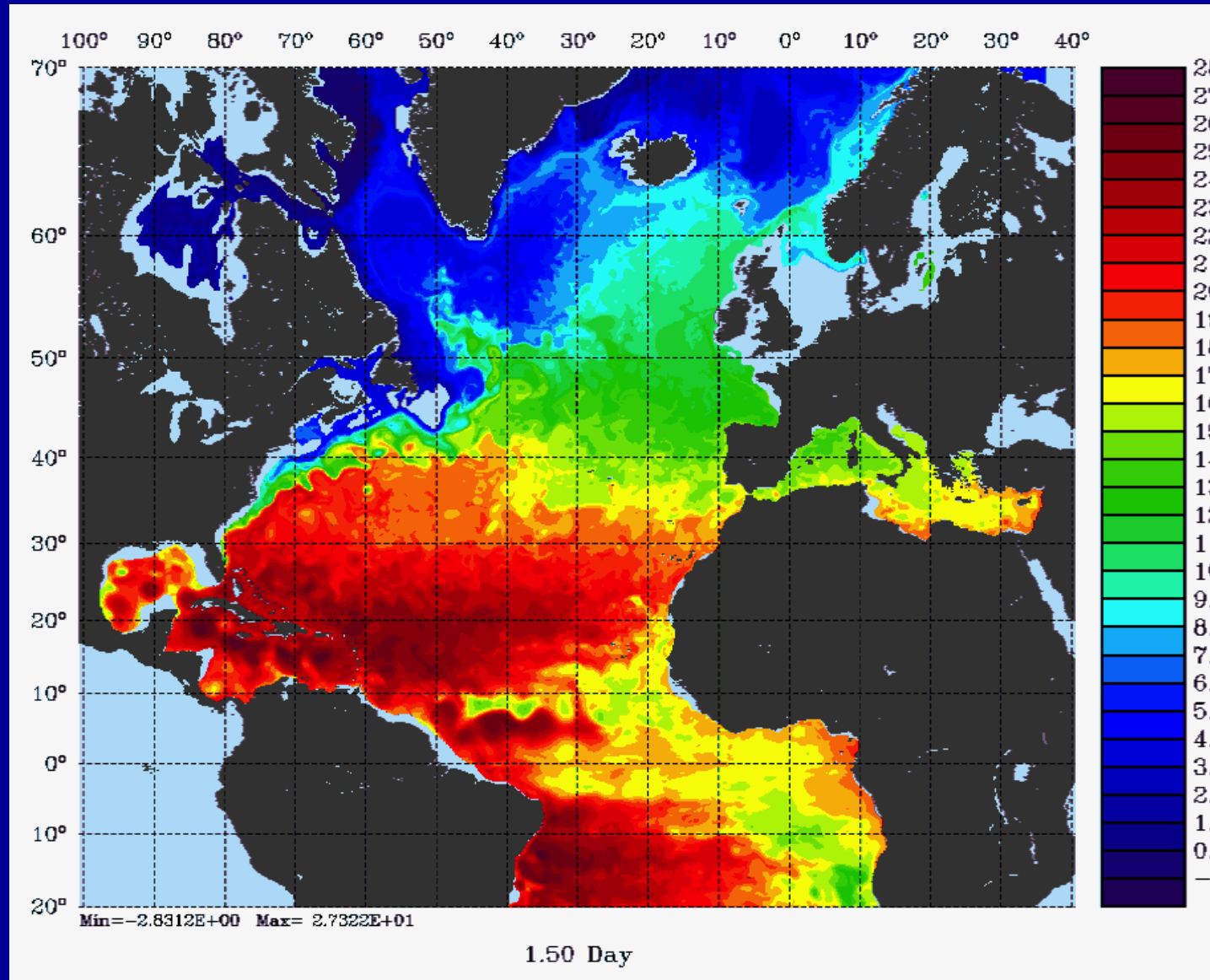
[e.g. WWW.Fishbase.org](http://www.fishbase.org)

The trend will continue



# Globalizing Modelling

- **Generic models** adapted to each region
- Adapted from generic ROMS model
- French-SA PLUME and SAFES Models
- Atlantic Model - unthinkable 17 years ago





# Remote Sensing revolution

Observing the surface ocean by satellite from space

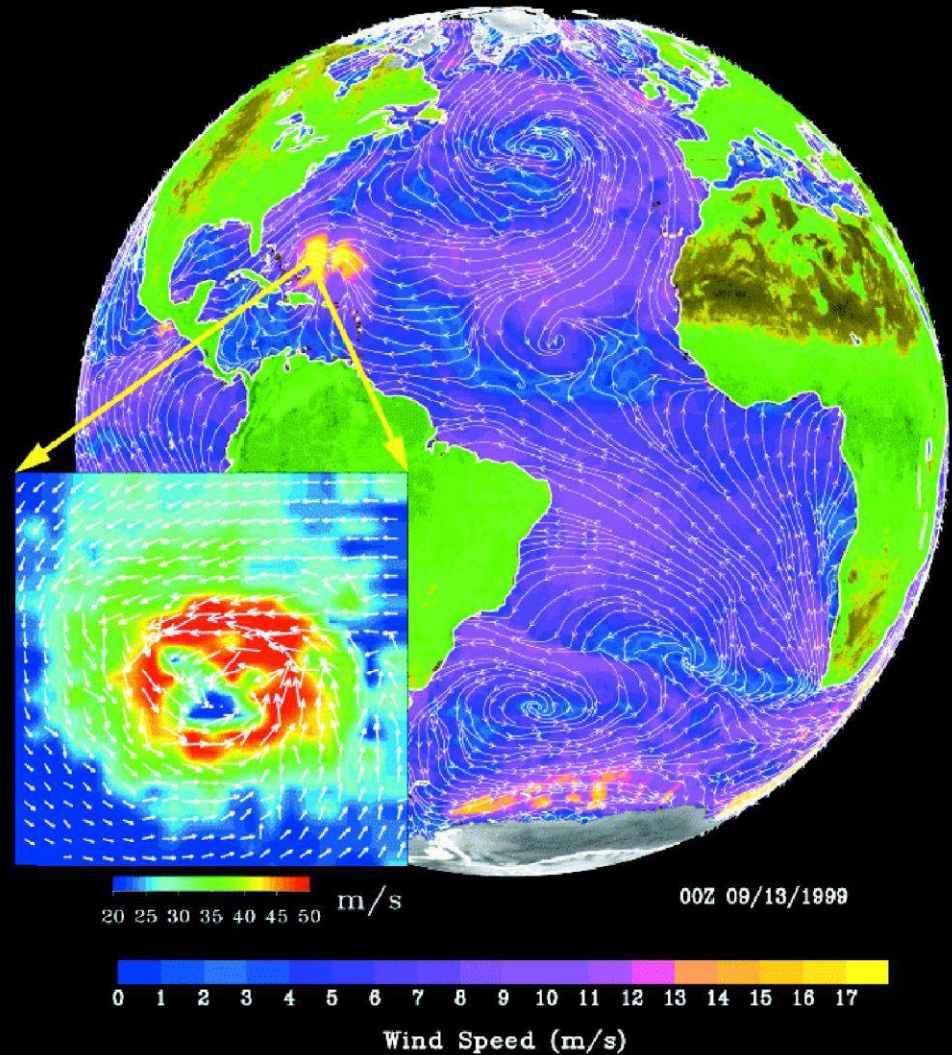
- e.g. Temperature
- Chlorophyll (plankton)
- Winds
- Currents and eddies
- Sea surface elevation
- Underwater objects



# Remote sensing:

## Atlantic Winds

- Hurricane Floyd



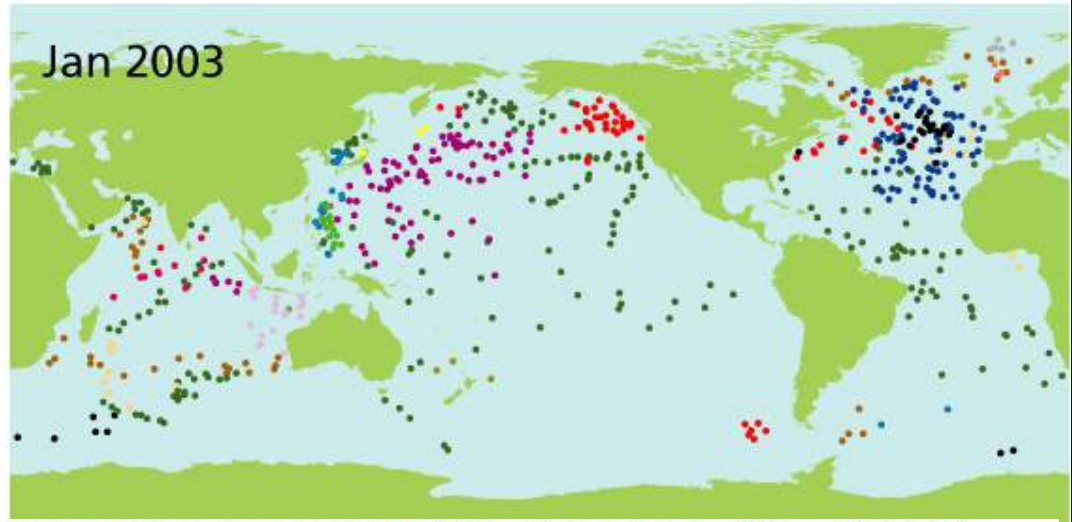
Part 3: Satellites only show the surface of the globe and ocean



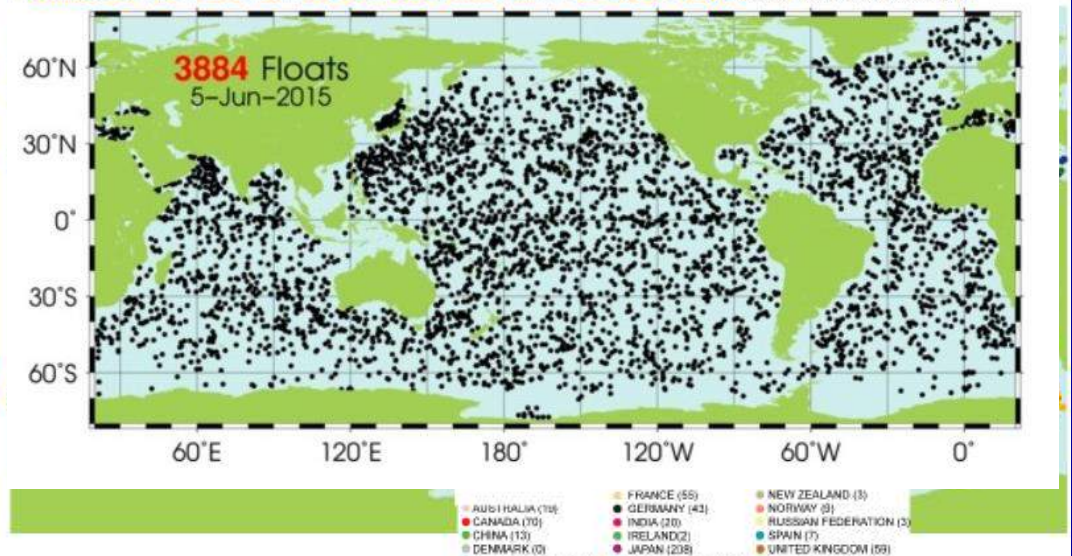
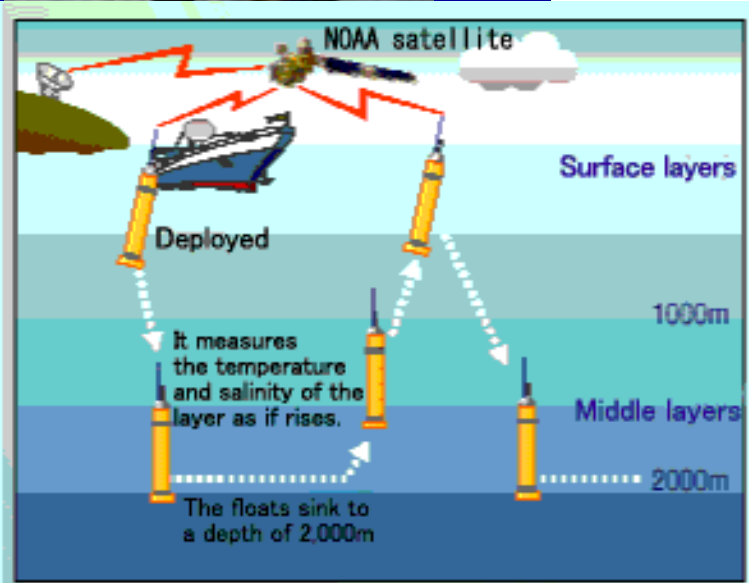
# What about under the surface?



Profiling floats deployed ARGO



Positions of the floats that have delivered data within the last 30 days (AIC, updated daily) :



# Part 3:

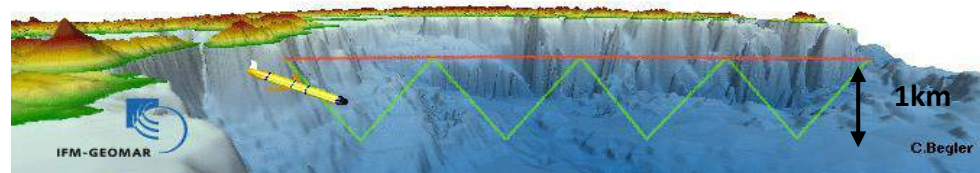
## SA Southern Ocean Climate Observatory: Why we utilise marine robots?



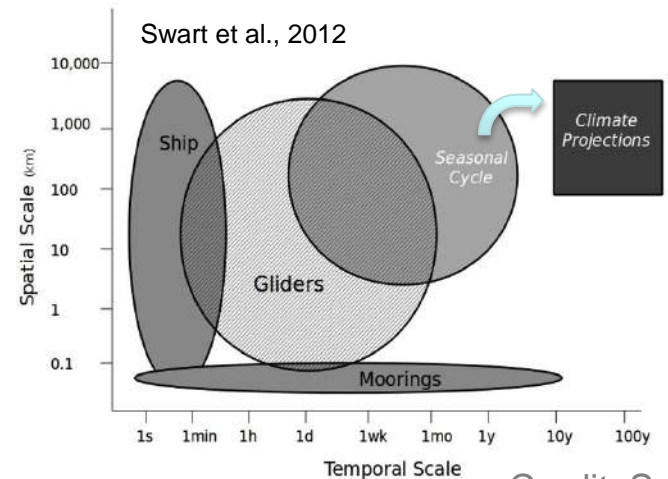
Robotics activities are well suited to meet our scientific sampling objectives  
And thus form a large contingent of our S. Ocean engineering facility



U = 25 km/day  
2-5 km between dives  
Autonomy = 2-10 months



overcoming the very low frequency “snapshot” sampling from ships



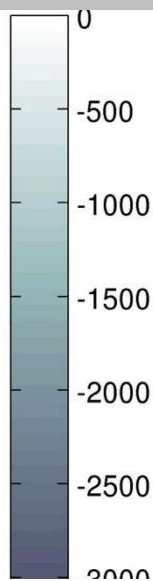
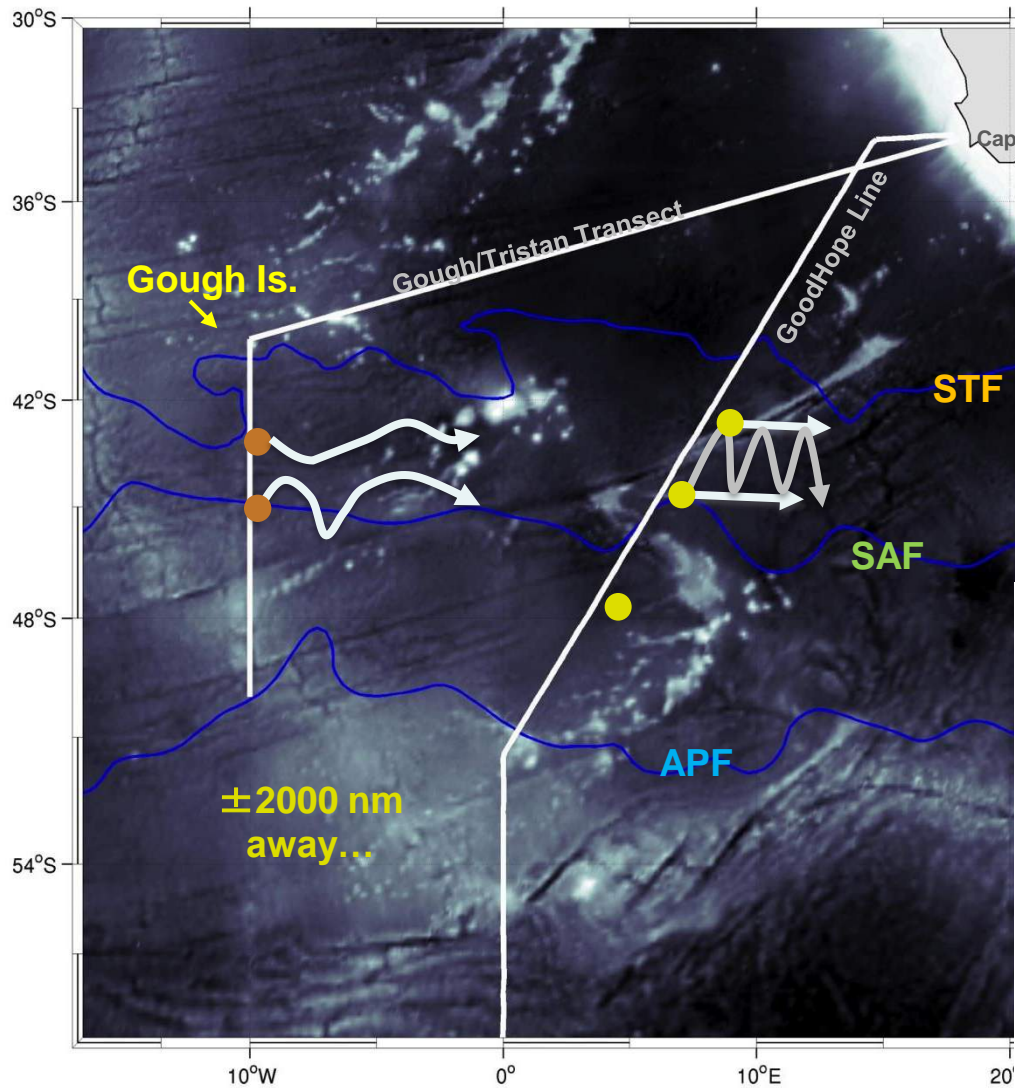
These platforms are greatly reducing our costs and saving us time...

Credit: Seb. Swart, CSIR

# Part 3: SO SEASONAL CYCLE EXPERIMENT

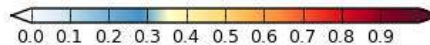
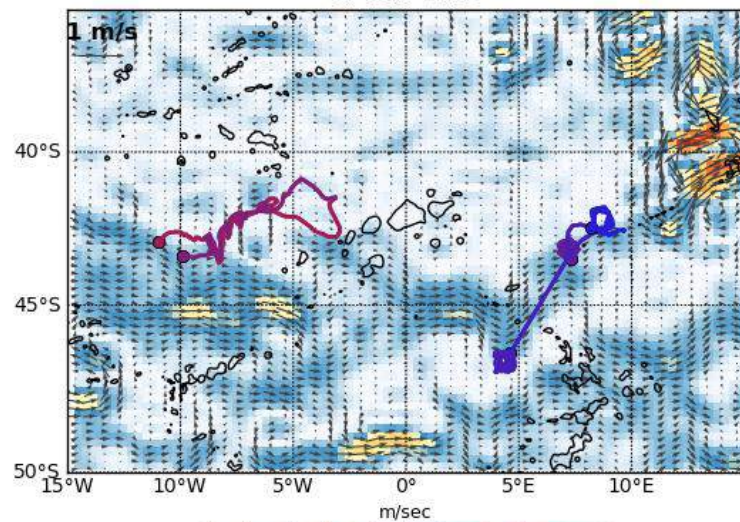
● = Glider deployment & ship CTD station

— = ship based underway measurements



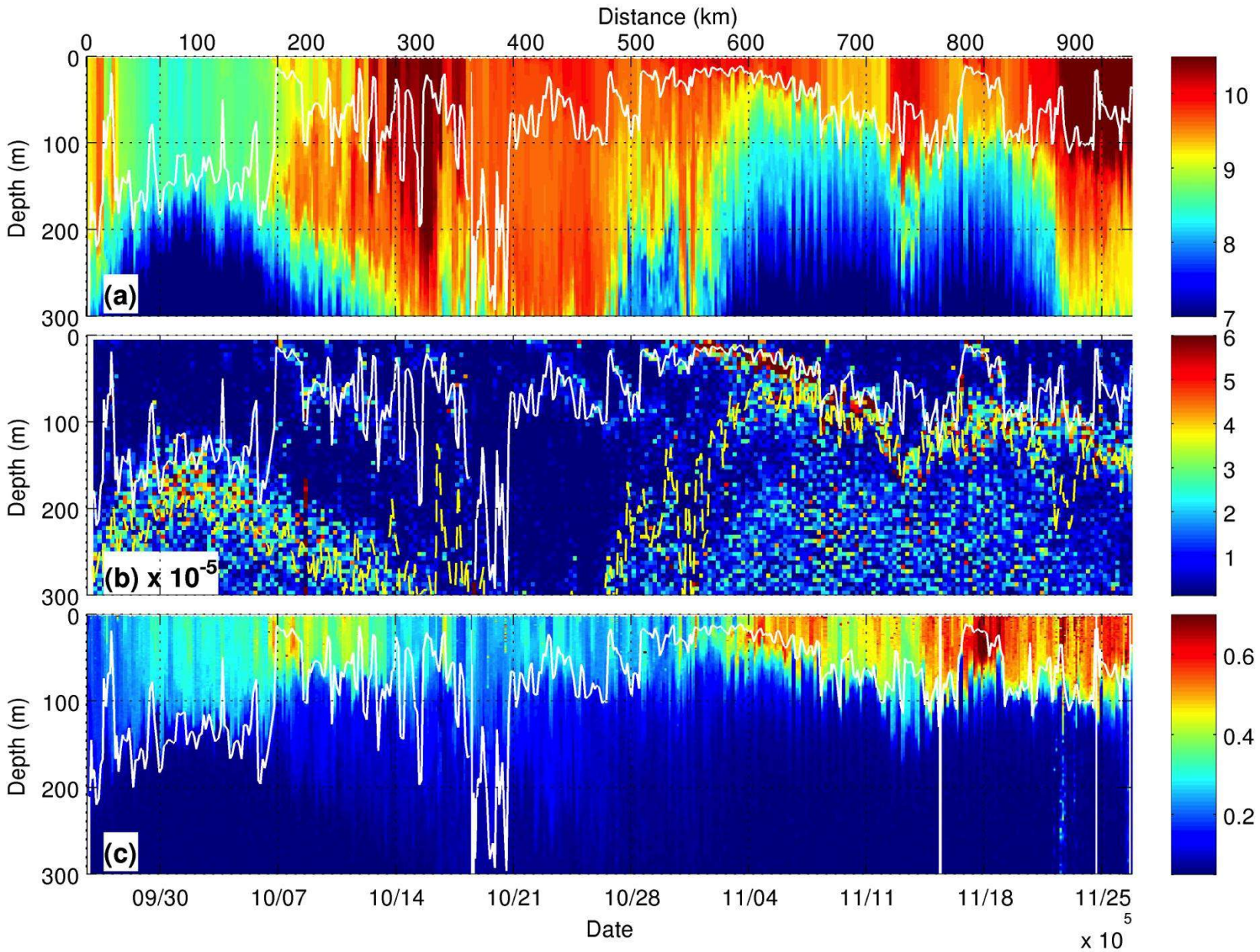
Bathymetry (metre)

07 Mar 2013



Map generated using AVISO Products  
(<http://www.aviso.oceanobs.com/>)

# Part 3: Glider data: temp, stratification, chlorophyll-a



Note fine scale of profiles obtained over 1,000 km and 2 months

# Part 3:

Barnacle  
fouling a  
problem after 6  
months

SG574

148 days

590 dives

1180 profiles

>2000 km

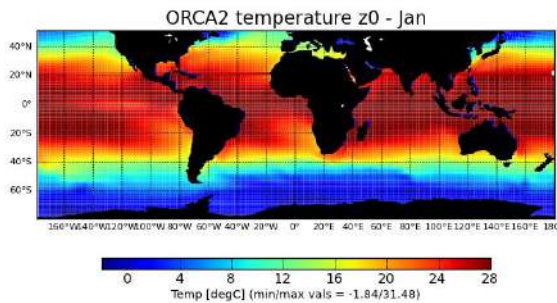
1.9km / profile



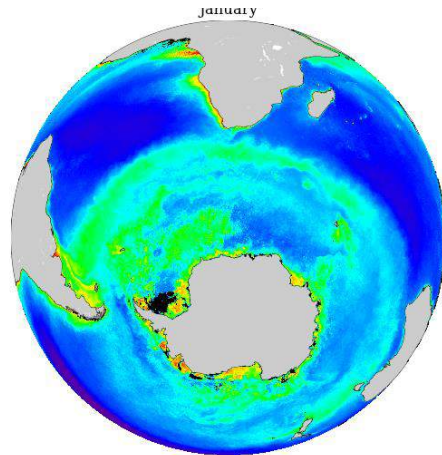


# Part 3:

## Integrated Earth Systems Research Platform: Systems scale climate research in Southern Hemisphere



Centre for High Performance Computing  
Global and Regional High Resolution  
Modelling



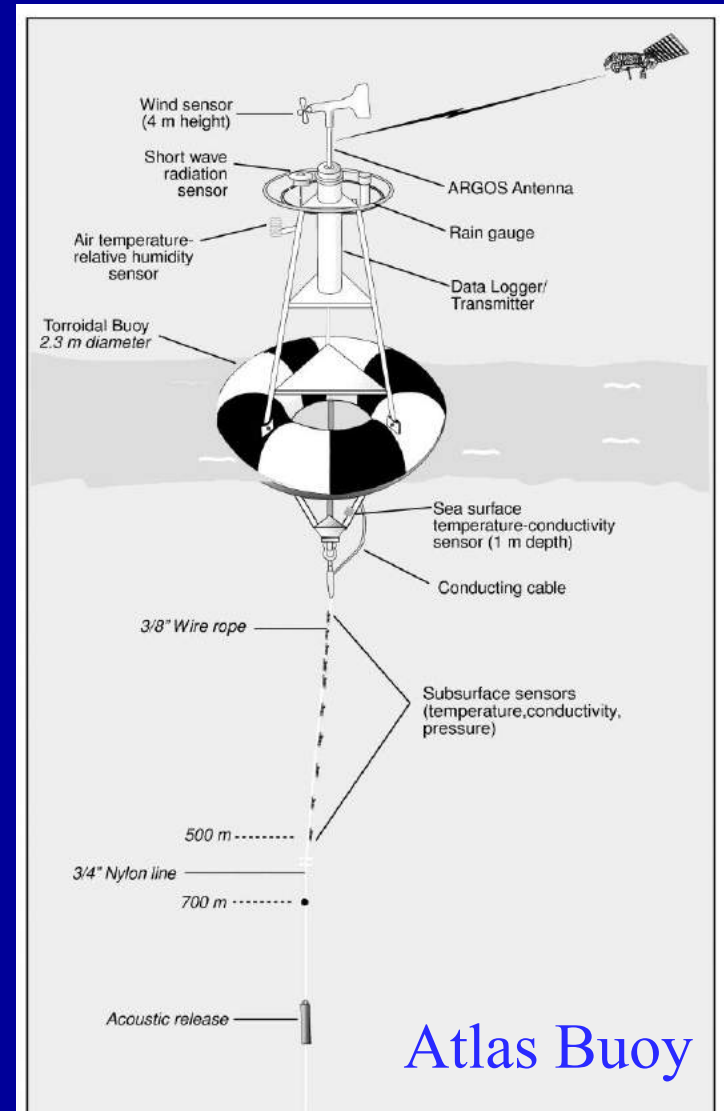
Interdisciplinary National Observational Facilities  
(Ocean Robotics)



SA Agulhas II: Interdisciplinary Process Studies

# Functional Biodiversity

- Molecular probes to identify ecological function (e.g. photosynthesis, nitrogen fixation)
- DNA chips to monitor organic pollution, harmful algal blooms, biological response to global warming, etc



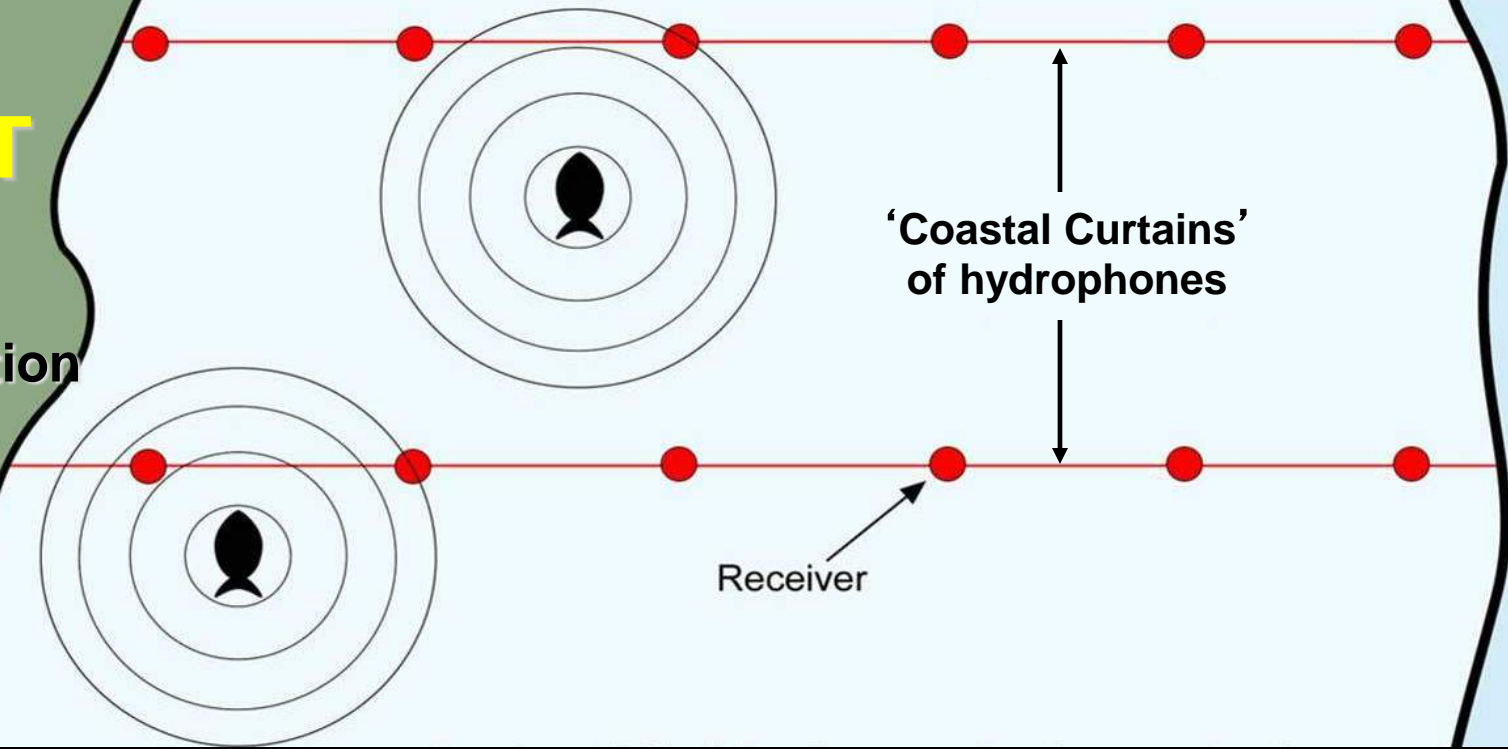
## Part 3:



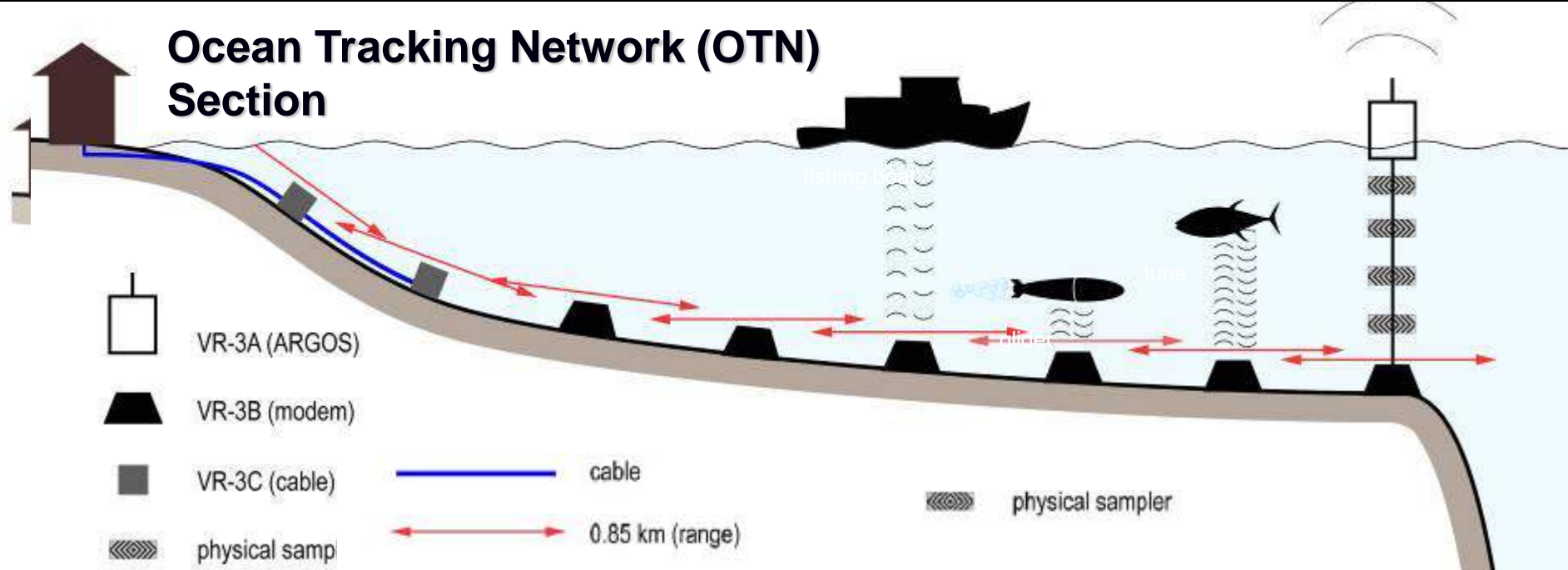
# Electronic Tags on animals

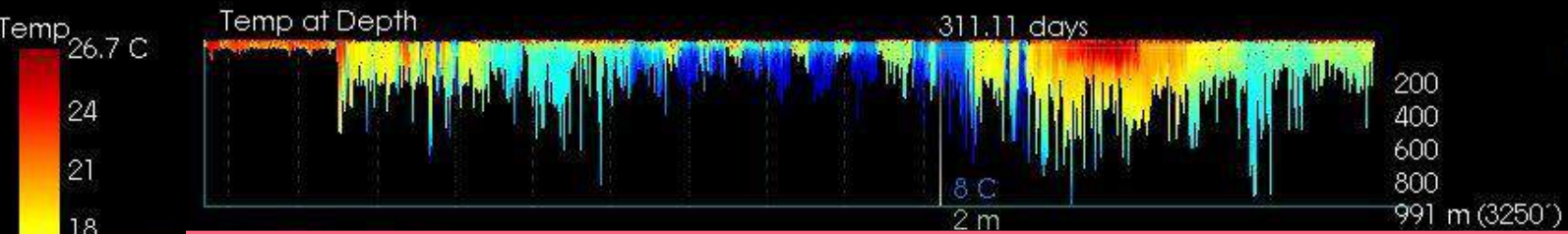
- *Record data (e.g. temp., depth) on fish and other large marine animals*
- *Radio transmission only works in air - only good for animals that surface*
- *Sound (acoustics) transmits information in water*
- *Acoustics provide our window into the ocean*
- *e.g. Ocean Tracking Network (OTN, Global Project)*

Part 3:  
**POST**  
OTN  
Distribution

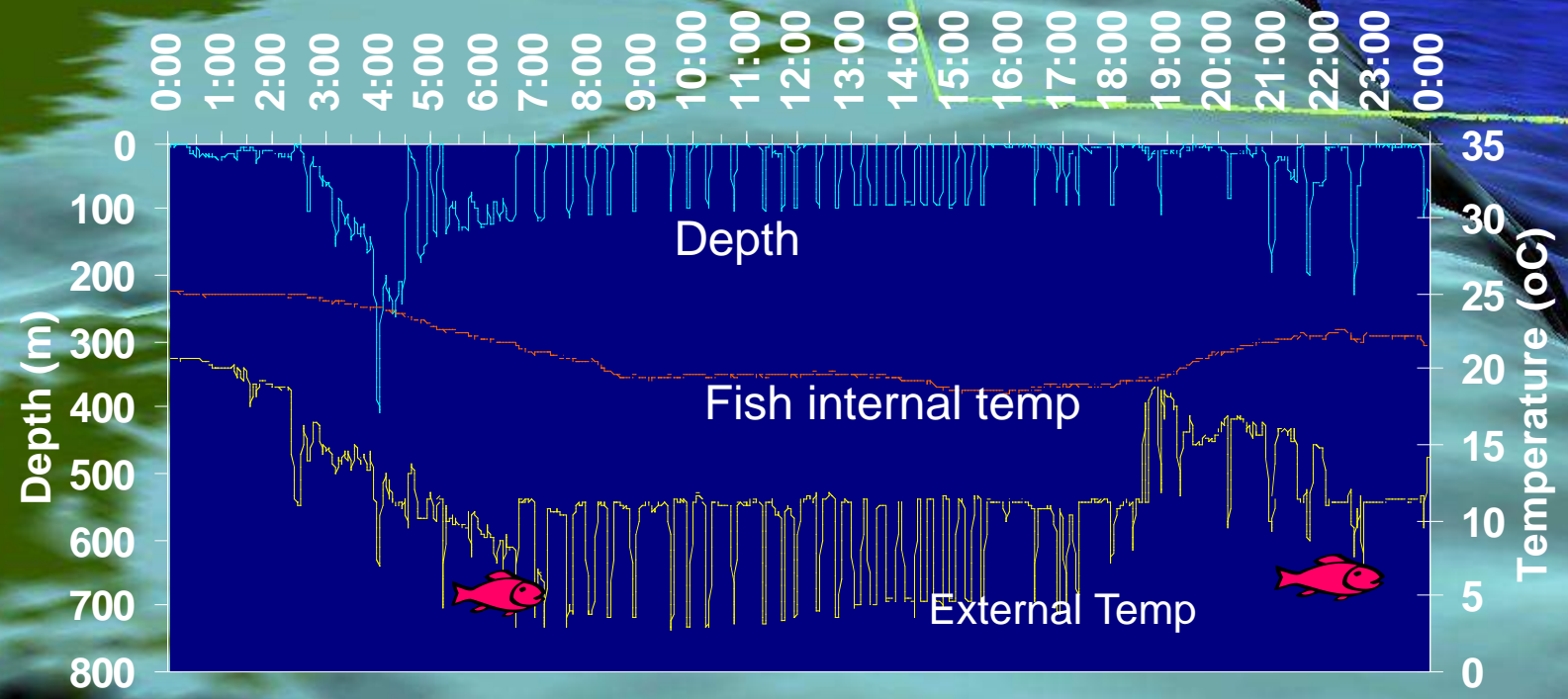


**Ocean Tracking Network (OTN)  
Section**





# A Day in the Life of a Bluefin Tuna



— Depth — Internal Temp — External Temp

# Salmon Sharks – Satellite Tags

Most days these shark fins emerge and talk to satellites

**LC 1, 2 or 3 Hit; Every One to Three Days, Species Dependent**

Part 3:



## Part 3:

Path of a shortfin Mako shark off California



# International Indian Ocean Expedition 2 (IIOE-2) 2016-2020

Technology Revolution since IIOE in 1960-65

Use new technologies:

- **IT (computer power and data capability)**
  - IT continues to expand and make it possible to handle massive data sets from satellites and in situ measurements
  - Integration of satellite and *in situ* datasets using artificial intelligence & neural network algorithms, etc.
- **Nano technology & molecular technology**
  - New probes being developed all the time
- **Modelling: sub-mesoscale modelling capability**
  - Much of the ocean's energy is in sub-mesoscale processes, so it is important to model these with modern computer power.



# IIOE-2 (2016-2020)

Technology Revolution since IIOE

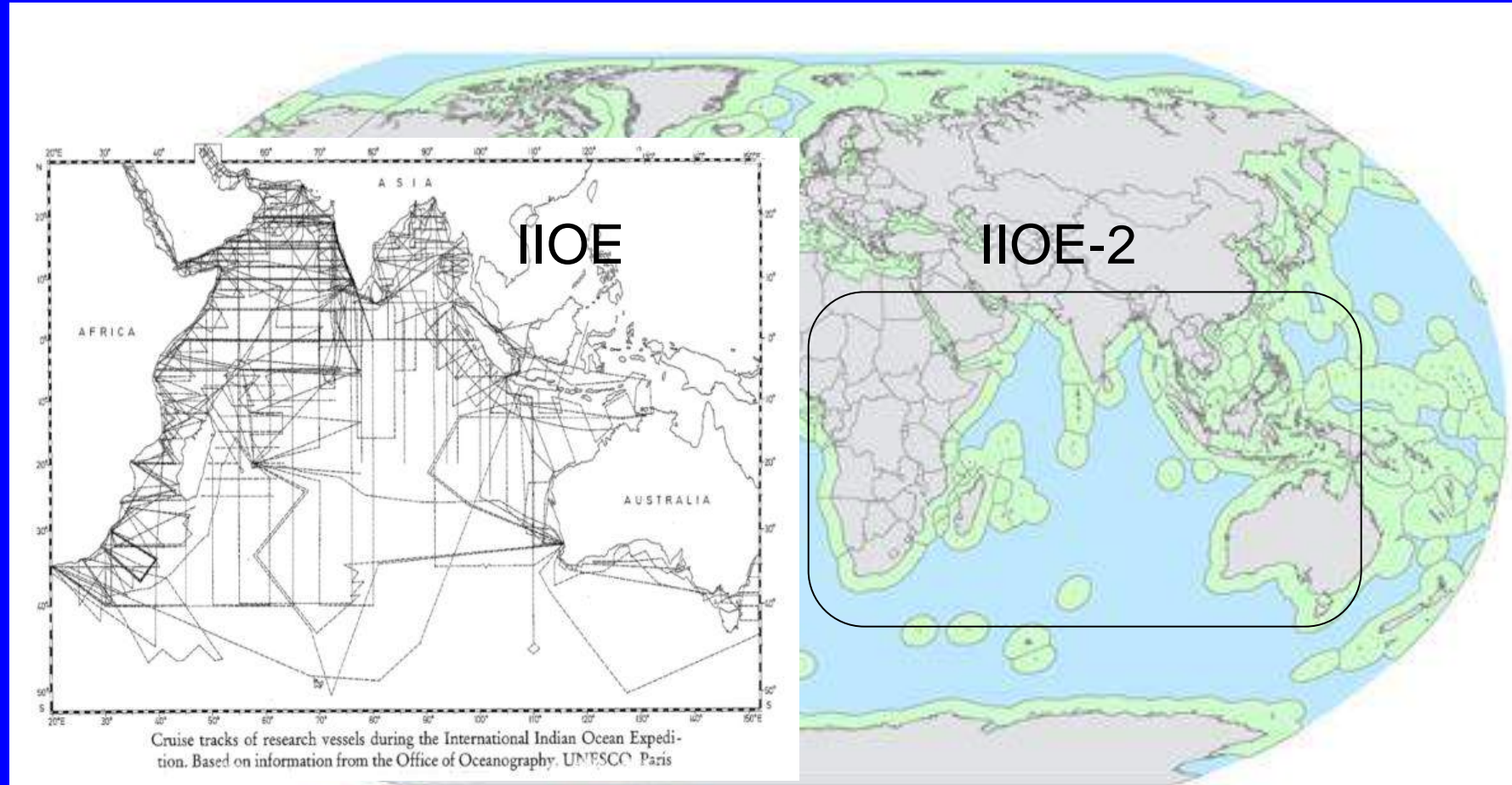
Use new technologies:

- Multi-frequency acoustics: macro-zooplankton and fish
  - There have been many developments that are ready to be implemented
- Satellite remote sensing (surface winds, currents, temp, chl)
- Gliders and profilers (sub-surface)
- Animal telemetry (sub-surface)

# Part 4: The International Indian Ocean Expedition 2 (IIOE-2)

- But there are new problems of access to national EEZs & piracy

Global map of exclusive economic zones (green) and high seas (blue) oceanic areas



Cruise tracks of research vessels during the International Indian Ocean Expedition. Based on information from the Office of Oceanography, UNFSCC Paris

# Thank You!

# Merci Beaucoup!



View from Robben Island

[www.ma-re.uct.ac.za](http://www.ma-re.uct.ac.za)