United Nations
Educational, Scientific and
Cultural Organization

Intergovernmental
Oceanographic
Commission

Organisation
des Nations Unies
pour l'éducation
la science et la culture

Commission
océanographique
intergouvernementale

Organización
de las Naciones Unidas
para la Educación
la Ciencia y la Cultura

Comisión
Oceanográfica
Intergubernamental

Организация
Объединенных Наций по
вопросам образования
науки и культуры

Межправительственная
океанографическая
комиссия

Ocean Warming - rising evidence of physical & ecosystem change

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Based at National Oceanography Centre until 31/3/17, then at Society for Underwater Technology HQ

www.sut.org


H.M.S. Challenger under Sail, 1874.


2FGX5
DISCOVERY
SOUTHAMPTON

Talk Outline:

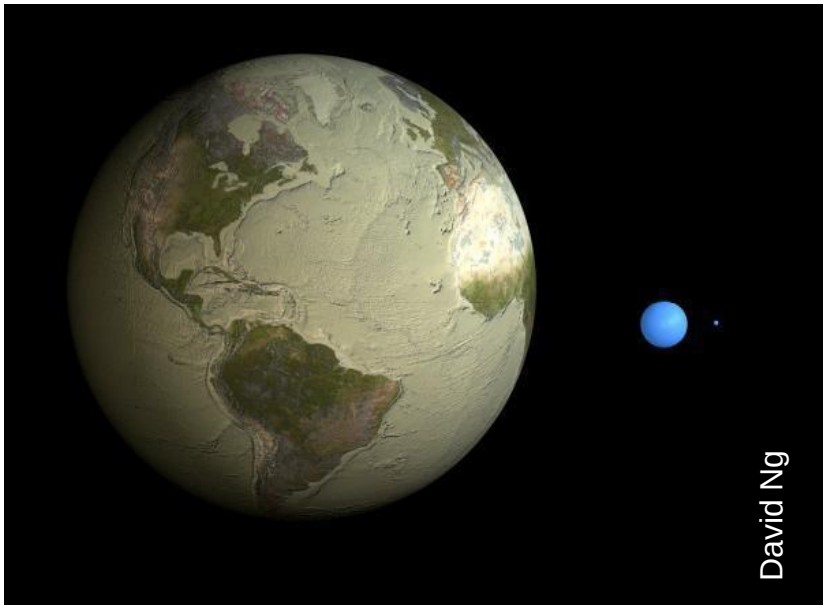
- How do we know anything about ocean warming? Observing systems and new technologies.

- What have we discovered?

- The 2016 IUCN Report on Ocean Warming – where you can find a detailed look at impacts on a wide selection of species..

Why is a warming ocean such a critical issue?

It is because the water of the ocean covers ~71% of the surface of the globe (with an estimated area of 360,600,000 km^2). The scale of this enormous volume of water (1,334,900,000 km^3) that covers the solid Earth is mind boggling..



All the ocean fills a sphere approx 1200 km diameter, similar to Pluto's moon Charon, larger than Saturn's moon Tethys & many others.

By absorbing a disproportionate amount of heat from global warming and by taking up the rapidly increasing emissions of carbon dioxide, the ocean has shielded the world from rapid changes in climate.

However, the extent to which it can continue to do so in the near and distant future is far from clear.

The Global Ocean Observing System

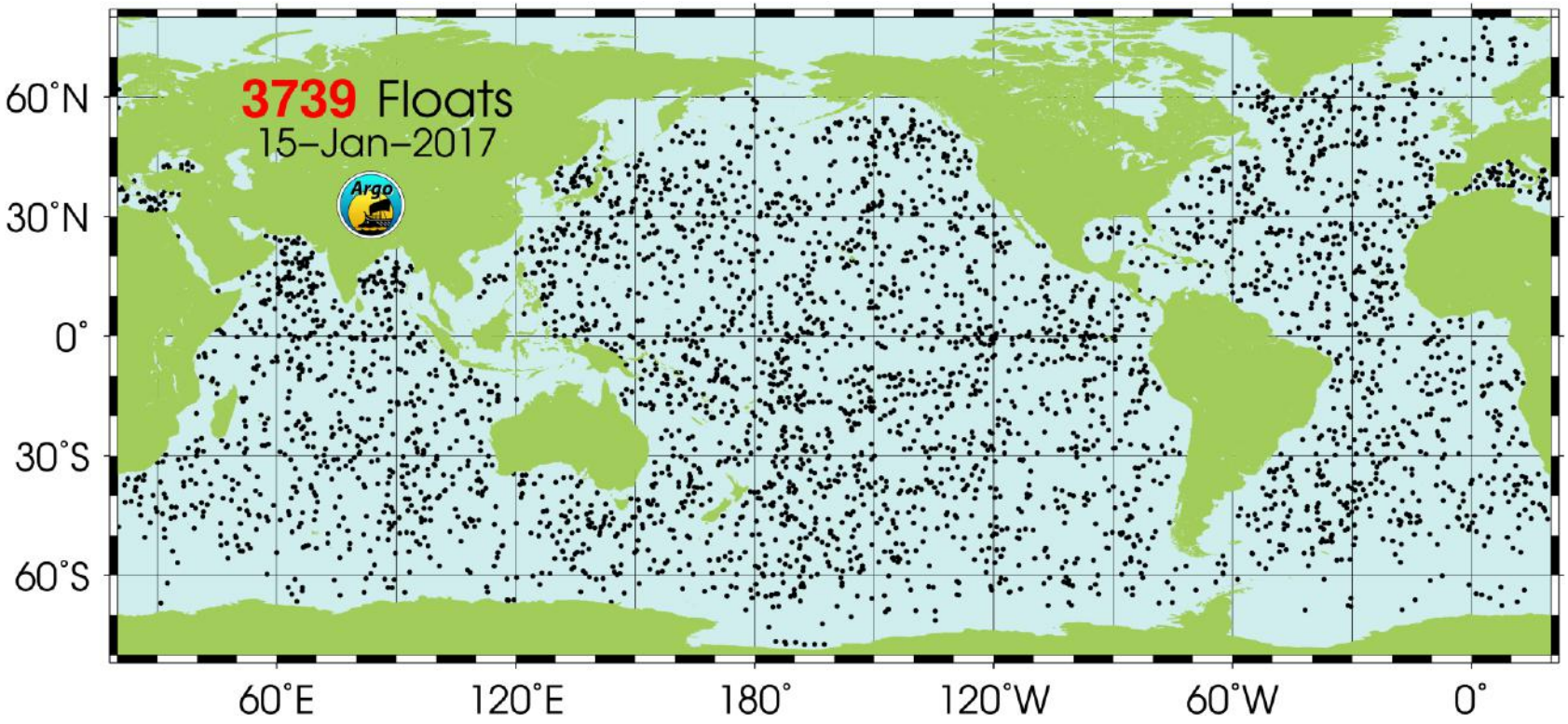
GOOS

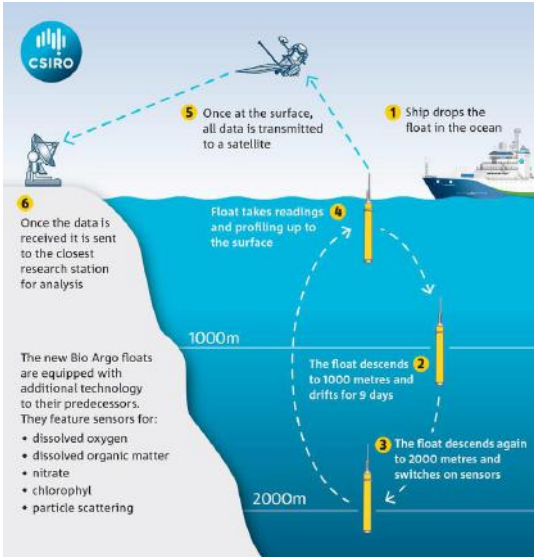
VOS Voluntary Observing Ship Scheme

UNESCO

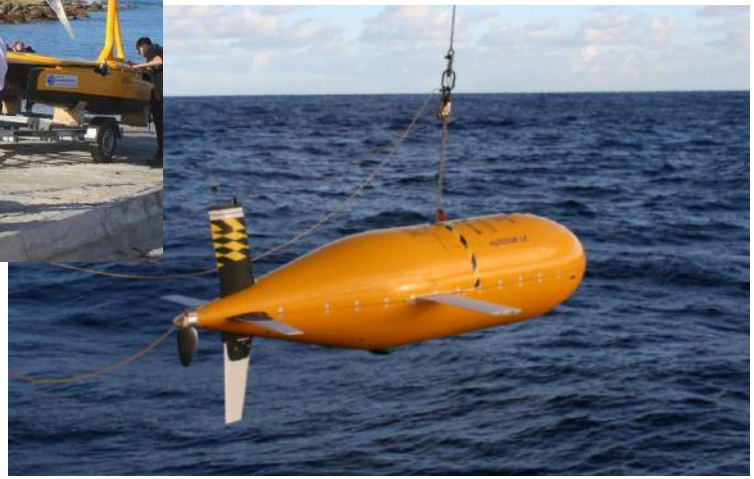
jcomm OCEANOGRAPHY & MARINE METEOROLOGY

IOC

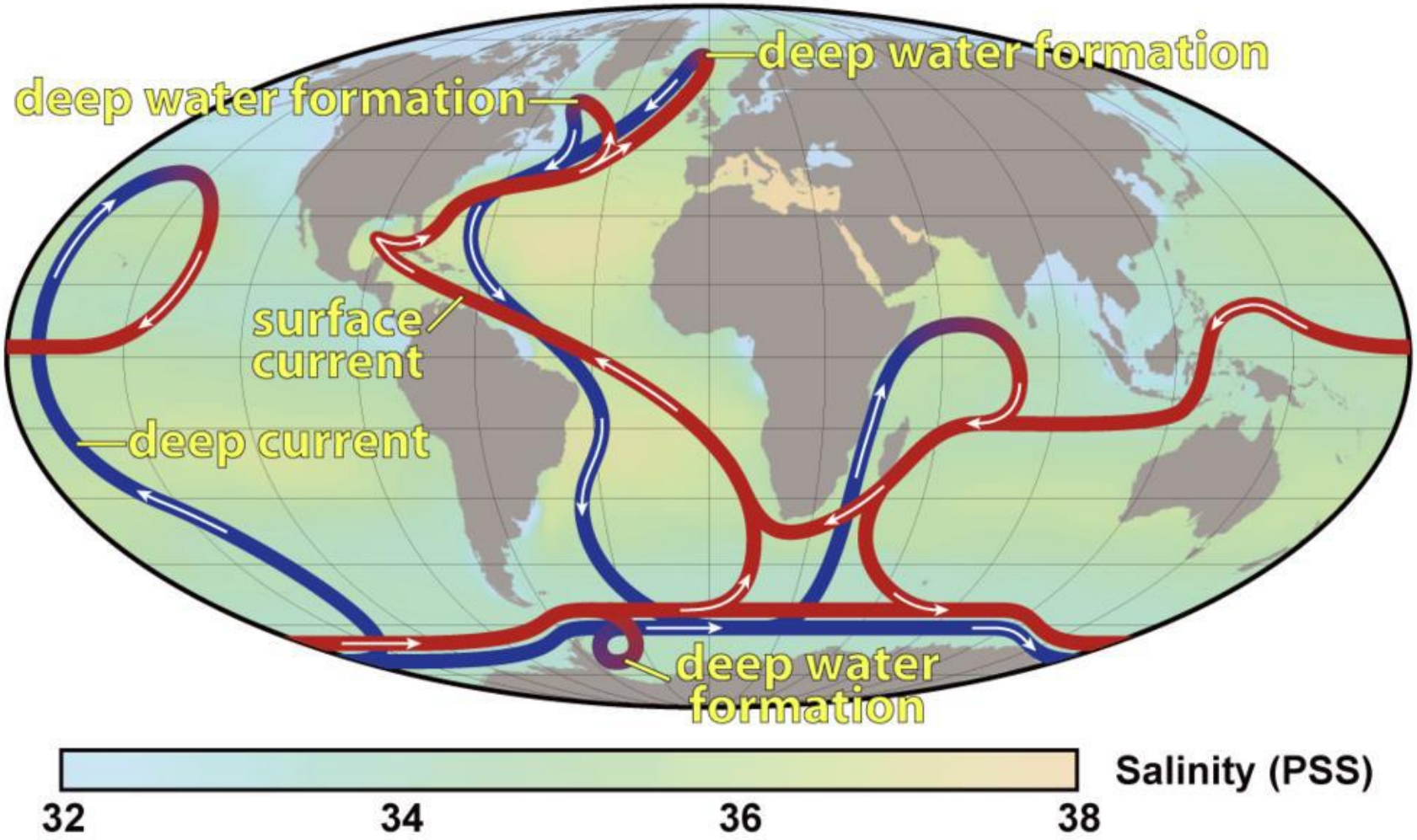

3739 Floats
15–Jan–2017
Argo
60°N
30°N
0°
30°S
60°S
60°E
120°E
180°
120°W
60°W
0°

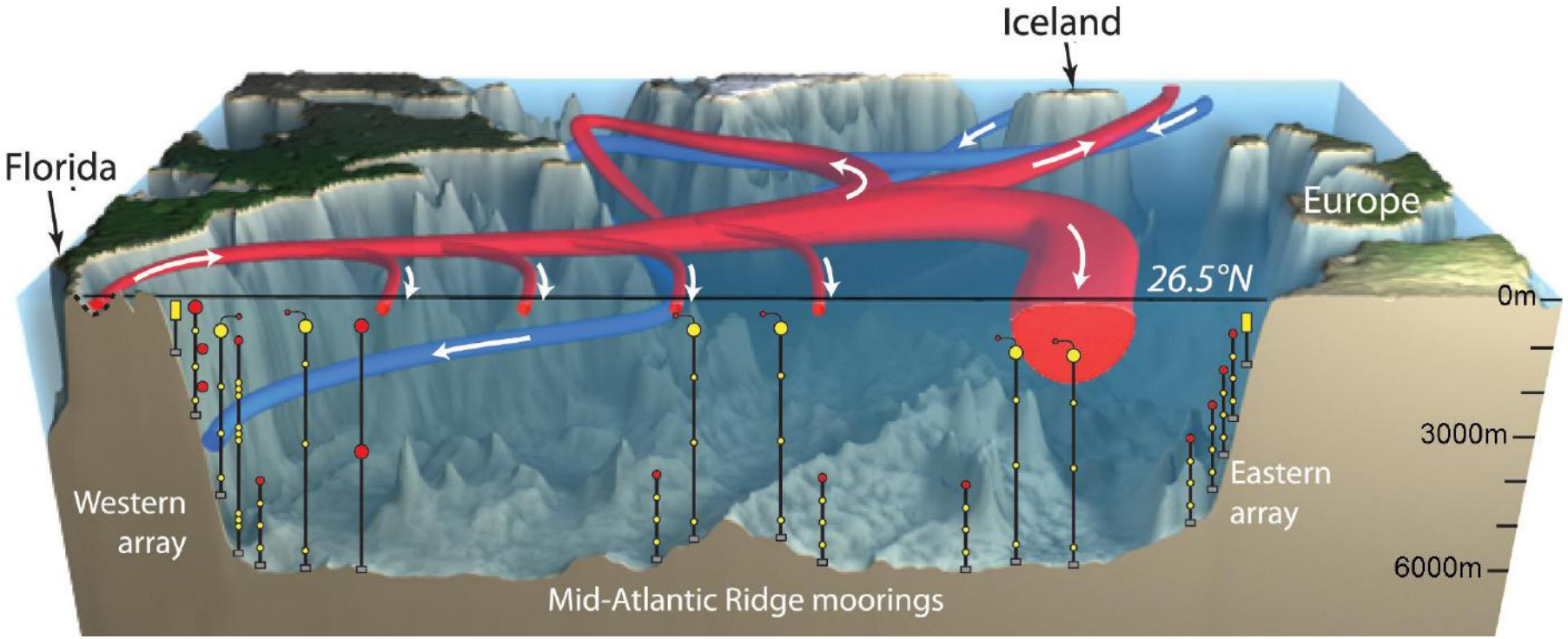

CSIRO
5 Once at the surface, all data is transmitted to a satellite
1 Ship drops the float in the ocean
6 Once the data is received it is sent to the closest research station for analysis
Float takes readings 4 and profiling up to the surface
1000m
The float descends 2 to 1000 metres and drifts for 9 days
3 The float descends again to 2000 metres and switches on sensors
2000m
The new Bio Argo floats are equipped with additional technology to their predecessors. They feature sensors for:
• dissolved oxygen
• dissolved organic matter
• nitrate
• chlorophyl
• particle scattering

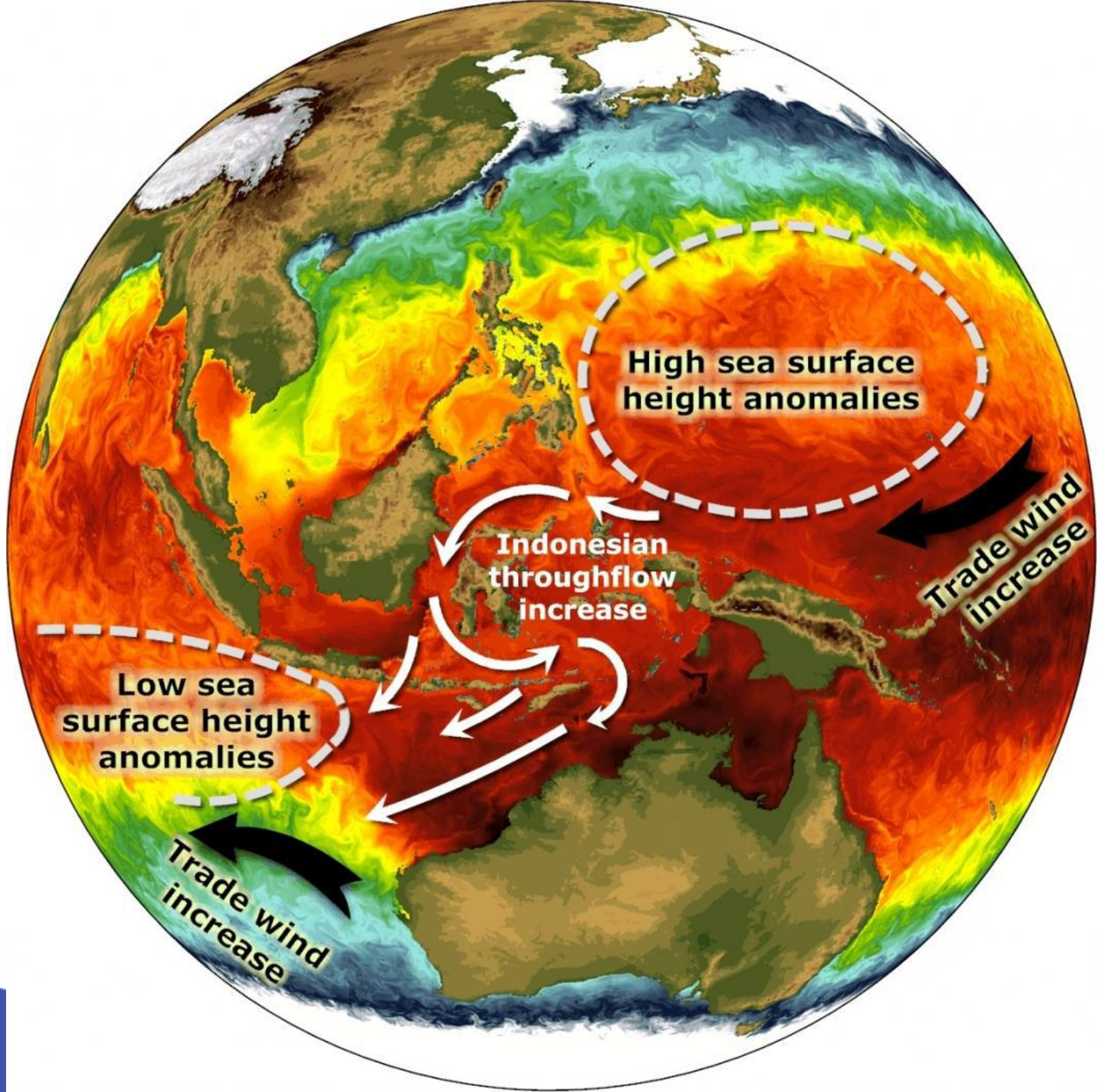
Ship-free systems gradually becoming commonplace, UK in the lead..



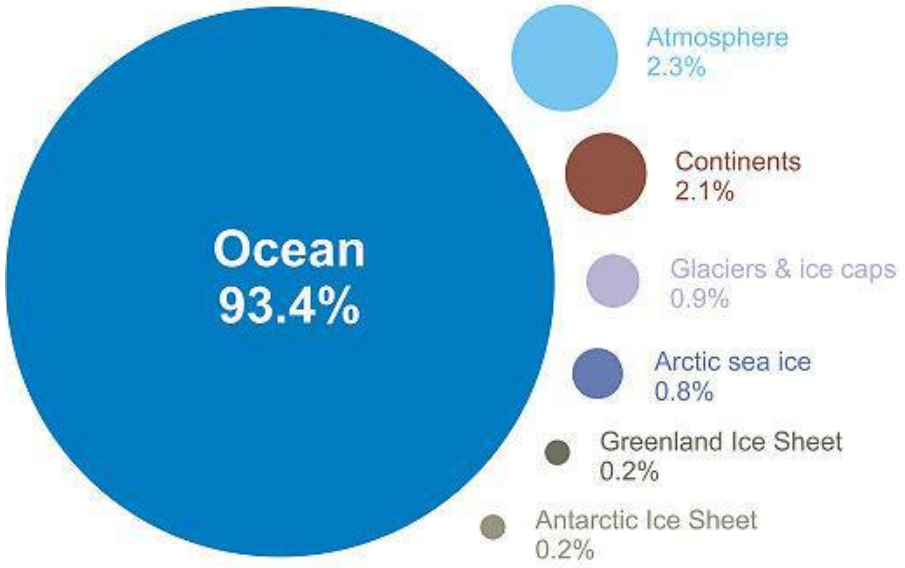
Thermohaline Circulation

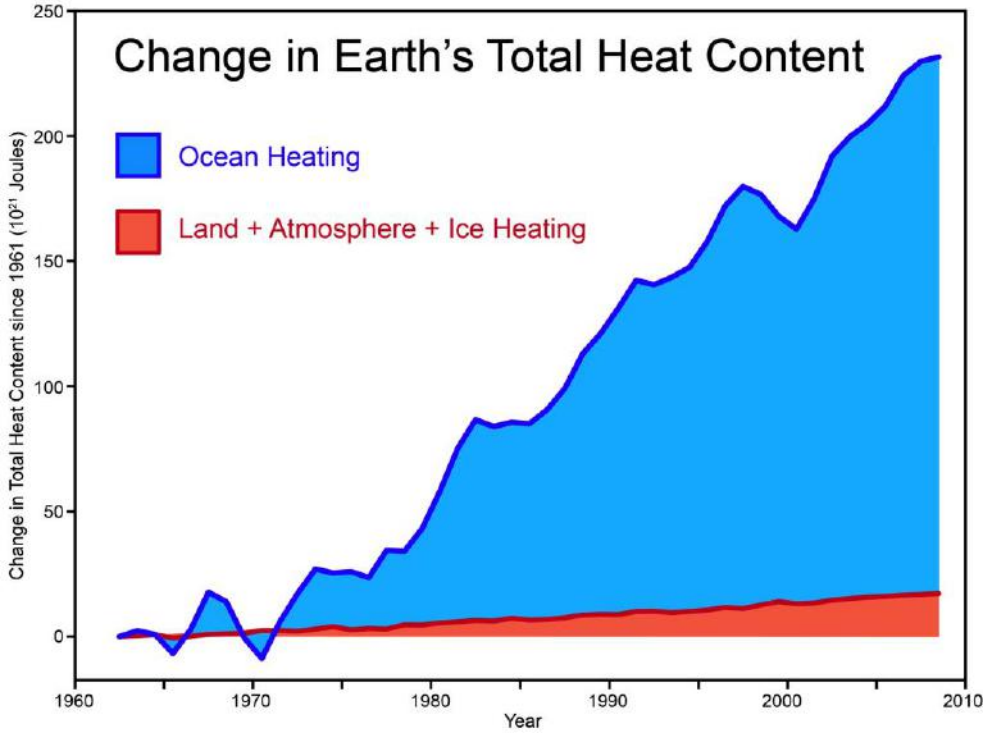



Iceland
Florida
Europe
26.5°N
0m
3000m
6000m
Western
array
Eastern
array
Mid-Atlantic Ridge moorings


High sea surface height anomalies
Indonesian throughflow increase
Trade wind increase
Low sea surface height anomalies
Trade wind increase

Where is global warming going?

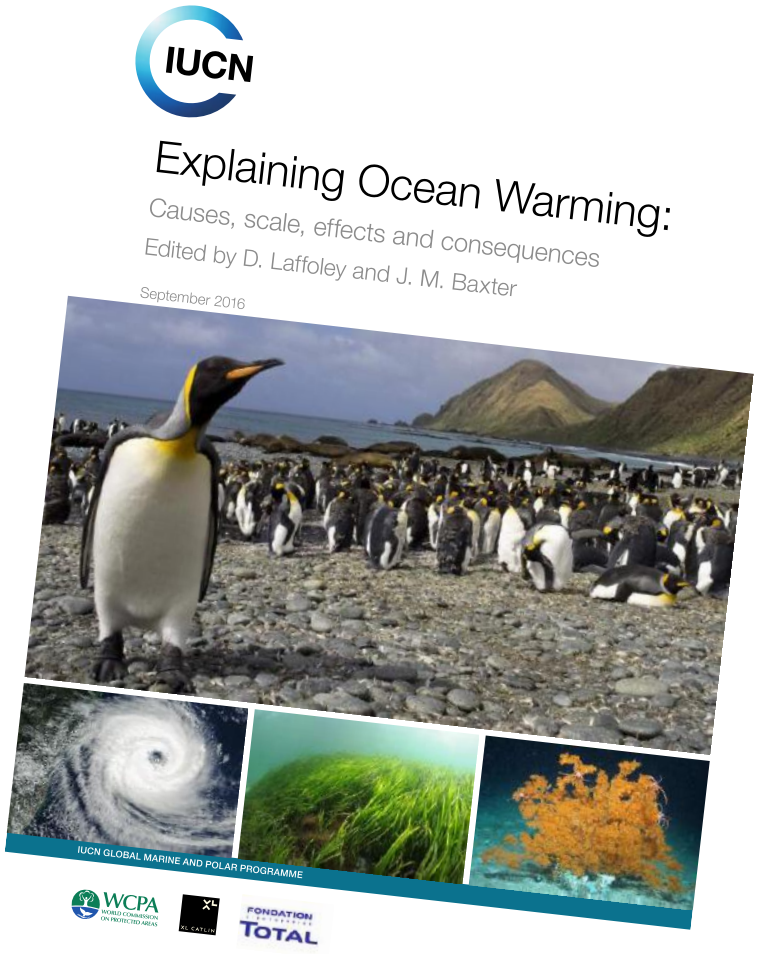




"Because of its high density and specific heat sea water takes up heat more than **4000 times as effectively as air**, volume to volume, and can thus transport and store large quantities of heat.
As a consequence, the ocean, due to its large surface area, volume and low albedo, has absorbed more than 93% of the heat generated by anthropogenic global warming since 1971 (Wijffels et al. , 2016), as well as buffering year-to-year variability in atmospheric, land and sea surface temperatures."

(IUCN report, 2016)

“The most comprehensive review available of the science and implications of ocean warming.”
Sir David King, UK Foreign Secretary’s Special Representative on Climate Change



“In the ocean, 2015 was recently analysed to have been the warmest year within the 136-year records of extended reconstructed sea surface temperature and the fourth such record-breaking year since 2005.
The scale of ocean warming is truly staggering with the **numbers so large that it is difficult for most people to comprehend**.” *(from Introduction)*

Download from:
https://portals.iucn.org/library/sites/library/files/documents/2016-046_0.pdf

Key warming facts

• Sea surface temperature, ocean heat content, sea level rise, melting of glaciers and ice sheets, CO2 emissions and atmospheric concentrations are **increasing at an accelerating rate** with significant consequences for humanity and the marine species and ecosystems of the ocean.

• There is likely to be an **increase in mean global ocean temperature of 1-4 C** by 2100. The greatest ocean warming overall is occurring in the Southern Hemisphere and is contributing to the subsurface melting of Antarctic ice shelves. Since the 1990s the atmosphere in the polar regions has been warming at about twice the average rate of global warming.

• There is **likely to be Arctic warming and ice loss**, and possibly the essential removal, in some years, of the summer Arctic sea ice within the next few decades. In the Antarctic the extent of the sea ice has been growing at a rate of ~1.3% per decade, although there is strong inter-annual variability.

• Over the last 20 years there has been an **intensification and distinct change in El Niño events**, with a shift of the average location of sea surface temperature anomalies towards the central Pacific.

• Currently **2.5 Gt of frozen methane hydrate** are stored in the sea floor at water depths of 200 – 2000 m. **Increasing water temperature could release this source of carbon** into the ocean and ultimately into the atmosphere.

“The impacts of the increase in seawater temperature on micro-organisms, which represent the vast majority of the biomass (organic carbon) in the ocean, will significantly alter the biogeochemical cycles and the functioning of food webs at the global scale.”
Section 3.1 authors

“The oceans around Antarctica are changing rapidly, with average rates of warming and freshening that greatly exceed the global mean, but with complex regional structure to the changes. “

“There remains high uncertainty of how individual populations will respond to long-term rising average ocean temperatures and synergistic effects of other climate change outcomes.
Oceanic tunas and billfishes may adopt new cooler subtropical areas for spawning, either replacing or in addition to existing tropical spawning sites.
Theymay change their migration phenology, including altering the timing of spawning and truncating the spawning season.”
Section 3.12 authors

The IUCN report contains over 450 pages, with detailed references and case studies, from algae to mangroves & marine mammals – a very worthwhile resource indeed.

Thank You

Email sph@noc.ac.uk
Until end of March – then at …

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