# Science Needs for Voluntary Ocean and Atmospheric Observations

Doug Wallace
Dalhousie University, Halifax, Canada



MEOPAR
MARINE ENVIRONMENTAL OBSERVATION PREDICTION & RESPONSE NETWORK

WOC/ MEOPAR Workshop, Montreal, May 28, 2014

# What is a Volunteer Observing Ship or Platform?

- Common feature: recruitment of non-specialist vessels and/or platforms to make and report atmospheric and oceanic measurements on a voluntary, opportunistic basis.
- VOS: initially a mechanism to collect meteorological observations for forecasting
- SOO: intialy to collect upper ocean data for climate monitoring programs
- Both coordinated by the SOT of JCOMM (Kelly's presentation)

However missions are broadening and deepening… there are new needs and more coordinating bodies emerging.

WORLD OCEAN COUNCIL

**Smart Ocean/Smart Industries Workshop**

**(UNESCO-IOC, Paris, 12-13 December 2011)**

WOC Smart Ocean / Smart Industries Program.

Principles:

Clear value proposition / accessible
Inclusive, integrated and building on existing efforts
Global in scope / simple in design (scalable from regional to global scales)
Quality-focussed / standardised
Research and development component
Effective government and transparency
Compliance

Only two Canadian participants (both from Ocean Networks Canada)

# OceanScope

**A Proposed Partnership between the Maritime Industries and the Ocean Observing Community to Monitor the Global Ocean Water Column**


# A proposed OceanScope North Atlantic Test Bed

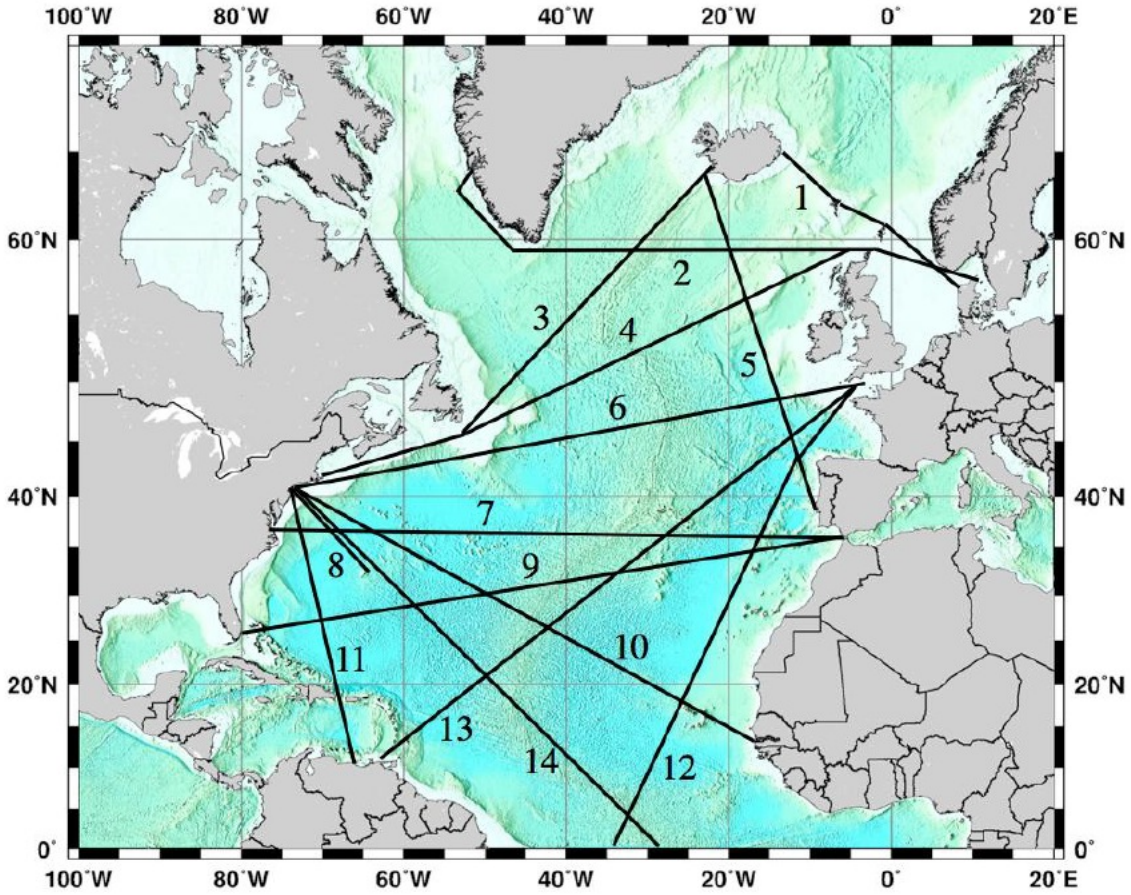



**Figure 3.1:** Potential OceanScope routes spanning the North Atlantic Ocean. Routes 1-6 span the subpolar gyre and routes 7-14 the subtropics and tropics.

**There were no Canadian members of the OceanScope Working Group**

# What are VOS measurements used for? Application classes (from OceanScope)

- Forecasting / nowcasting → operational efficiency, safety
- Study processes and dynamics → understanding!
- Climatologies and change→ monitoring
- State-of-the-Ocean → management / regulation

"What's the opposite of 'Eureka!'?"

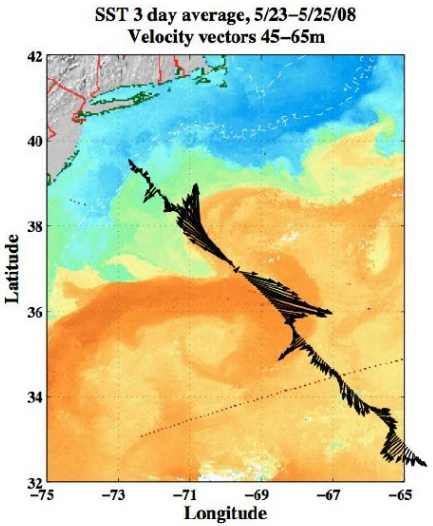



Fig. 1) Plastic from the stomach of a Fulmar

# Why Use VOS?

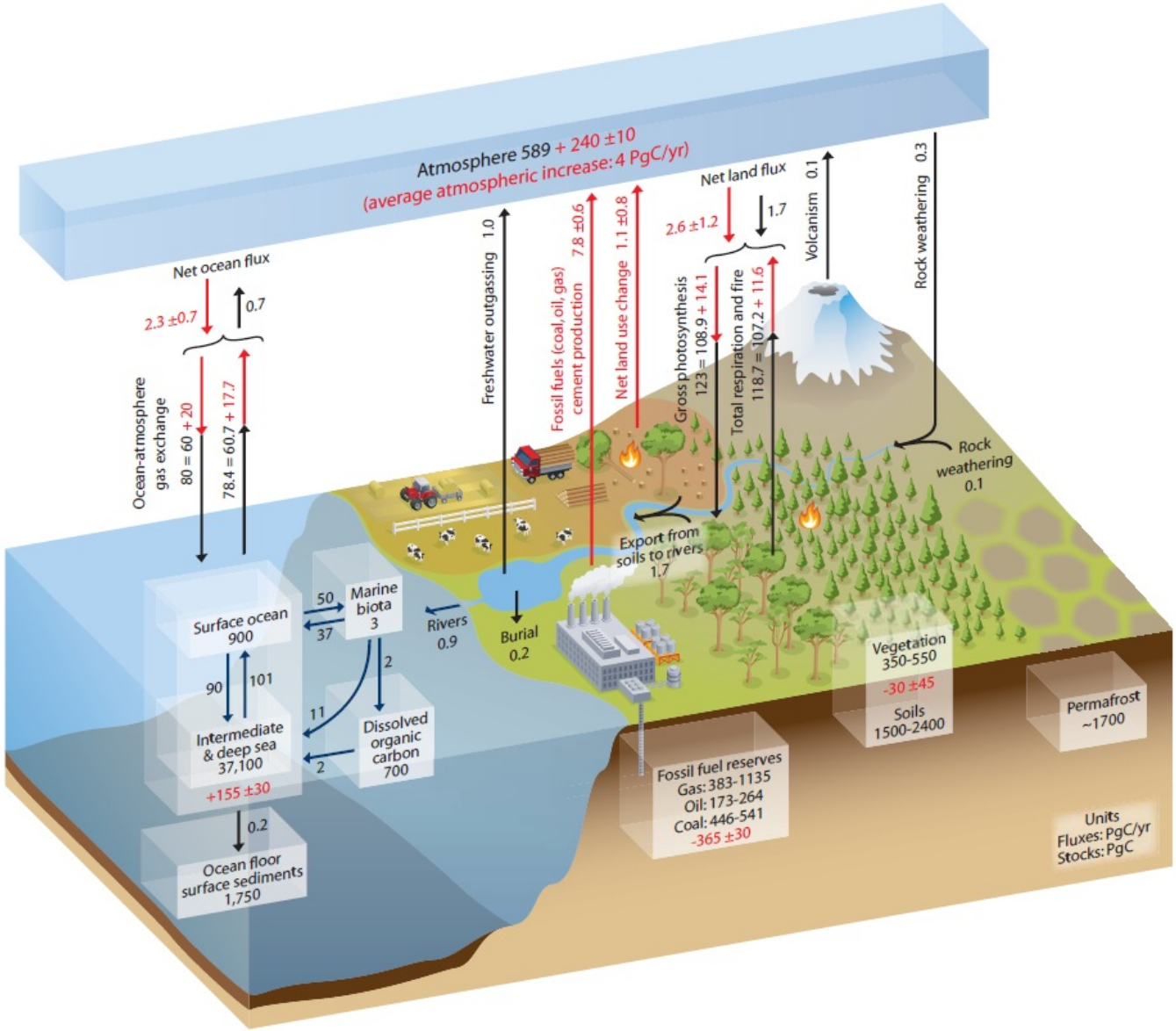
- Because they are there…
  - Where research vessels and other observing platforms are not
  - When you want them to be there (and when you aren't)
- Because the ocean is vast and undersampled
- Because they can support *complex measurement systems (power, space, data)*
- Because they are cost-effective
- Because they can "see" beneath the sea surface
- Because you can collect and return water or samples if necessary
- Because they can provide *repeated measurement at high spatial resolution*

# Examples of Big Science Questions Accessible by VOS

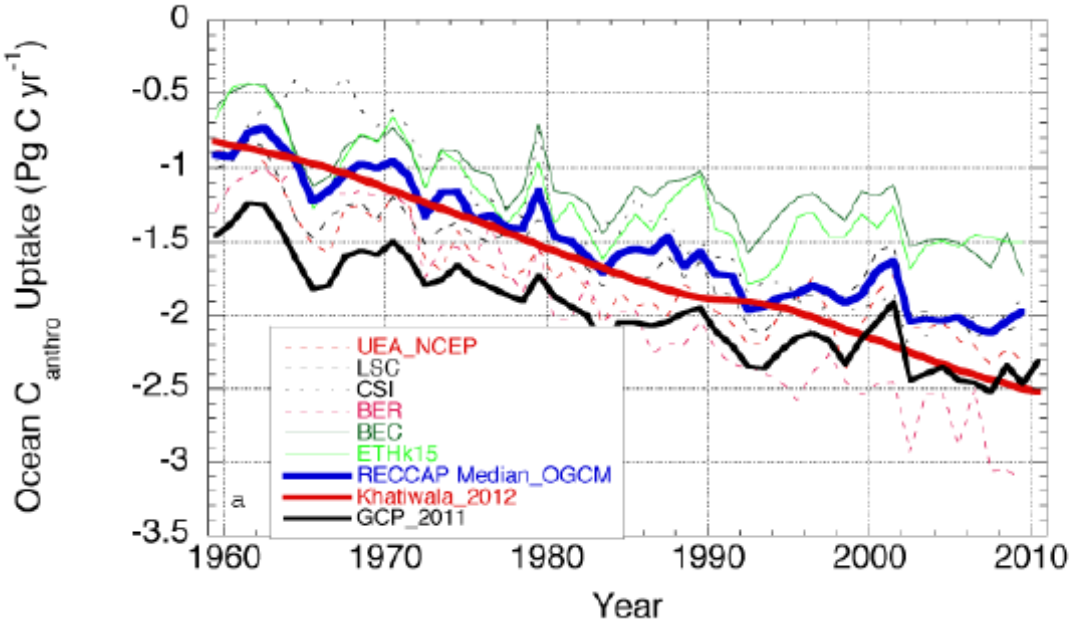
- How is the oceanic uptake of CO2 changing?
- Is the plankton biomass of the ocean decreasing?
- How rapidly are surface waters acidifying?
- How does plankton biomass respond to climate variability?
- How accurate are satellite measurements of SST, chlorophyll, atmospheric $CO_2$, salinity, etc..?
- How can we use satellite altimetry in coastal seas?
- How is the atmospheric composition changing?
- Is the Gulf Stream transport changing?
- How is the discharge of freshwater from the Arctic Ocean changing?
- What happens to freshwater released from the melting Greenland Ice cap?

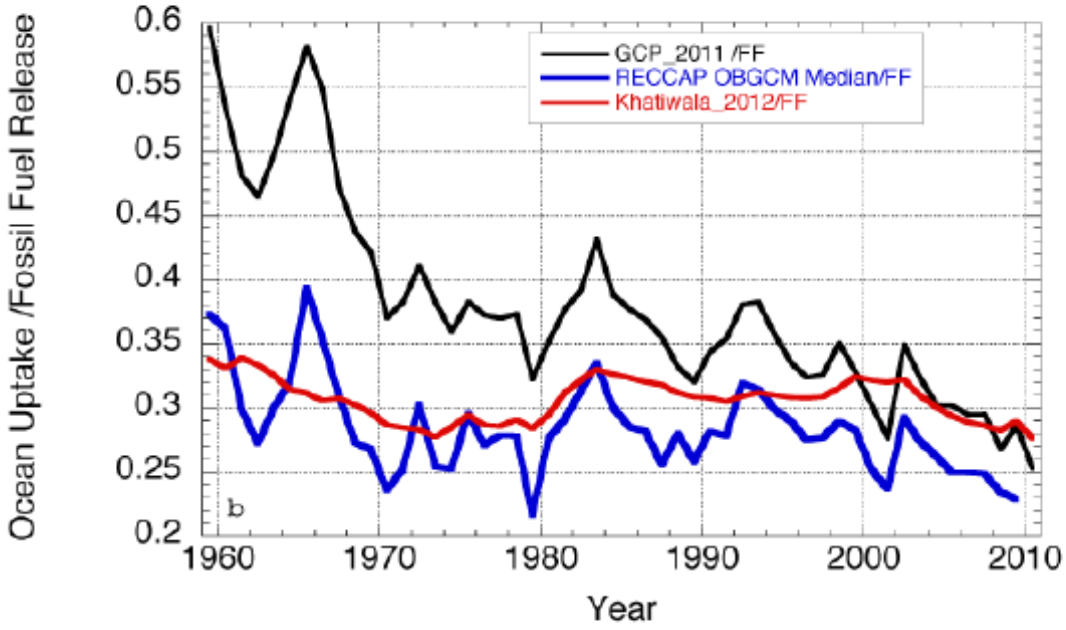
- etc…

# Example 1: Ocean's role in Global Carbon Cycle and Fate of Man-made $CO_2$ ($C_{ant}$)



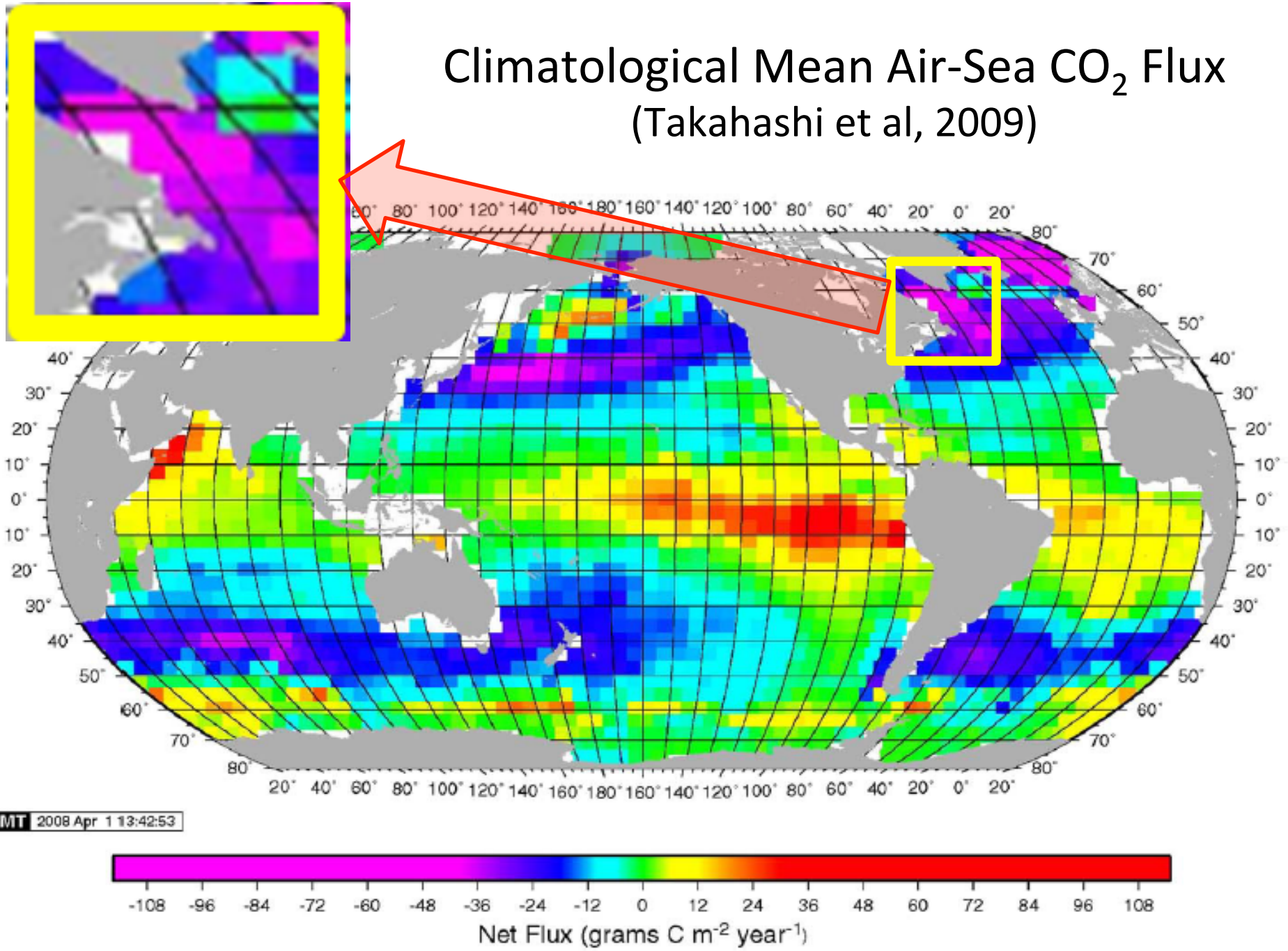

IPCC, AR5



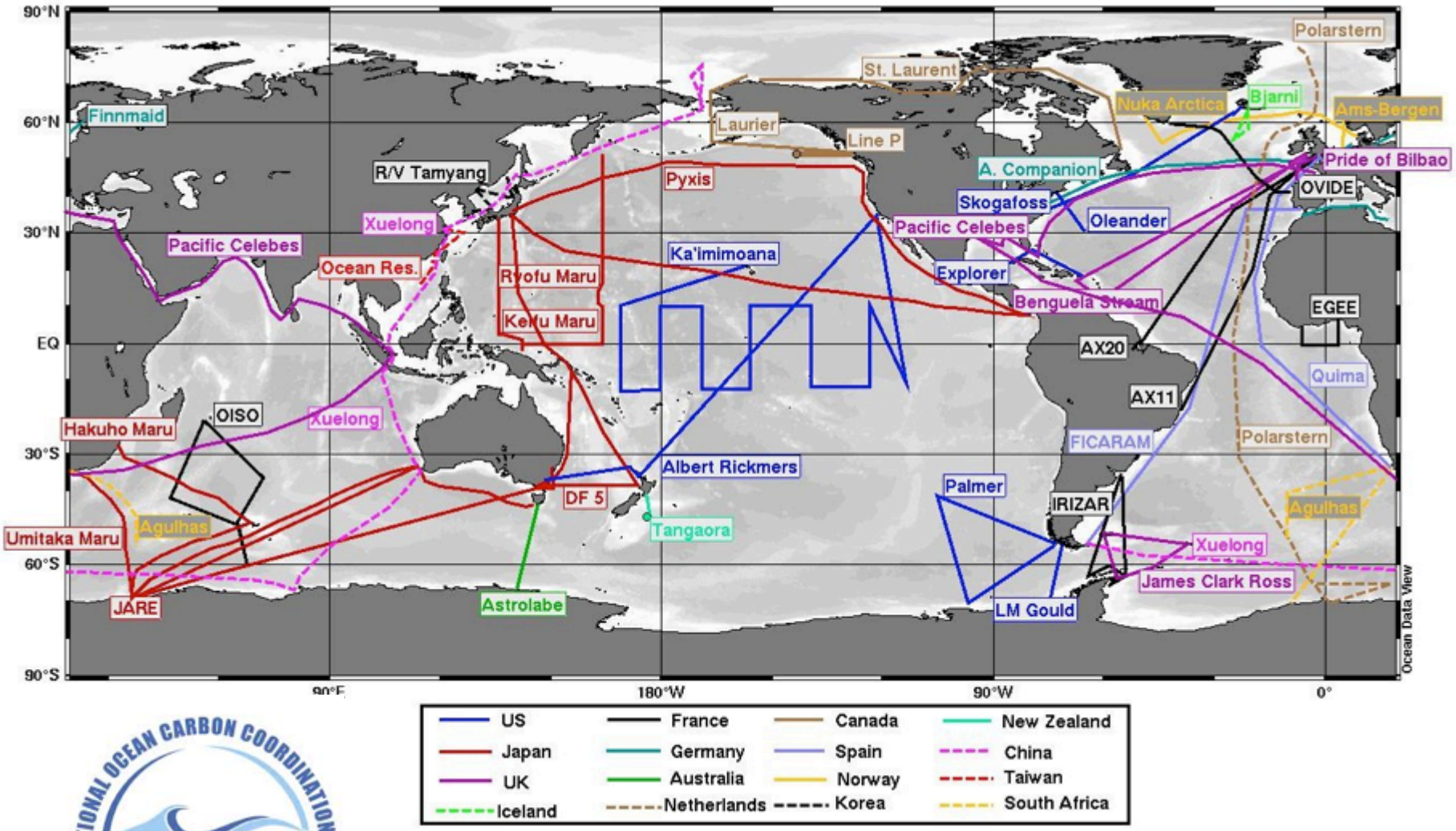




Longer-term trends in $C_{ant}$ uptake seem somewhat uncertain or at least variable between models

# Climatological Mean Air-Sea $CO_2$ Flux
(Takahashi et al, 2009)

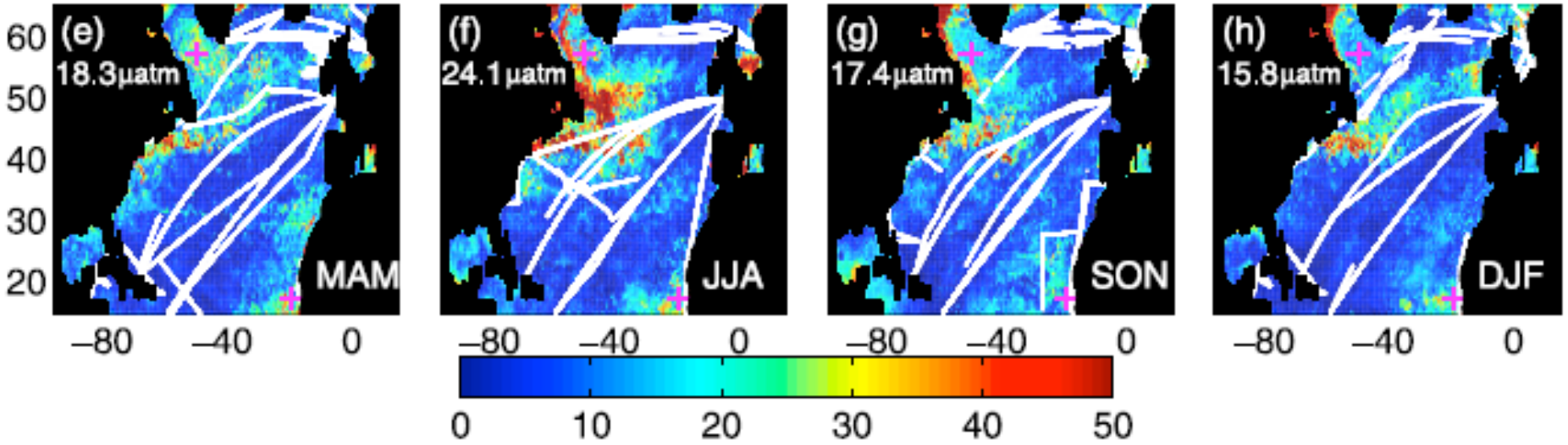


# VOS are the major data acquisition platforms for surface ocean $CO_2$ data




INTERNATIONAL OCEAN CARBON COORDINATION PROJECT
IOCCP

# Accuracy of Basin-Wide $pCO_2$ Maps




Seasonal mean RMS error (µatm)

**Large mapping errors in the Labrador Sea and around the Grand Banks … a consequence of the lack of training data in this area.**

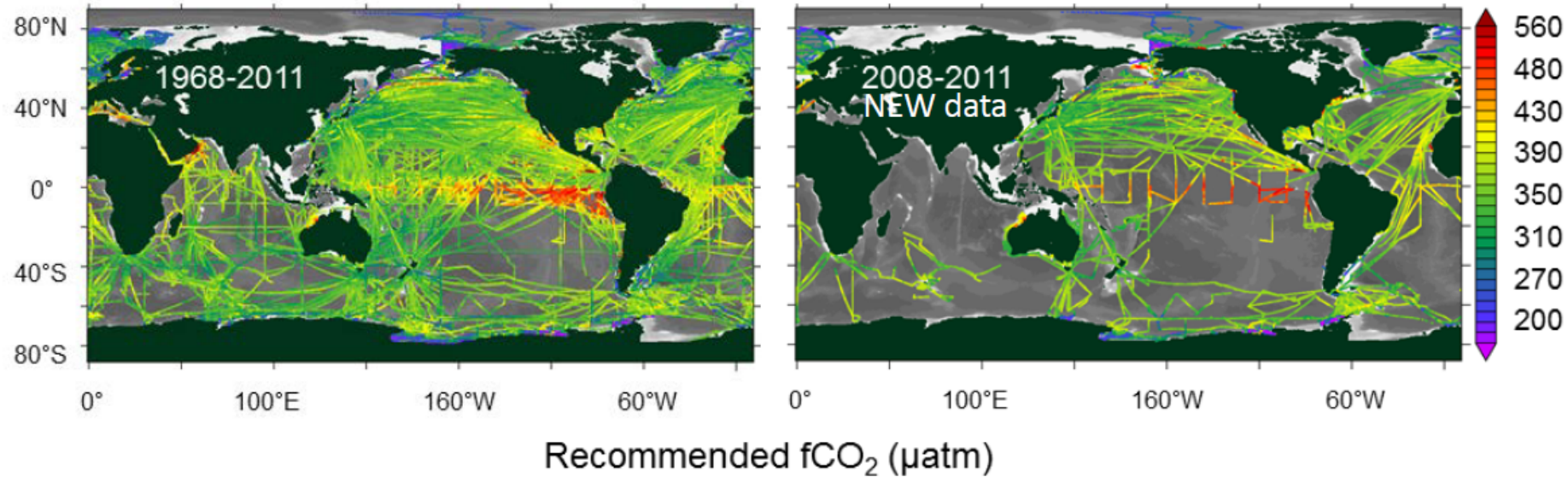
**The extension of monitoring pCO2 is highly recommended as our results indicate a significant improvement in the basin-scale pCO2 maps for an increased VOS line coverage. For this purpose, more observations would be particularly useful in the Labrador Sea and the NAC area.**

Friedrich, T., and A. Oschlies (2009), Neural network-based estimates of North Atlantic surface pCO2 from satellite data: A methodological study, J. Geophys. Res., 114, C03020, doi:10.1029/2007JC004646

www.socat.info

# An update to the Surface Ocean $CO_2$ Atlas (SOCAT version 2)

*D. C. E. Bakker, S. Hankin, A. Olsen, B. Pfeil, K. Smith, S. R. Alin, C. Cosca, B. Hales, S. Harasawa, A. Kozyr, Y. Nojiri, K. O'Brien, U. Schuster, M. Telszewski, B. Tilbrook, C. Wada and all SOCAT contributors*

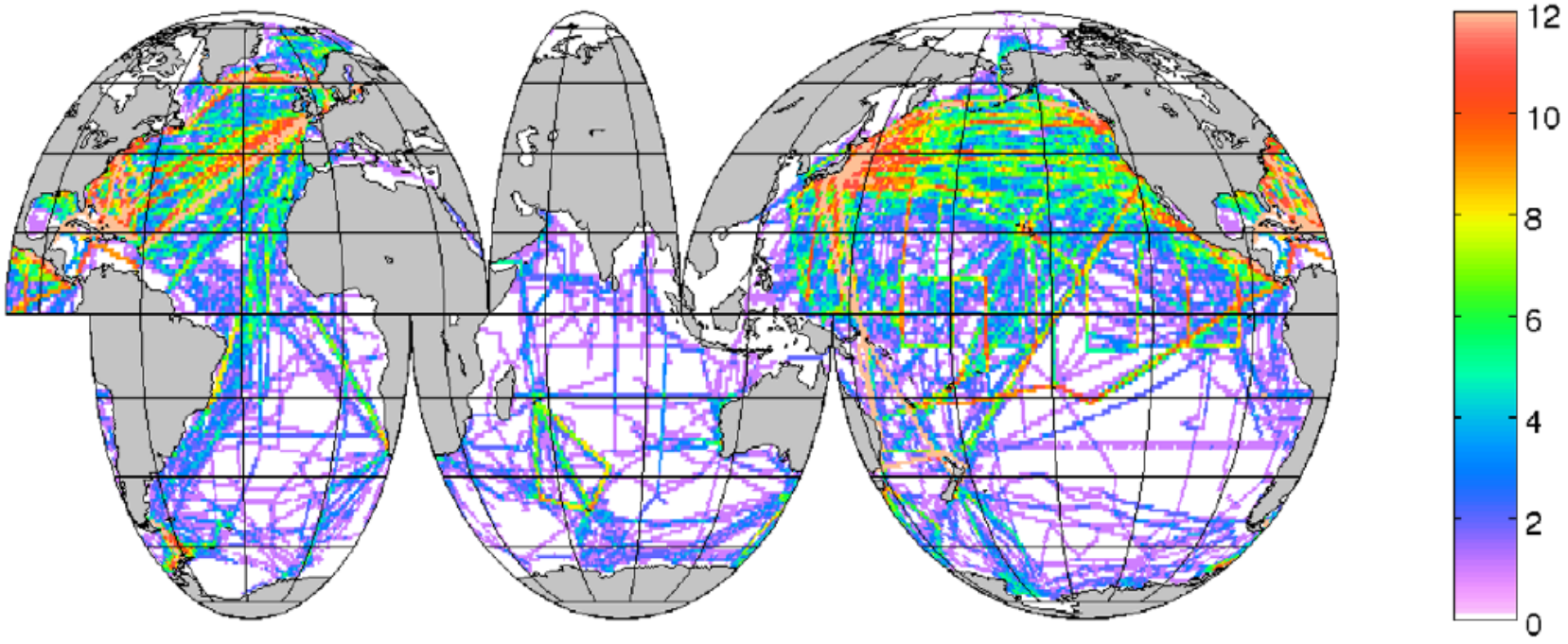



**Significant gaps in data coverage off Atlantic Canada**

SOCAT
SURFACE OCEAN CO2 ATLAS

www.socat.info

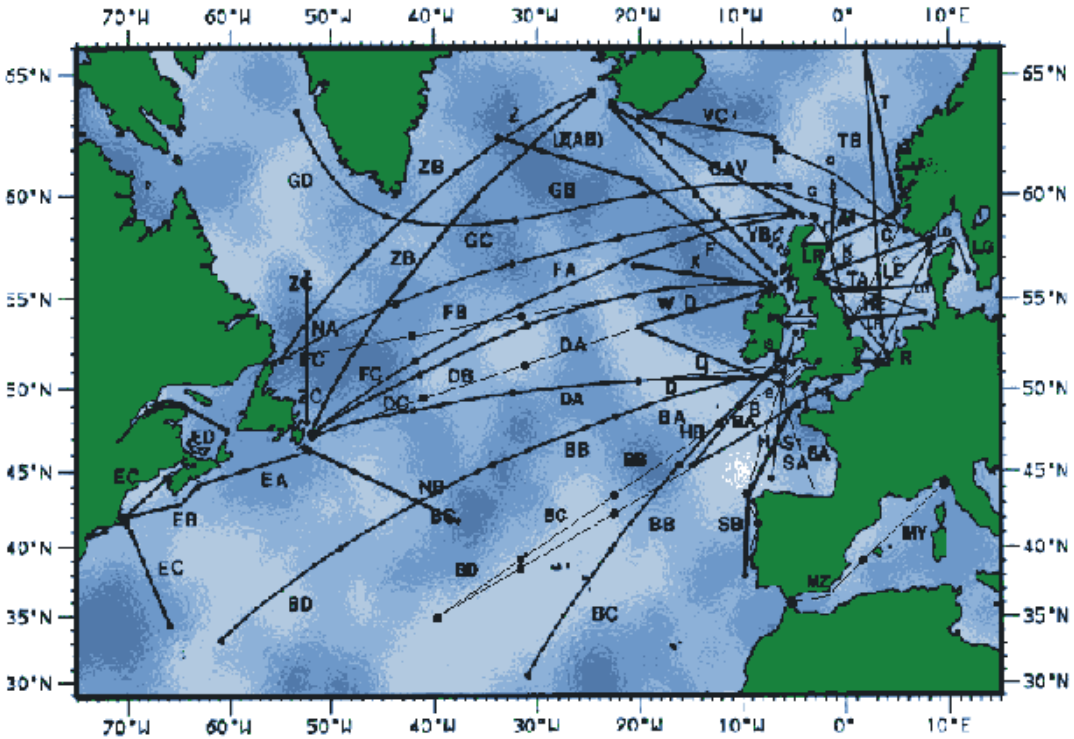
# Data coverage (1970-2011)

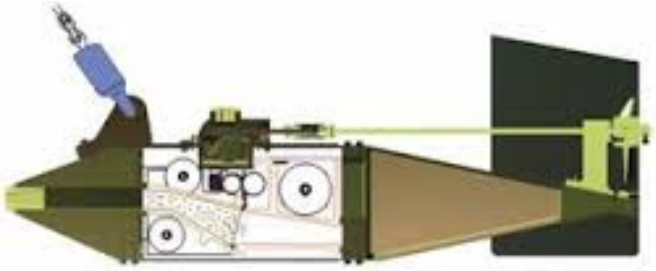



Number of unique months with $fCO_2$ observations per 1° x 1° grid cell (1970-2011)

# Example 2. Plankton biomass and biodiversity

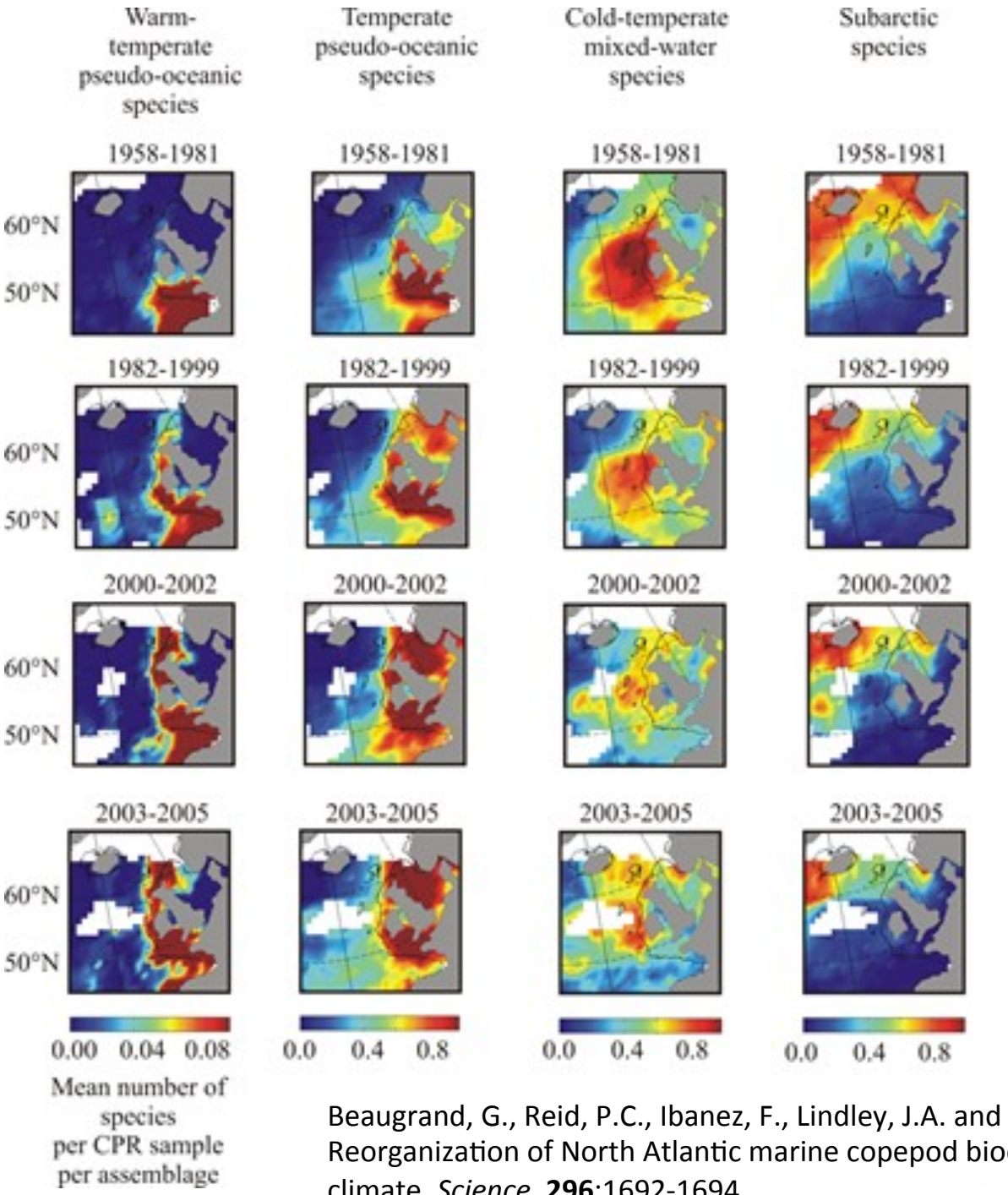
## Continuous Plankton Recorder (since 1931)



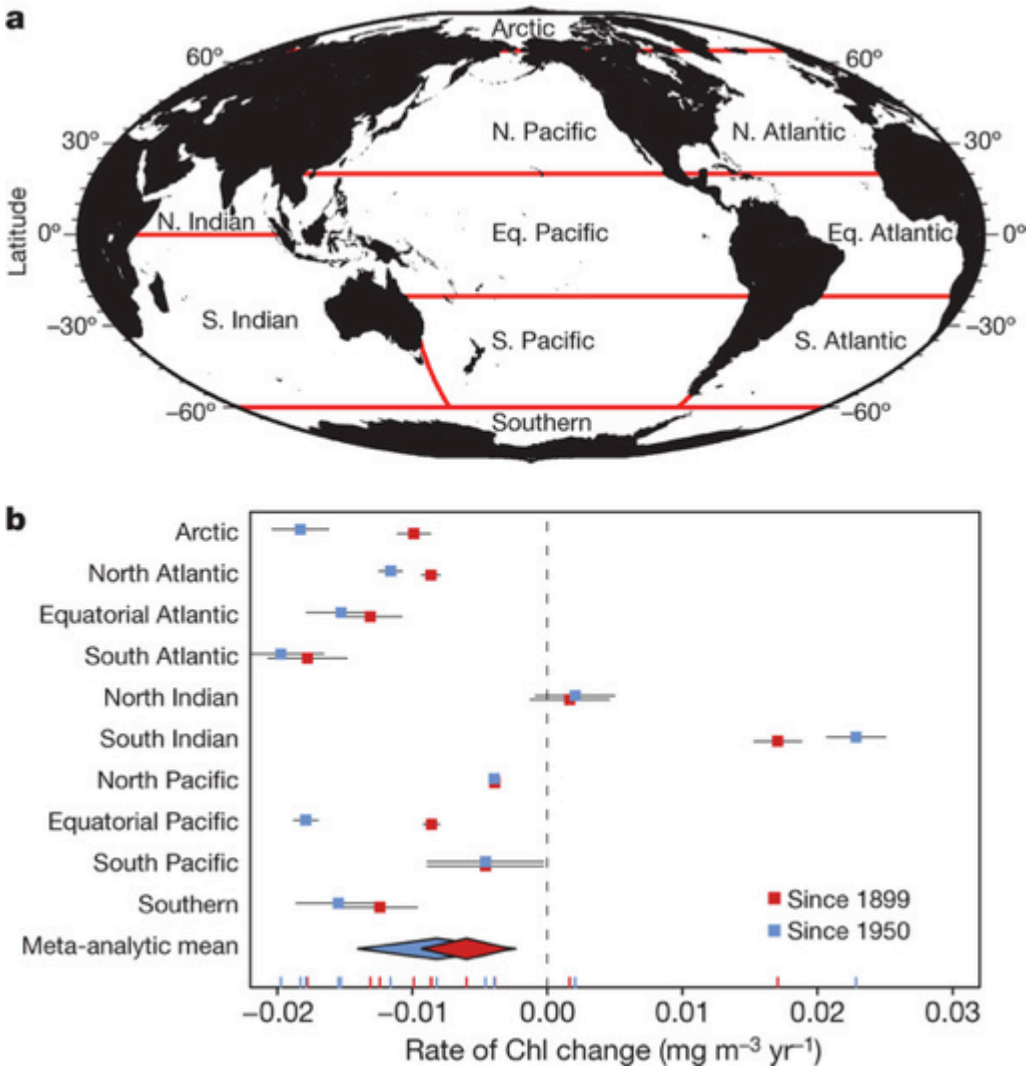
CONTINUOUS PLANKTON RECORDER SURVEY

SAHFOS




Beaugrand, G., Reid, P.C., Ibanez, F., Lindley, J.A. and Edwards, M., 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. *Science*, **296**:1692-1694

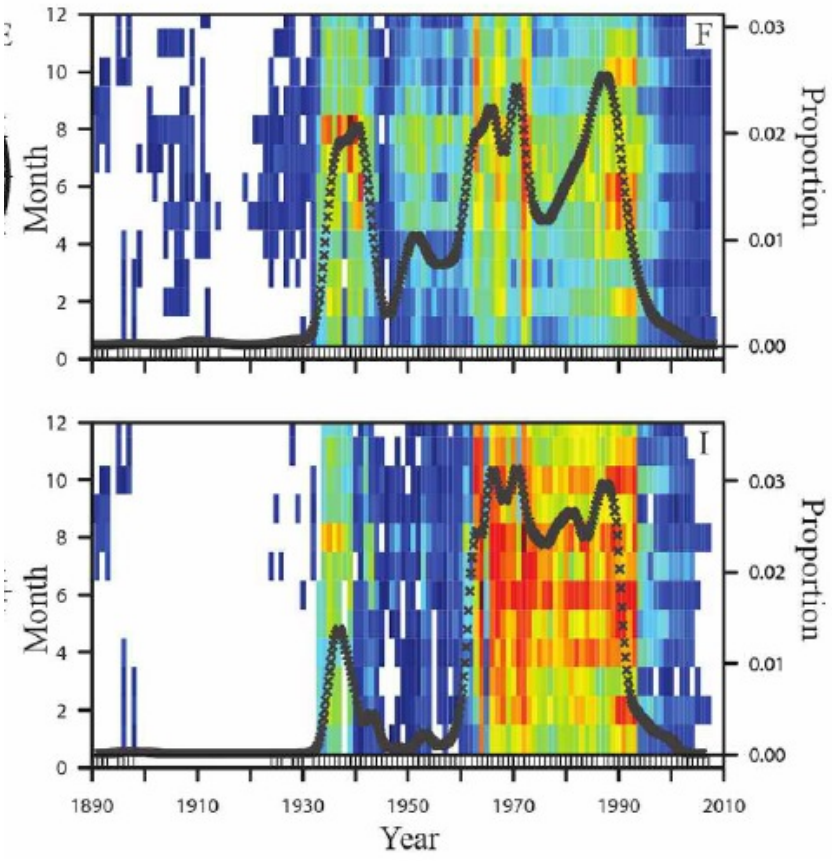
# Global phytoplankton decline of 1% per year over the past century?




Boyce et al., Nature, 2011

Observations of phytoplankton biomass:
Secchi disk (transparency)
Colour index

Boyce et al., 2012




**If biomass WAS changing, would we be able to tell?**

# Summary of Science Issues That Are Accessible to VOS

- Large-scale, climatology, monitoring:
  - Air-sea CO2 flux magnitude and variability
  - Global biomass
  - Ocean circulation (vertical structure, choke points, shallow water)
  - Atmospheric composition
- Ground-truthing of remote sensing
  - SST, chlorophyll, altimetry (coastal), atmospheric gases including CO2, waves, wind, slicks, etc.
- Regional prediction and forecasting
  - Weather, currents, sediments/bedforms, mammals, fog, etc.

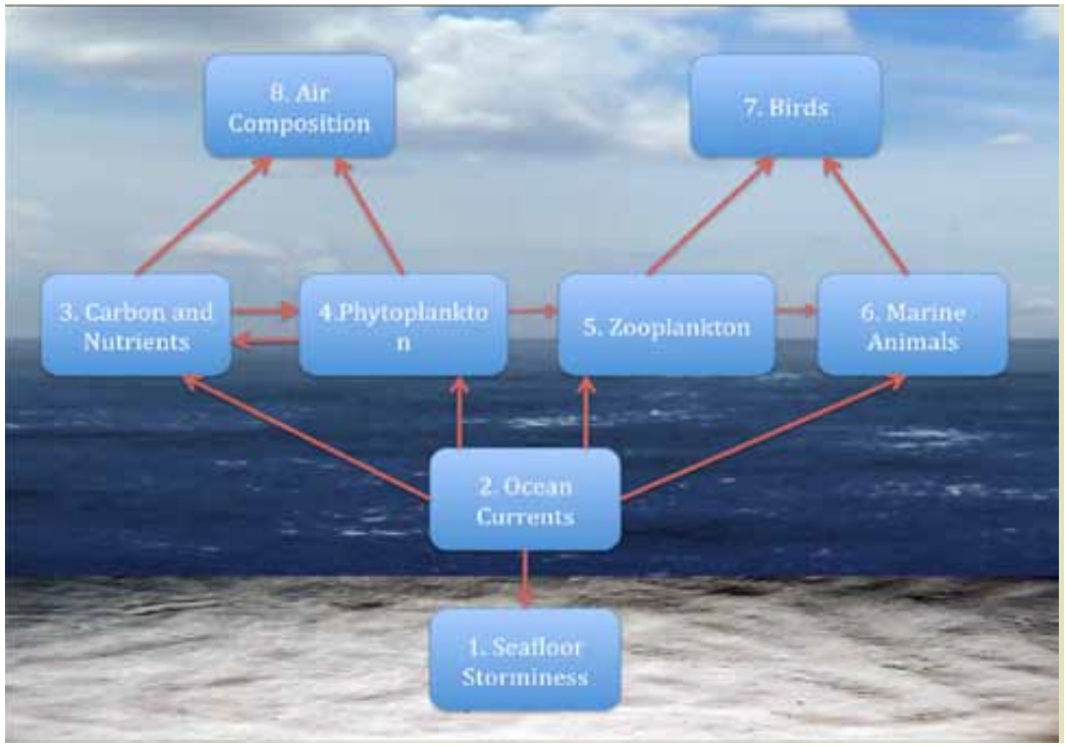
# Multipurpose VOS

MV Atlantic Companion
Atlantic Container Lines

Northern Europe – Halifax – Eastern US

Meteorology (VOS, SOOP)
Plankton Recorder
Radiosondes (German Weather Service)
$CO_2$, chlorophyll, $N_2O$

# *Multipurpose VOS:*
# *Offshore Supply Vessels*: A Unique Science Platform?




e.g. Deep Panuke, near Sable Island; Grand Banks
Transit frequency of 1-2 x per week for c. 10 years.

Could support autonomous instrumentation to examine:

Marine ecosystem; Ocean currents; Boundary-layer dynamices and fog; Carbon cycle; Distribution of birds and animals; Response of the sea floor to storms; Air quality; equipment testing and development.

# Context: new top-level initiative for international cooperation on ocean observation…

# New funding for ocean observation (in the EU)


**BG 14 - 2014: Supporting flagship international cooperation initiatives: Atlantic Ocean Cooperation Research Alliance**

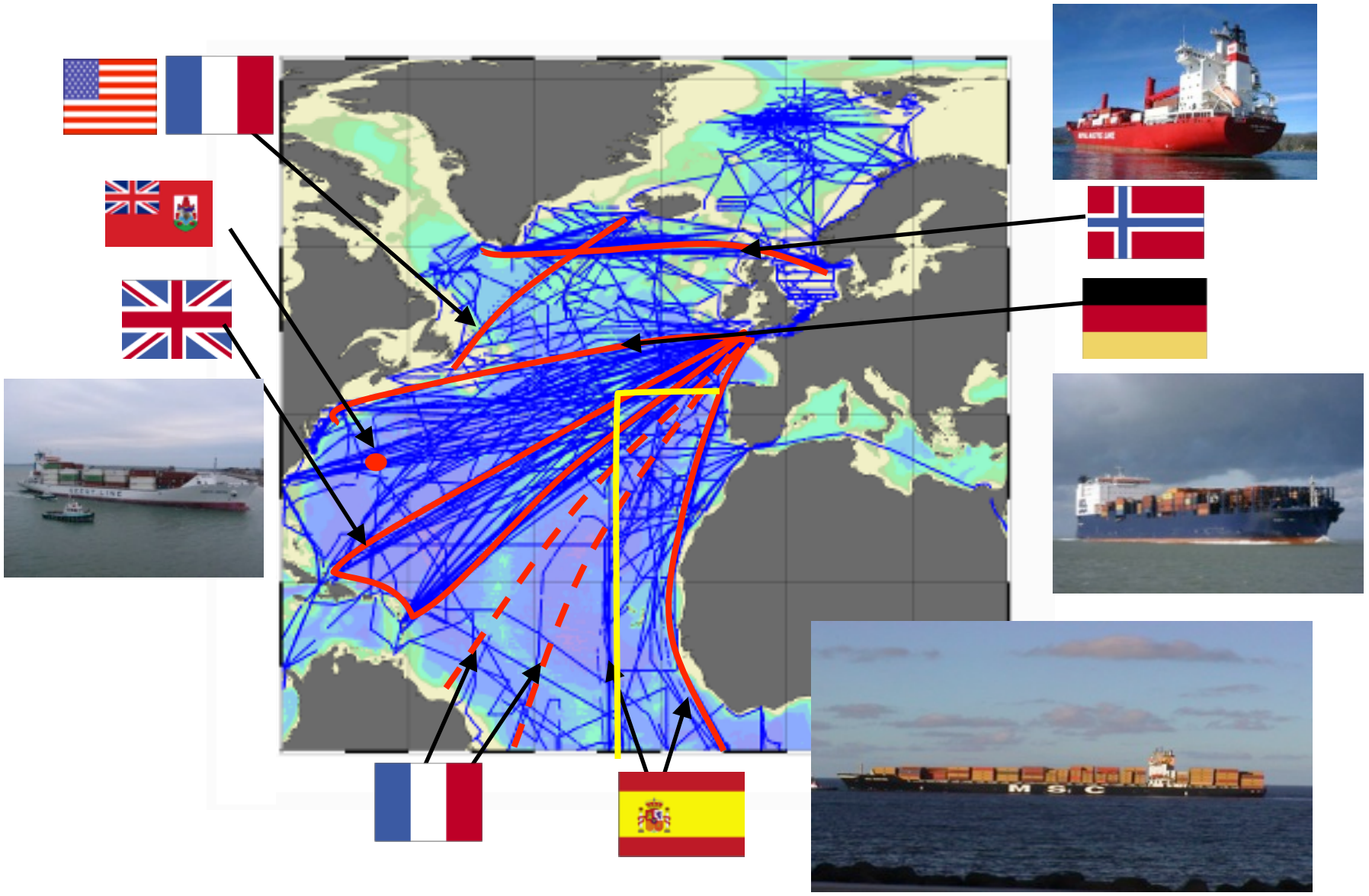
(i) Marine ecosystem-approach, (ii) Observing systems, (ii) Marine biotechnology , (iii) Aquaculture (iv) Ocean literacy – engaging with society, (v) seabed and benthic habitat mapping. EU 3.5 million

**BG 8 - 2014: Developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources** EU 15-20 million

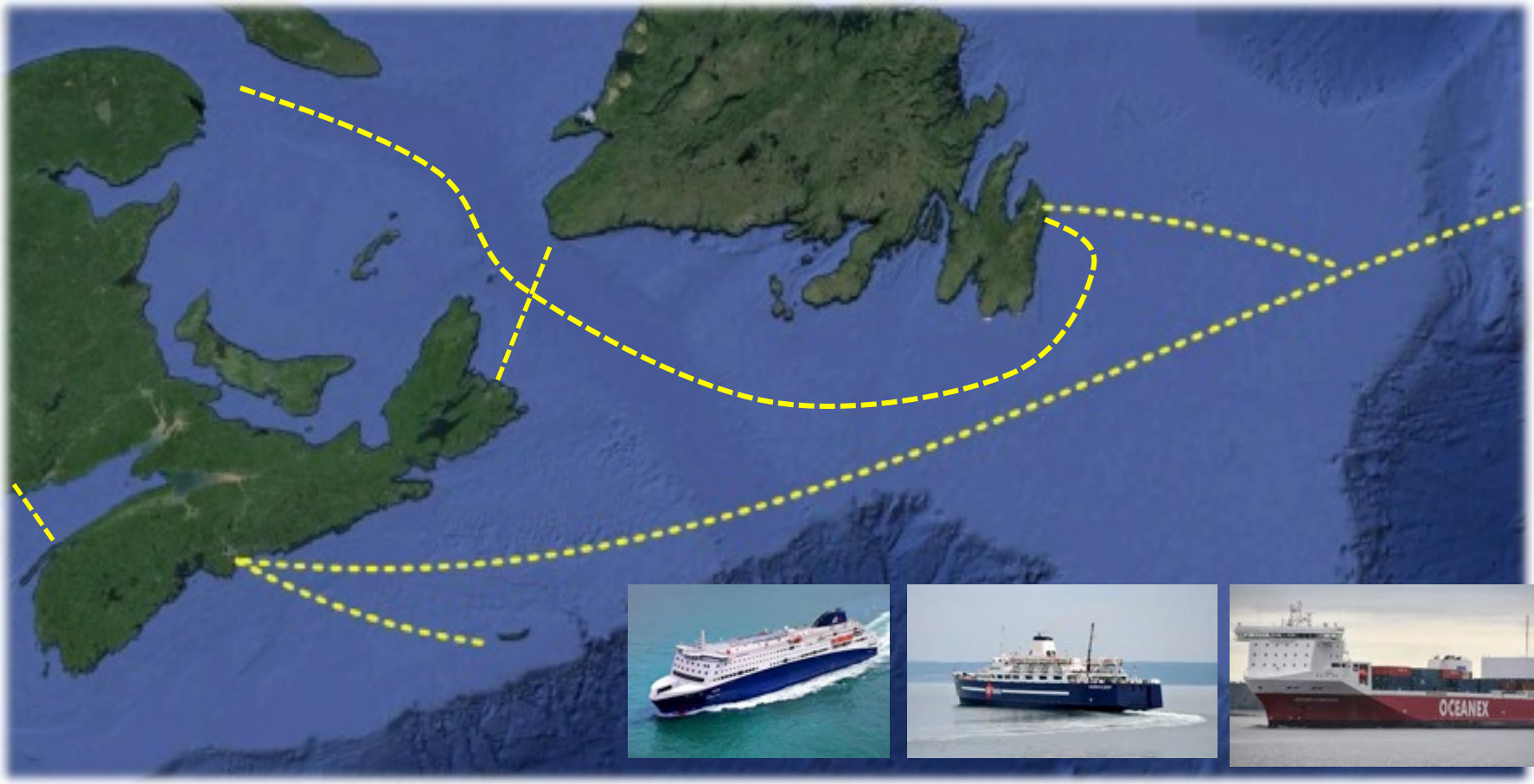
**BG 7 - 2015: Response capacities to oil spills and marine pollutions** EU 6 million

Volunteer Observing Ships (VOS) for Surface Carbon Studies

***Time-variability of air-sea flux is now accessible on basin scales***



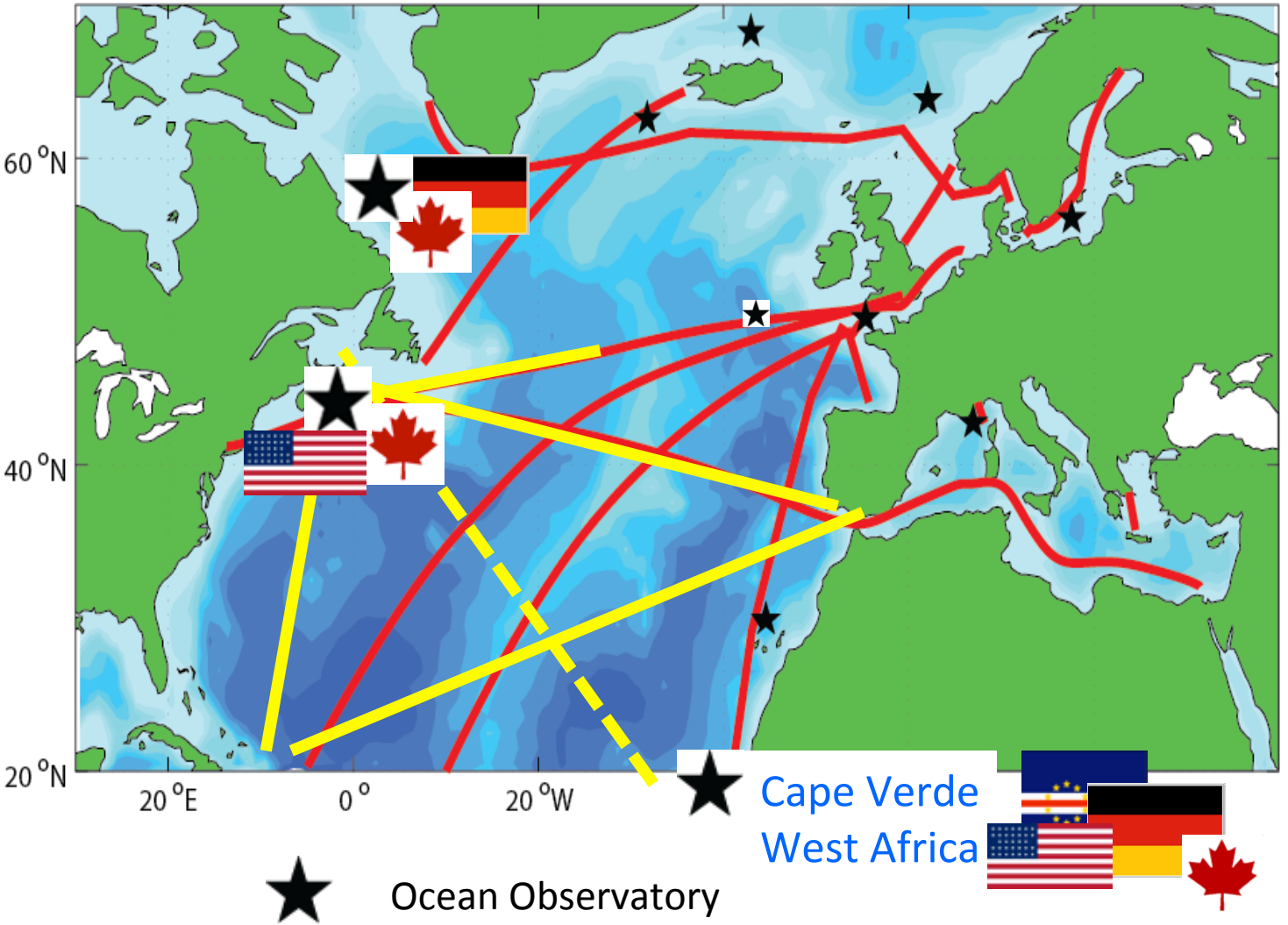
# A Coastal VOS Network in Atlantic Canada?



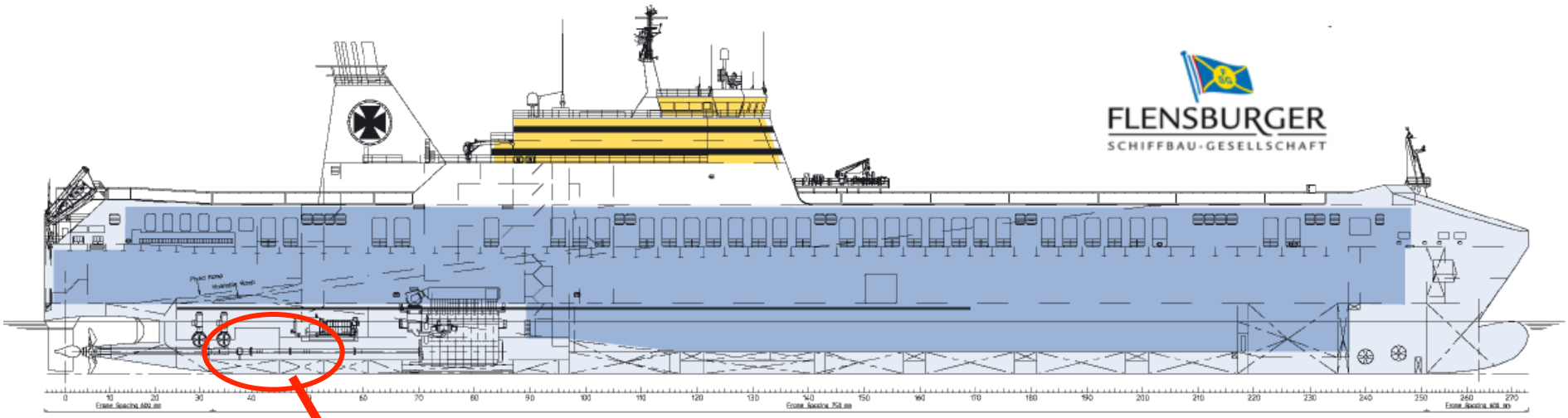
# MEOPAR

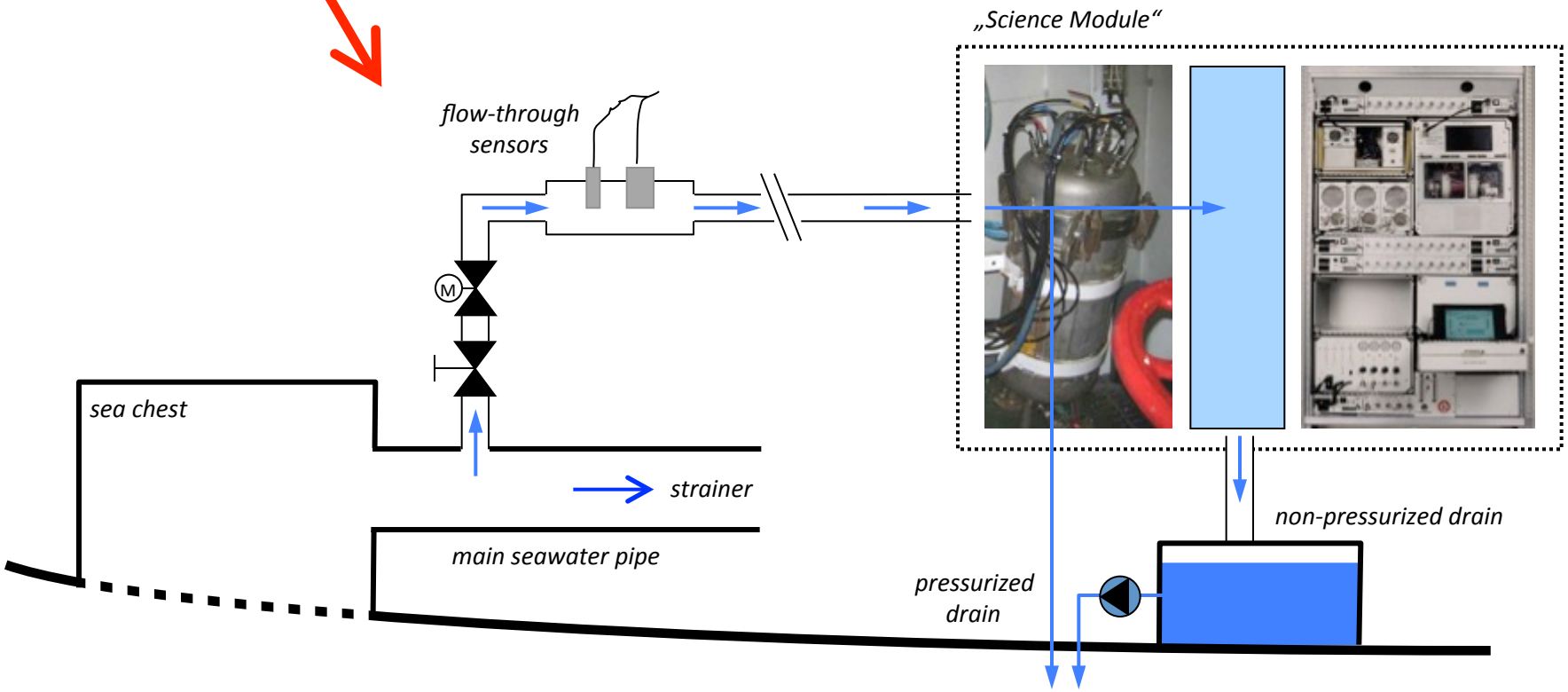
**MARINE** ENVIRONMENTAL OBSERVATION
PREDICTION & RESPONSE **NETWORK**

# CERC.OCEAN: Specific Areas of Interest in the Atlantic Ocean



# „VOS“ are still too difficult — towards a standard built-in ”Science Module“



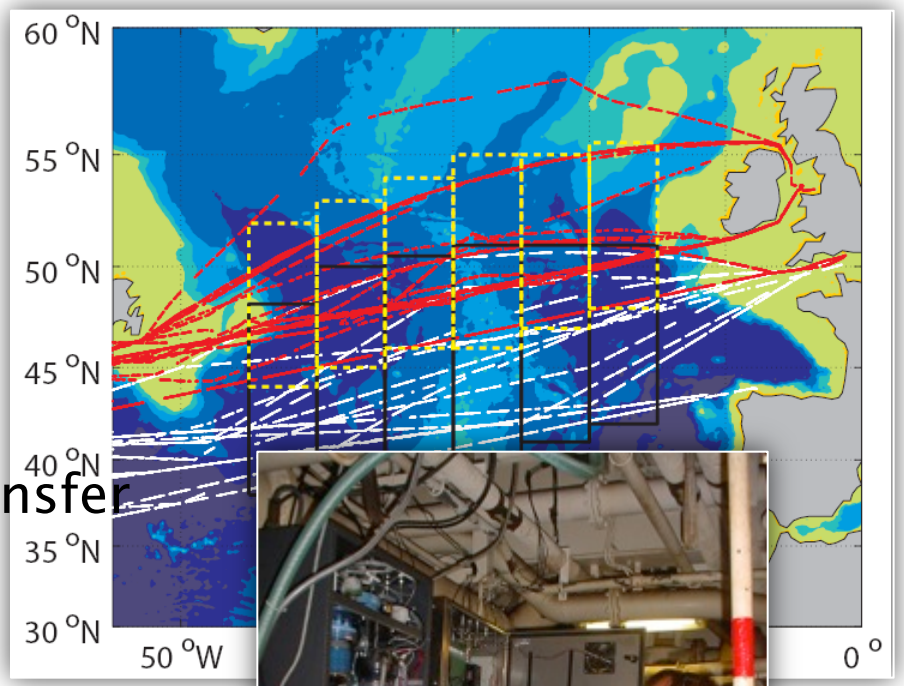



# Commercial “Voluntary Observing Ships“

**For Sustained, Frequent Observations of the Surface Ocean**

Halifax

Hamburg




e.g. For measuring air–to–sea $CO_2$ transfer

*Thanks to Atlantic Container Lines*

Implement unobtrusive, technologies that do not impact vessel operations.