GO-SHIP, OneArgo, GO-BGC and SOCCOM: Status and Contributions to the Global Ocean Observing System

Pathways Connecting Climate Changes to the Deep Ocean Workshop
April 23-25, 2024 Lewes, DE
On Behalf of the U.S. GO-SHIP Executive Council, and the GO-BGC and SOCCOM Executive Committees
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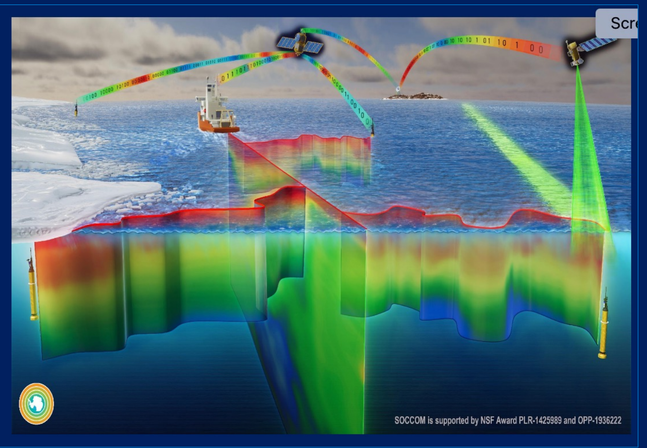
International GO-SHIP, rooted in multiple decades of ocean measurements, and Biogeochemical Argo, which is newly developing and will reach full global coverage by 2025, provide the bulk of highly accurate carbon, oxygen, and nutrient information for the global ocean, and which are necessary for understanding and quantifying the distributions and changes of BGC properties in the open ocean.

'You can't manage what you don't measure.'

Satellite measurements
Ship-based surface measurements

Open ocean below the sea surface
- Profiling Floats
- Research Ships
- Fixed locations

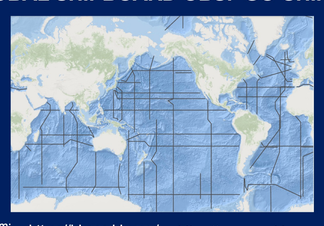


While U.S. GO-SHIP will likely continue with its current mode of 6-year proposals to NSF and NOAA, after 2025, the U.S. contribution to the global array of 500 BGC Argo floats will collapse unless a source of funding is found, and the exponentially growing use of these data will face a decline to nearly zero over the subsequent 3 to 6 years as the deployed floats reach the end of their lifetimes.

PROGRAMS

GO-SHIP

SUSTAINED, DECADAL GLOBAL SHIPBOARD OBS. GO-SHIP



Repeat crossings of ocean basins to ocean bottom:
5 to 10 years apart since 1990s
Highest accuracy 'gold' standard.
Surface to bottom

https://biogoship.org/ https://www.go-ship.org

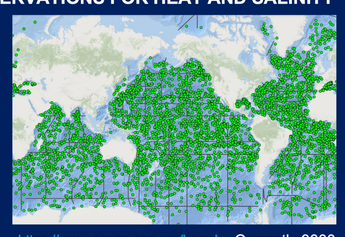
Emerging 'Bio GO-SHIP'

OneArgo

SUSTAINED, FREQUENT OBSERVATIONS FOR HEAT AND SALINITY

Core Argo - since 2004

- Every 10 days
- Temperature and salinity
- Surface - to - 2000m
- Target number: 4000 floats

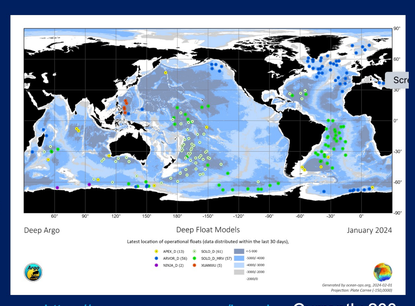


https://www.ocean-ops.org/board Currently 3800

Deep Argo - since 2014

Every 10 days

Temperature, salinity
Surface - to - bottom
Target number: 1200 floats



https://www.ocean-ops.org/board Currently 200

SUSTAINED, FREQUENT OBSERVATIONS FOR CARBON, OXYGEN, ECOSYSTEM

Biogeochemical Argo - since 2012

Every 10 days

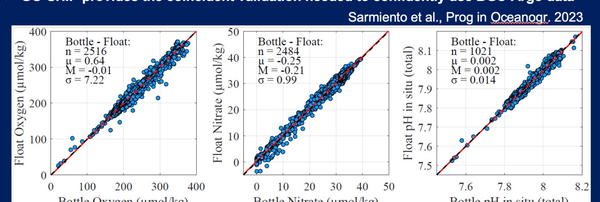
Temperature and salinity
Oxygen, Nitrate, pH
Chlorophyll, Backscatter, Irradiance
Surface - to - 2000m
Target number: 1000 floats

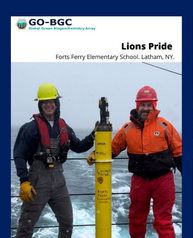
https://www.ocean-ops.org/board Currently ~350

GO-SHIP and Core/Deep & BGC-Argo synergy (cal/val)

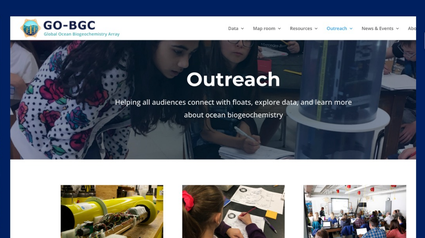
- **GO-SHIP provides reference standard temperature, salinity, oxygen, nutrients, carbon system observations for reference climatologies (e.g. GLODAP) and T/S data bases, used for calibration of the autonomous Argo float sensors**
- **GO-SHIP provides the coincident validation needed to confidently use BGC-Argo data**

Sarmiento et al., Prog in Oceanogr. 2023

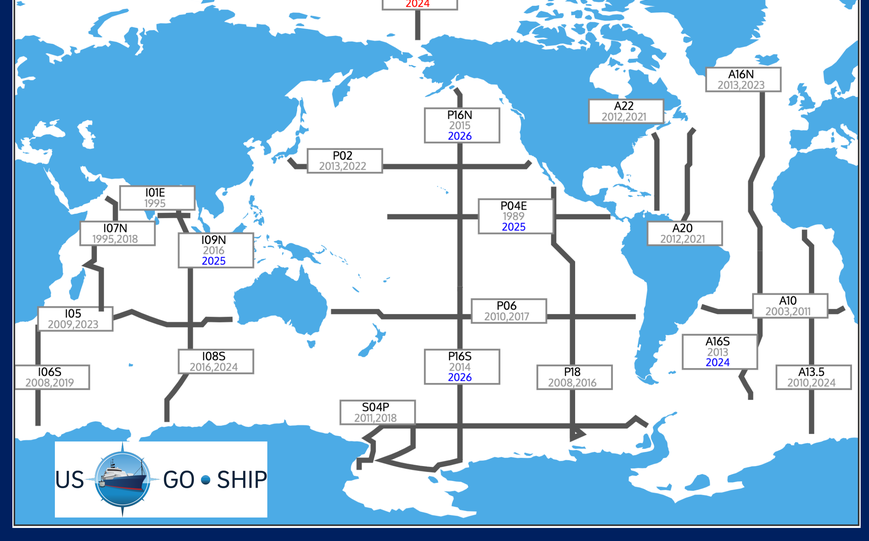


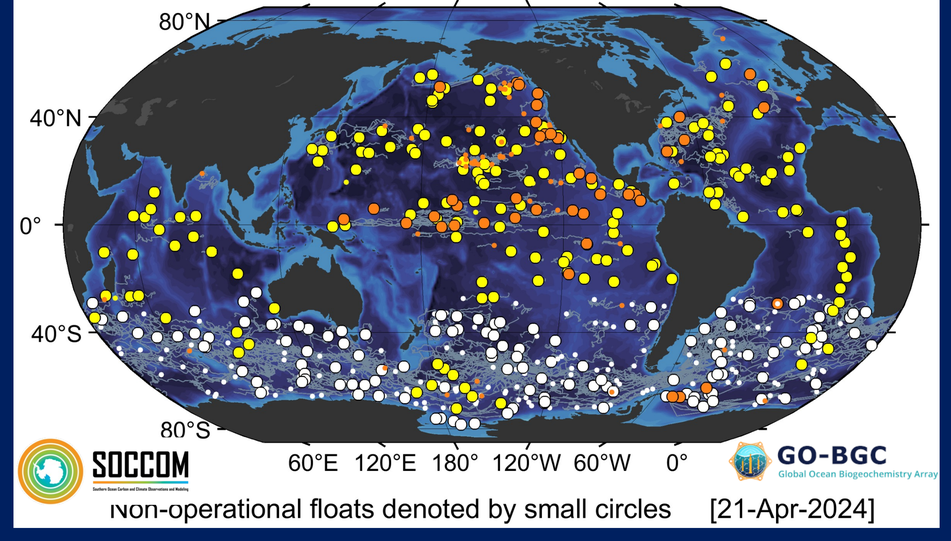


https://soccom.princeton.edu/broader-impacts



https://www.go-bgc.org/outreach





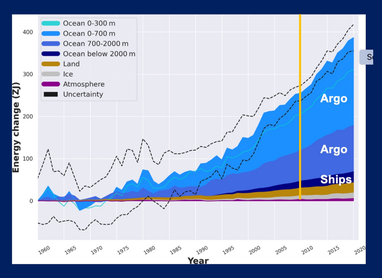
SOME USES and RESULTS

OCEAN HEAT UPTAKE

The ocean takes up 90% of the excess heat

We know this because of Argo T/S observations & GO-SHIP (deep ocean).

Argo T/S is essential for climate assessment.



von Schuckmann et al. (Earth System Science Data, 2023)

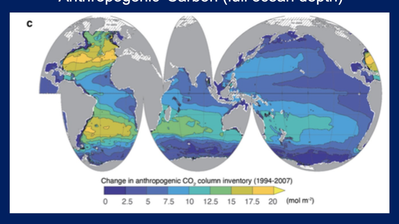
OCEAN CARBON UPTAKE

The ocean takes up 25 to 30% of the excess CO_2 in the atmosphere.

GO-SHIP (5-10 yr repeats) used for the map

Seasonal sampling needed for closed C budgets and mCDR. -> BGC Argo sampling.

'Anthropogenic' Carbon (full ocean depth)



Gruber et al. (Nature, 2023)

OXYGEN VARIABILITY FROM ONEARGO AND GO-SHIP

We can already estimate the global oxygen distribution from Argo:

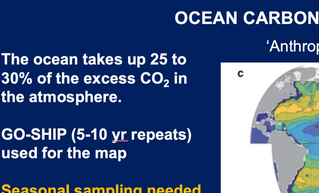
GO-SHIP oxygen
BGC Argo oxygen
⇩
Training machine learning to use much more completely sampled Argo T/S
⇩
Monthly, global oxygen

Brand new – emerging data products for carbon, nutrients, pH, alkalinity, productivity

Sharp et al. (ESSD 2023)

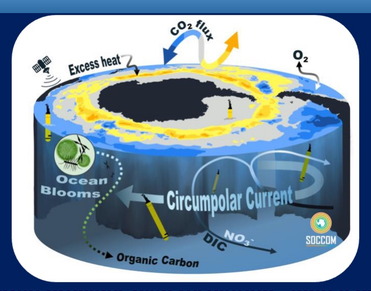
BGC-ARGO Extends Satellite Observations into the Interior

Merging float profiles of POC with high resolution satellite observations



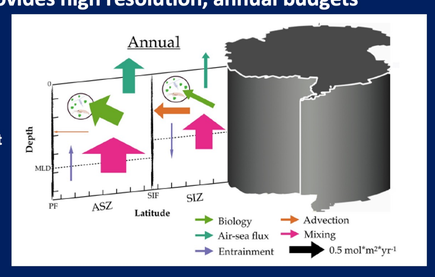
Global estimates of particulate organic carbon from the surface ocean to the base of the mesopelagic

James Fox[1], Michael J. Behrenfeld[2], Kimberly H. Halsey[1], Jason R. Graff[2]



BGC-Argo provides high resolution, annual budgets

Antarctic Circumpolar Current carbon budget based on SOCCOM float observations

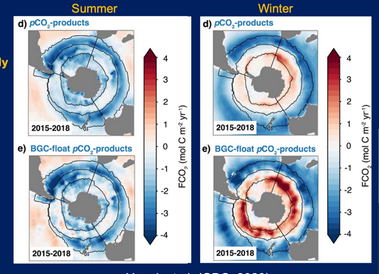


Sauve et al., JGR, 2023

OCEAN CARBON UPTAKE

Air-sea flux of CO_2 mapped now using very sparse shipboard observations. Ships only

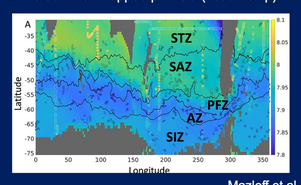
BGC Argo floats begin to provide seasonal fluxes. Add BGC floats



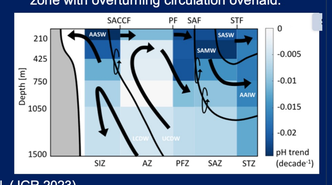
Hauck et al. (GBC, 2023)

Ocean Acidification: SOCCOM floats and GLODAP

The summer mapped pH field (float + ship)

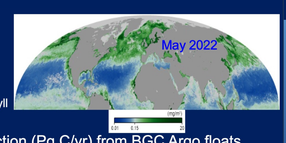


Rates of pH change (pH/decade) in each zone with overturning circulation overlaid.

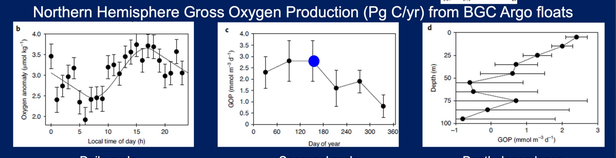


Mazloff et al. (JGR 2023)

ECOSYSTEMS: TIME & SPACE SCALES



Northern Hemisphere Gross Oxygen Production (Pg C/yr) from BGC Argo floats

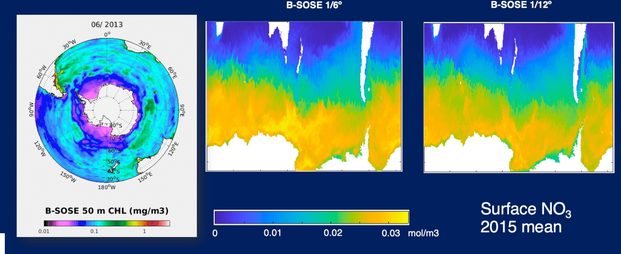


Daily cycle | Seasonal cycle | Depth dependence

Johnson and Bif (Nat. Geosci. 2021) https://earthobservatory.nasa.gov/global-maps/MY1DMM_CHLORA

SOCCOM: B-SOSE (BGC Southern Ocean State Estimate)

All output is publicly available through SOCCOM website and http://sose.ucsd.edu/

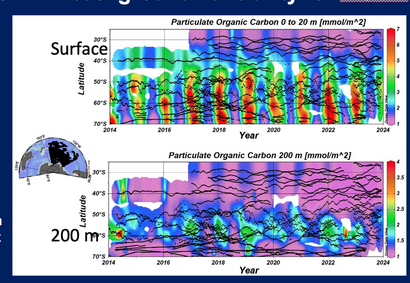


BGC-Argo defines MVR background variability for mCDR

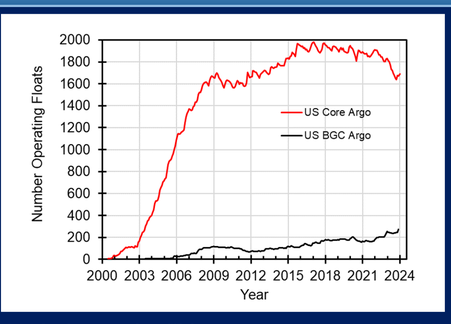
SOCCOM observations 2014-2024

Seasonal cycles and interannual variability of particulate organic carbon

- **Production of organic carbon**
- **Transport into deep-ocean**
- **Change in air-sea CO_2 flux**



STATUS & FUTURE



Current NOAA budgets are insufficient to support Core-Argo, and that array is in decline. BGC floats, mostly funded by NSF, are mitigating this decrease.

But GO-BGC funding ENDS in 2025
No continuation funding has been identified as of now

SOCCOM has ended. Continuation is under consideration.

Include the data in projects proposed to NSF, NOAA, NMFS, DOE, NASA, etc

NSF: proposal pressure is essential
Publicly available data and data tools through GO-BGC and SOCCOM websites
Publicly available through the Argo GDAC