Why are we measuring oxygen?

Scientific challenges:

- Detect and document the ocean's deoxygenation (expansion of OMZ)
- Estimate variability in ocean circulation/mixing (e.g. ventilation)
- Determine seasonal to interannual changes in NCP and export production
- Improve atmospheric $O_2/N_2$ constraint on the oceanic uptake of anthropogenic CO$_2$
- Prediction and assessment of anoxic or hypoxic events
- Provide constraints for ocean biogeochemistry models

The ocean is losing its breath

- During the past 50 years oxygen-depleted waters have expanded fourfold and some areas of the ocean have lost up to 40% of their oxygen
- Loss of oxygen is a threat to marine life, the ocean's ecosystems and coastal communities
- Global warming limits the supply of oxygen from the atmosphere (reduce mixing and deep ventilation)
- Inputs of nutrients and organic waste increase oxygen demand (biological production and consumption)
- Deoxygenation can accelerate global warming via enhanced marine production of greenhouse gases under low oxygen conditions

Several $O_2$-minimum zones have lost $O_2$ in the recent decades, resulting in a expansion of the regions with hypoxia
Global oceanic $O_2$ content since 1960

- Global $O_2$ inventory
- Change in $O_2$ per decade

Expanded observation is immediately required for accurate documentation and prediction of ocean oxygen changes.

To meet these objectives, we are dependent on the quality of the $O_2$ measurements performed.

### Essential Ocean Variable (EOV) for oxygen

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<td>Accuracy ($\mu$mol/kg)</td>
<td>± 2.0</td>
<td>± 0.5</td>
<td>± 2.0</td>
<td>± 2.0</td>
<td>± 0.5</td>
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</tbody>
</table>

Objective: achieve an accuracy of 1 $\mu$mol/kg with an accuracy of 0.5 $\mu$mol/kg (Gruber et al., 2010).

### Where are the $O_2$ data archived?

Oxygen seawater spatial coverage from Argo

333 Argo-$O_2$ floats acquisition in real-time

Oxygen seawater spatial coverage from GO-SHIP

$O_2$ is a core parameter measured systematically during GO-SHIP cruises (full cruise every 10 years).
Oxygen seawater data available

\textit{gloDAP v2 = gloDAP v1 + CARINA + PACIFICA}

722 oxygen cruises data with accuracy better than 1%:
- 378 accurate with no adjustment necessary
- 207 adjusted (secondary QC flag)
- 127 good quality but have not been subjected to full secondary QC

CARIMED: 26 cruises with QC2 (1981-2016)

All of them with \( O_2 \) data with QC 2 (\textit{Alvarez et al., CIESM 2016})
Some applications with O$_2$ adjusted data

Deep convection in the Labrador Sea using Argo-O$_2$ float

Deep ventilated volume using combined Argo-O$_2$ fleet and ship

Convection and deep biological activity – O$_2$ mooring

Submesoscale eddies, fronts – O$_2$ gliders

Net community production – O$_2$ ARGO floats

Convert O$_2$ production to carbon uptake with the modified Redfield ratio $(150 \times 10^{-6})$ + extrapolate to an annual value by multiplying the daily increase by 365