

Tracing deoxygenation signals in the Mediterranean Sea through a Delayed-Mode Quality-Controlled BGC-Argo dataset

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Who — OGS team (Trieste, Italy) for Copernicus Marine Service

Why — Improving BGC Analysis & Forecast Mediterranean Sea

How — Integrating in-situ data and numerical model

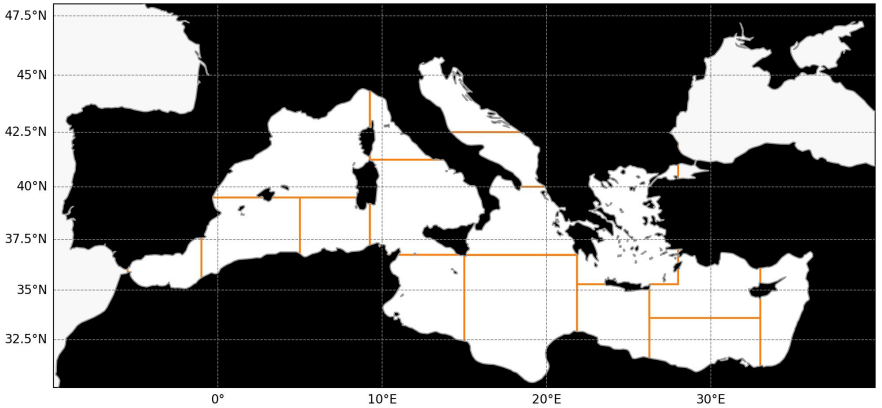
What — Detecting Oxygen Trends/Regime Shifts


Carolina

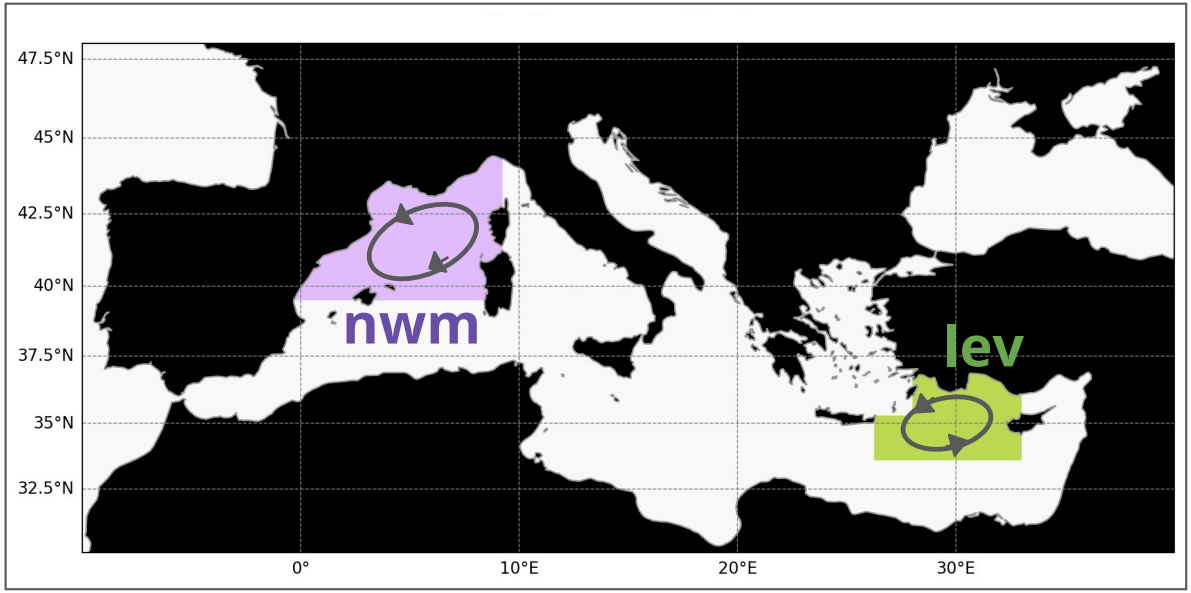

Gianpiero

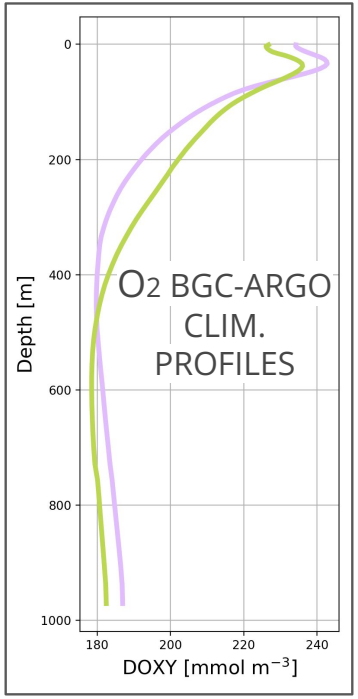

Anna


Giorgio



Study Area: Physical and Biogeochemical Context





O_2 West
O_2 East

I. Anti-estuarine overturning circulation
II. Deep water formation (e.g. Gulf of Lion, Rhodes gyre) and mesoscale intermittent convection events
III. Oligotrophic west–east gradient (Chla;Nutrients)
IV. DCM and nutricline West <100m; East >100m

I. O_2 West > O_2 East at surface
II. O_{2min} ~400 m West
O_{2min} ~600 m East

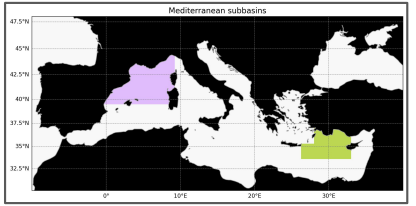
About Oxygen Datasets : Quality-controlled BGC-Argo data

Filter/exclusion QC:	**Profiles rejected if…** (details in Amadio et al., 2024 & OGS Audit)	**% of rejection**
O_2 Saturation for Adjusted Mode (surface)	$\lvert [O_2]_{Argo} - [O_2]_{satur} \rvert$ >10 mmol m^{-3} (See Garcia & Gordon, 1992)	12%
Climatology (at 600 m)	$\lvert [O_2]_{Argo} - [O_2]_{EMODnet} \rvert > \mathbf{min}(2\sigma_{EMODnet}, \mathbf{15\ mmol\ m^{-3}})$	6%
Shape correction QC:	**Profiles is corrected if…**	**% of corrected**
O_2 sensor drift (at 600 m)	O_2 trend for **each WMO*** is between ± (**2–10***) mmol m^{-3} yr^{-1}	20%

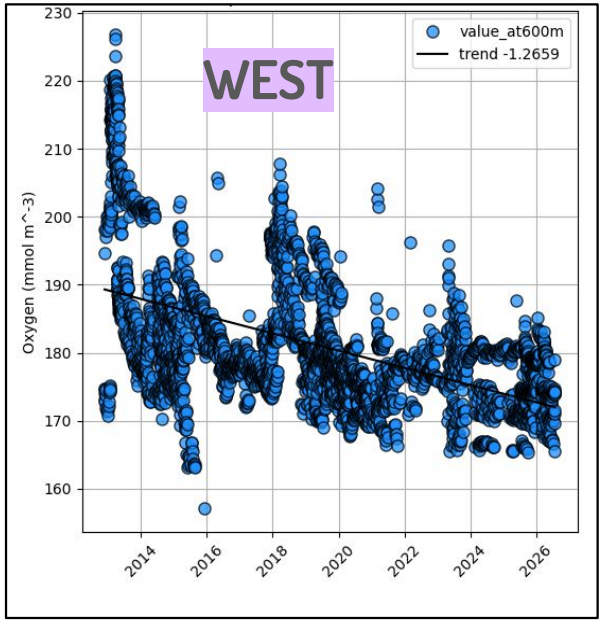
Tracing Deoxygenation Signals / Regime Shifts

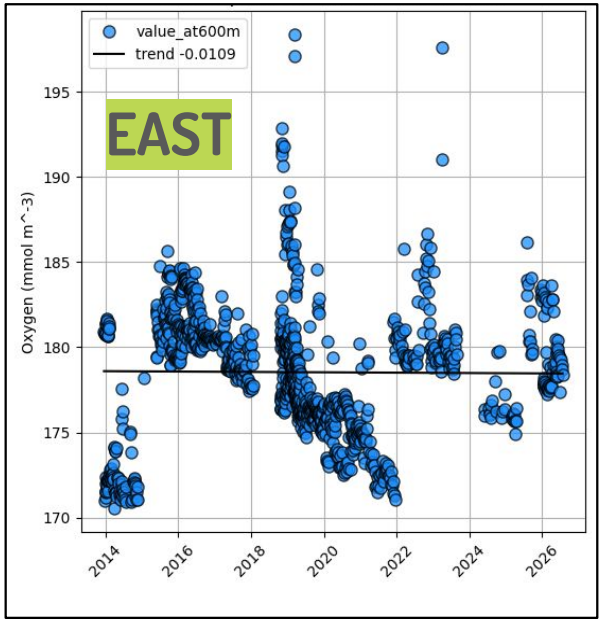
We analyzed deep water masses following:

1. an isobath criterion of 600 m.
2. an isopycnal criterion of ρ = 1031.35 ± 0.01 kg m^{-3} (see Table below column II)



Oxygen timeseries at 600m



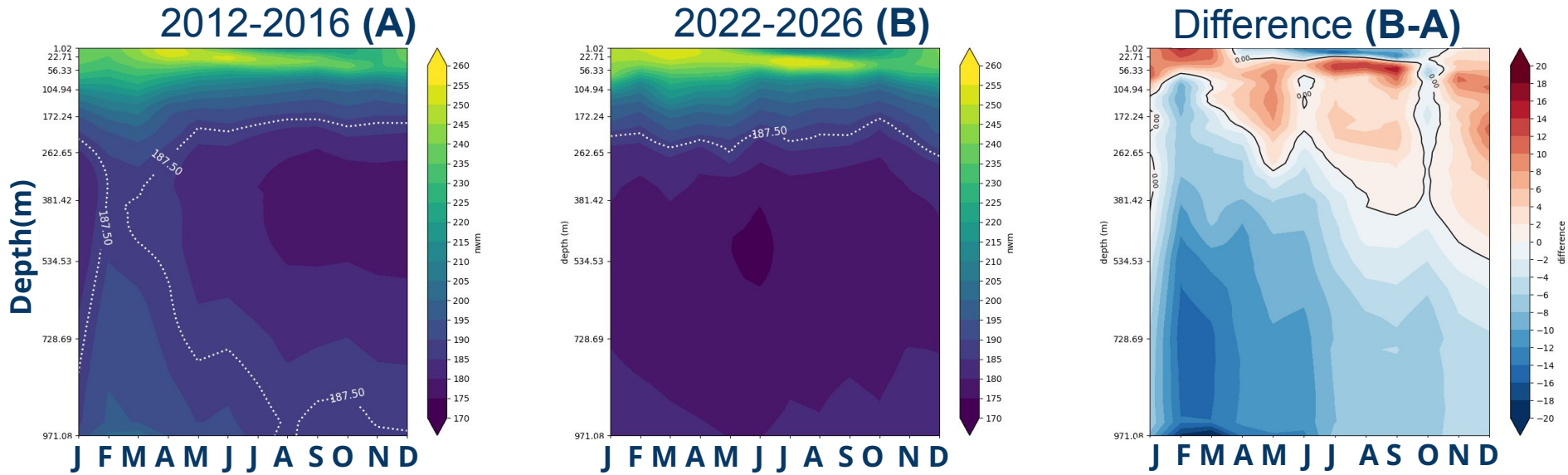


Yearly O_2 trend in **(mmol/m3/yr)**

isobath	isopycnal
-1.270*	-1.250*
-0.011	-0.002

*p<0.005

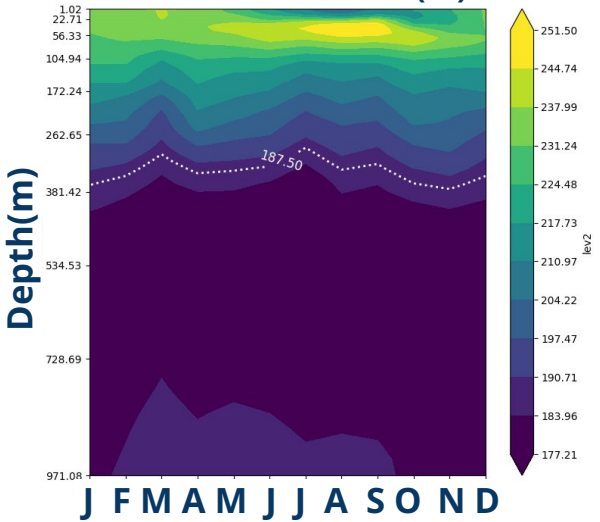
Oxygen Hovmöller Diagram – **West** Med. (Annual Climatology)



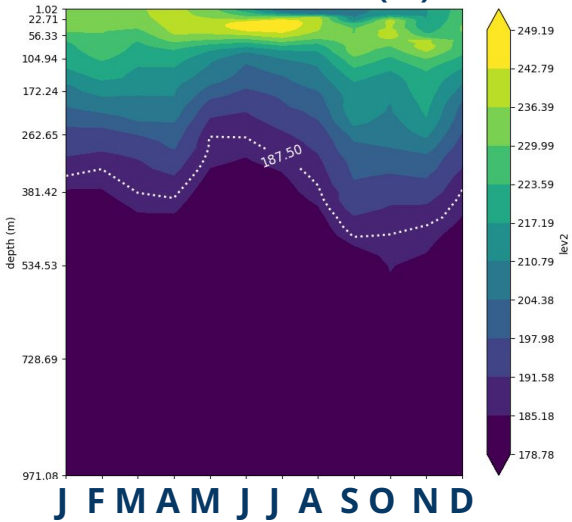
1. Surface: Summer O_2 loss. Potential increase of Net Community Production at subsurface
   Winter: O_2 gain (probably due to physics)
2. Depth: General decrease of O_2 < 600m
   Enlarged oxygen minimum zone (OMZ) *(Coppola et al., 2018)*
3. 187.5 mmol/m^3 = O_2 threshold for sustaining aquatic life; now always found at 263 m

Oxygen Hovmöller Diagram – East Med. (Annual Climatology)

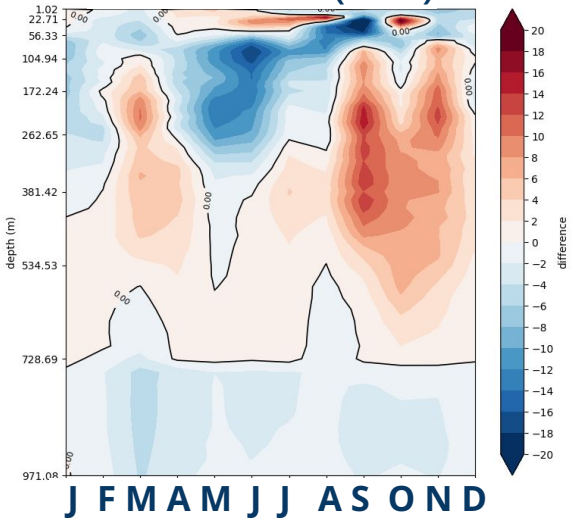
2012-2016 (A)



2022-2026 (B)



Difference (B-A)



1. Surface: O_2 gain during Spring-summer
2. Intermediate: O_2 increase in SOND
2. Depth: Stable O_2 at 600 m

Why are we interested in detecting long-term O_2 signals?

Within the Copernicus Marine Programme:

- **New Reanalysis planned in 2027 (1999-2020)**



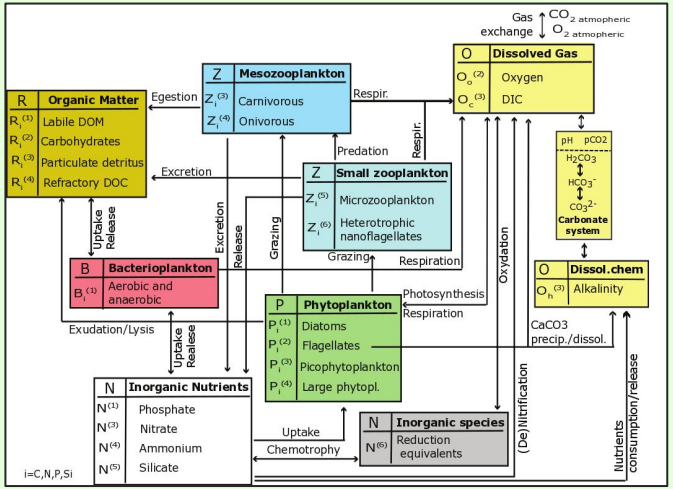
Copernicus
Europe's eyes on Earth

Copernicus
Marine Service

MedBFM model system

OGSTM: transport model
Resolution: 1/24°, 141 z levels

BFM: Biogeochemical Flux Model:
51 state variables



OASIM: ocean-atm spectral irradiance model

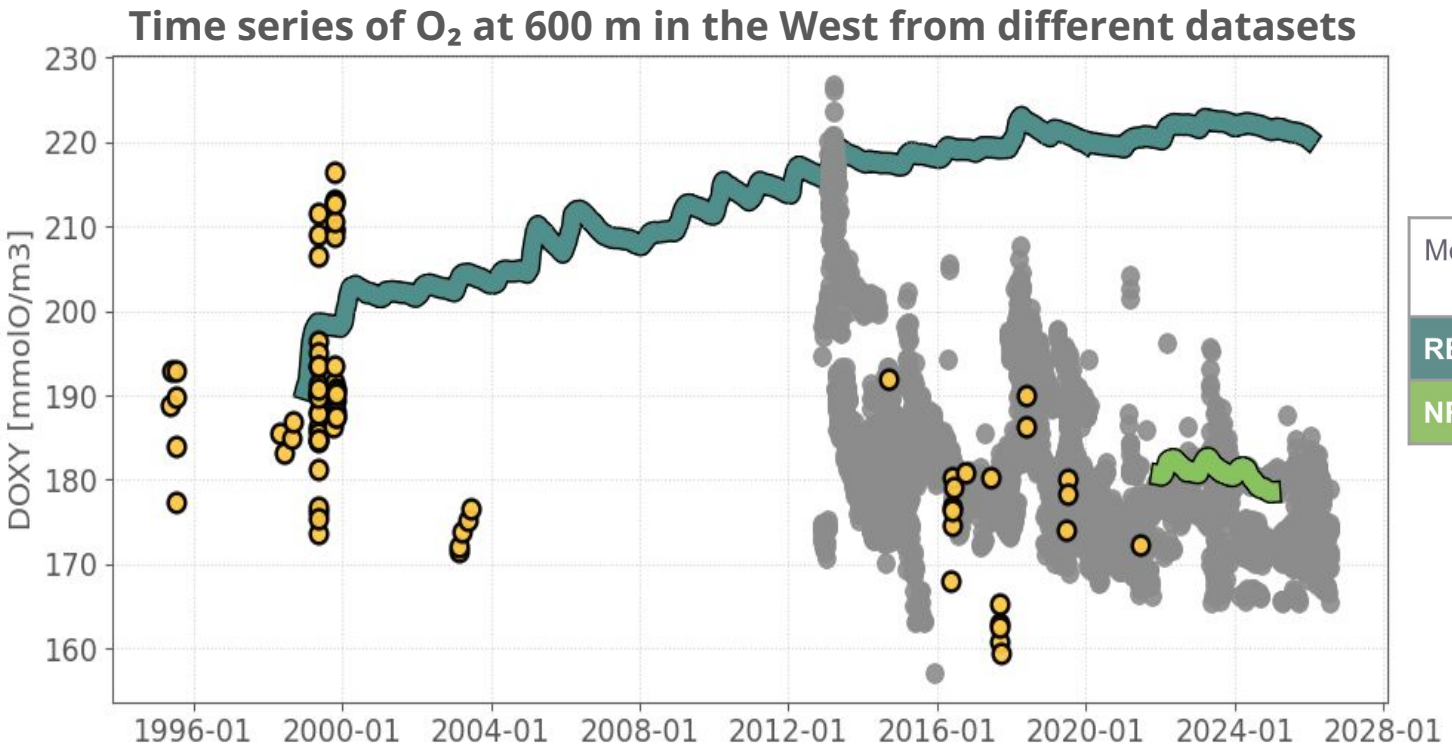
Chl NO_3 O_2

3DVar-Bio Assimilation:
- Ocean Colour (weekly)
- BGC Argo Chla, NO_3, O_2 (daily)

BGC-Argo data for:
1. Model Initialization
2. Data Assimilation
3. Model Validation
4. Assimilative dataset reconstr. of NN-derived Nitrate (from O_2;T;S)

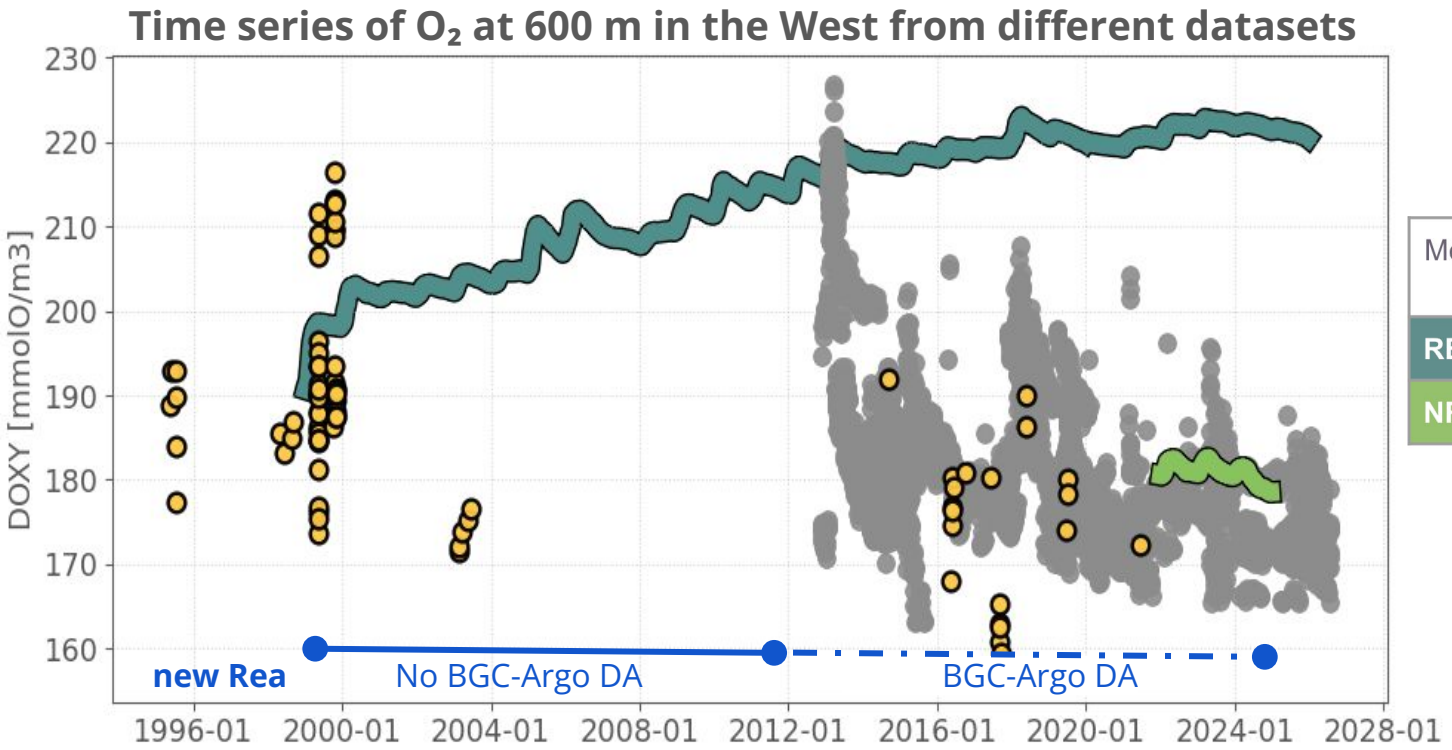
Details at: https://documentation.marine.copernicus.eu/QUID/CMEMS-MED-QUID-006-014.pdf

Current Status of Available O_2 Information



Model Run	DA O2	Obs & IC
REA (2020)	No	EMODNET
NRT (2026)	Yes	BGC-Argo

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What can we expect from the new reanalysis?
Could the introduction of O_2 data assimilation cause a discontinuity?

To recap:

- **BGC-Argo QC** provided a high-quality **dataset suitable** for operational oceanography
- BGC-Argo-based **time series/Hov.** show a **decline in oxygen** concentrations in the **West**
- BGC-Argo-based **time series/Hov.** show **stable oxygen** concentrations in the **East**

Our results are consistent with recent findings in the literature:

- **West:** Reduced deep ventilation / low oxygen at depth *(Coppola et al., 2018)*
- **East:** Net source of dissolved oxygen in the surface waters (*Habib et al., 2026)*
  Episodic ventilation events can replenish oxygen in intermediate and deep waters (*Habib et al., 2026)*

Grazie!



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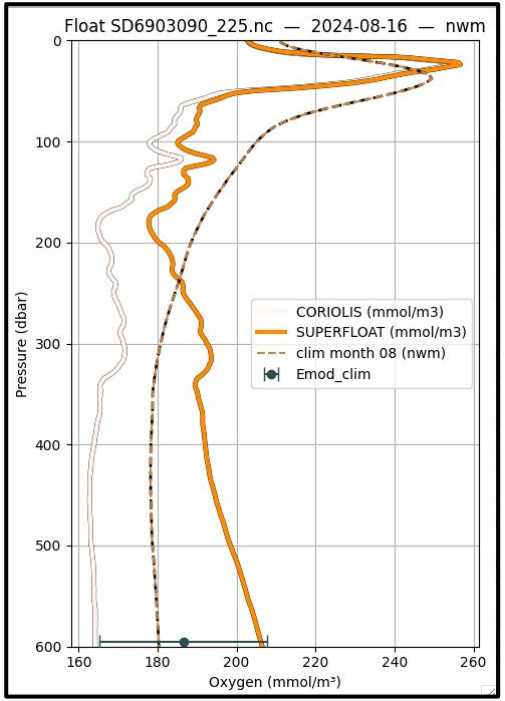
Contact: Carolina Amadio, camadio@ogs.it

Grazie per l'attenzione!

About Oxygen Datasets : Quality checked BGC-Argo

Correction-profiles shape QC: Profiles are corrected **if** DOXY sensor is potentially affected by a drift

O2 QC conditions:	In Amadio et al., 2024 & OGS Audit	This work
Length time series & data depths	> 1 year and 600–800 m	same
Two Statistical estimation	RANSAC (R) & Theil–Sen (TS)	same
Sign consistency	R_{600}, R_{800}, TS_{600}, TS_{800} must agree in sign	same
Drift calculation	For each profile	for each float
Drift threshold	mean(R_{600}, R_{800}, TS_{600}, TS_{800}) <1 mmol $m^{-3}yr^{-1}$	< **2** mmol m^{-3} yr^{-1}
Maximum correction	None	10 mmol m^{-3} to avoid strong correction see→



Oxygen Quality checks

Results

basin	N_PROFILES	DRIFT_CAL_PCT	MAE_DRIFT	ABS_MAX_DRIFT
WEST	5269	55.2	4.252356	9.032936
EAST	1226	9.8	2.598218	3.370505

