Use of BGC Argo data for the EU Copernicus Marine Service and Digital Twin Ocean

P.Y. Le Traon, Mercator Ocean International

Overview of Mercator Ocean International and Copernicus Marine Service

Mercator Ocean International

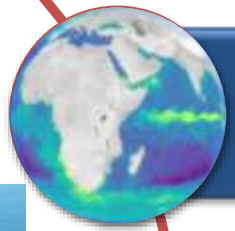
Multinational governance

Delegated entity of the European Union

Public interest mission

International partners network

A global ocean prediction center with 3 core missions:



DESCRIBES THE OCEAN ENVIRONMENT

- Global public service for **ocean data, information and knowledge**

PROVIDES OCEAN SERVICES & CAPACITIES

- Capacity sharing and cooperation through **a global ocean prediction network**

SUPPORTS OCEAN PROGRAMMES & POLICIES

- **Ocean intelligence** and policy-support services to States, EU, UN…

Copernicus Marine Service

EDITO Digital Twin Ocean

The EU Copernicus Marine Service

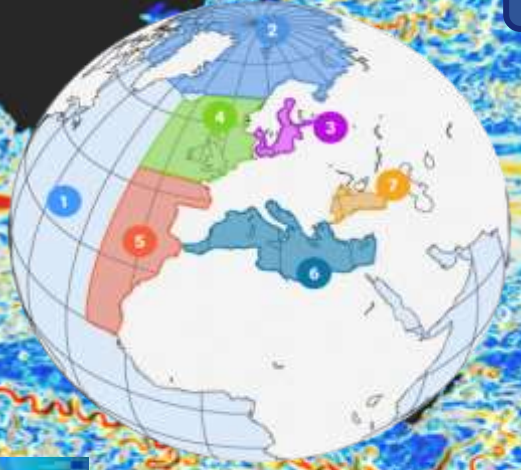
Global & Regional Ocean Monitoring and Forecasting

Copernicus Marine Service

MULTI-YEAR
10 to 45 years

REAL-TIME
Daily, hourly

FORECAST
2 to 10 days



ESSENTIAL OCEAN VARIABLES

BLUE OCEAN	WHITE OCEAN	GREEN OCEAN
Physics	Sea Ice	Biogeochemistry

OBSERVATIONS
In-situ & Satellites

NUMERICAL MODELS
& data assimilation

1 Global
2 Arctic
3 Baltic
4 NWS
5 IBI
6 Med Sea
7 Black Sea

marine.copernicus.eu

Free and Open

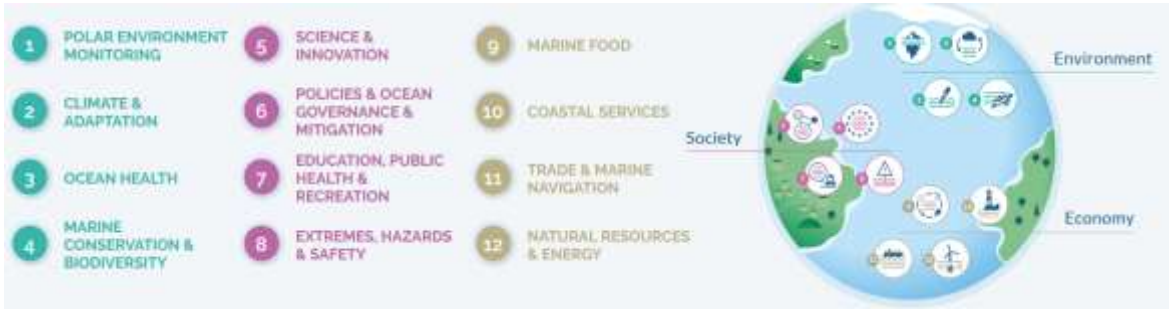
User Uptake

A wide range of applications (environment, society, economy)

Support to EU policies (Green Deal, Digital Strategy)

>120, 000 registered users

1,5 million single visitors / year on marine.copernicus.eu



https://marine.copernicus.eu/news/copernicus-marine-user-uptake-report-2024-kpi-highlights

The Copernicus Marine Green Ocean Offer and the use of BGC Argo data

Copernicus Marine Data Store : BGC 3D/4D products

Filters Clear ✓ Advanced

FREE-TEXT SEARCH
Free text

TIME RANGE
jj/mm/aaaa – jj/mm/aaaa
Covering full interval

WITH DEPTH

DEPTH RANGE

UNIVERSE
Ocean

MAIN VARIABLES
Carbonate system
Nekton
Nutrients
Optics
Organic carbon
Oxygen
Plankton
Sea surface height
Temperature
Velocity

ALL VARIABLES

AREA
Global Ocean
Arctic Ocean
Atlantic Iberia-Biscay-Ireland
Atlantic NW European Shelf
Atlantic North
Baltic Sea
Black Sea
Mediterranean Sea

FEATURE TYPE

TEMPORAL RESOLUTION
Hourly
Daily
Monthly
Yearly
Multi-yearly

SOURCE
Numerical models

Products 15 in **Copernicus Marine Service**

Global Ocean Biogeochemistry Analysis and Forecast

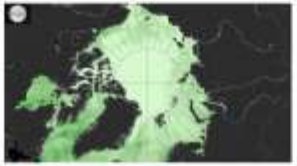
Models
Global, 0.25° × 0.25° × 50 levels
1 Oct 2021 to 5 Apr 2026, daily, monthly
Plankton, nutrients, oxygen, carbonate system, optics

Global Ocean Biogeochemistry Hindcast

Models
Global, 0.25° × 0.25° × 75 levels
1 Jan 1993 to 31 Jan 2026, daily, monthly
Plankton, nutrients, oxygen, carbonate system

Global ocean low and mid trophic levels biomass content hindcast

Models
Global, 0.083° × 0.083° × 1 levels
1 Jan 1993 to 31 Dec 2024, daily
Temperature, velocity, nekton, plankton, optics

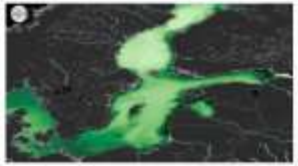


Arctic Ocean Biogeochemistry Analysis and Forecast

Models
Arctic, 6.25 × 6.25 km × 40 levels
1 Jan 2019 to 4 Apr 2026, daily, monthly
Plankton, organic carbon, nutrients, oxygen, carbonate system, optics

Arctic Ocean Biogeochemistry Reanalysis

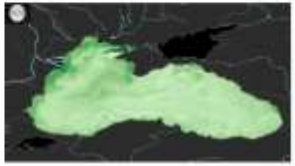
Models
Arctic, 25 × 25 km × 40 levels
1 Jan 2007 to 31 Dec 2022, daily, monthly, yearly



Baltic Sea Biogeochemistry Analysis and Forecast

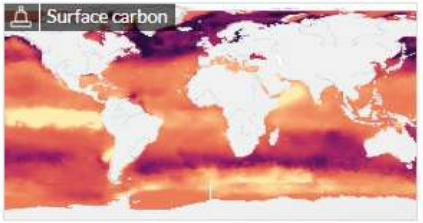
Models
Baltic, 2 × 2 km × 56 levels
1 Nov 2022 to 4 Apr 2026, daily, monthly

Baltic Sea Biogeochemistry



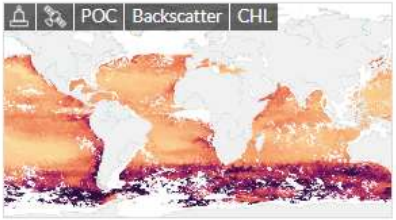
Black Sea Biogeochemistry Analysis

Black Sea Biogeochemistry



Surface ocean carbon fields

MULTIOBS_GLO_BIO_CARBON_SURFA... 015_008
In-situ
Global, 0.25° × 0.25°
1 Jan 1985 to 1 Jan 2026, monthly
Carbonate system



Global Ocean 3D Chlorophyll-a concentration, Particulate...

MULTIOBS_GLO_BIO_BGC_3D_REP_015_010
In-situ, satellite (L4)
Global, 0.25° × 0.25° × 36 levels
7 Jan 1998 to 27 Dec 2023, weekly, multi-yearly
Plankton, organic carbon, optics

https://data.marine.copernicus.eu/

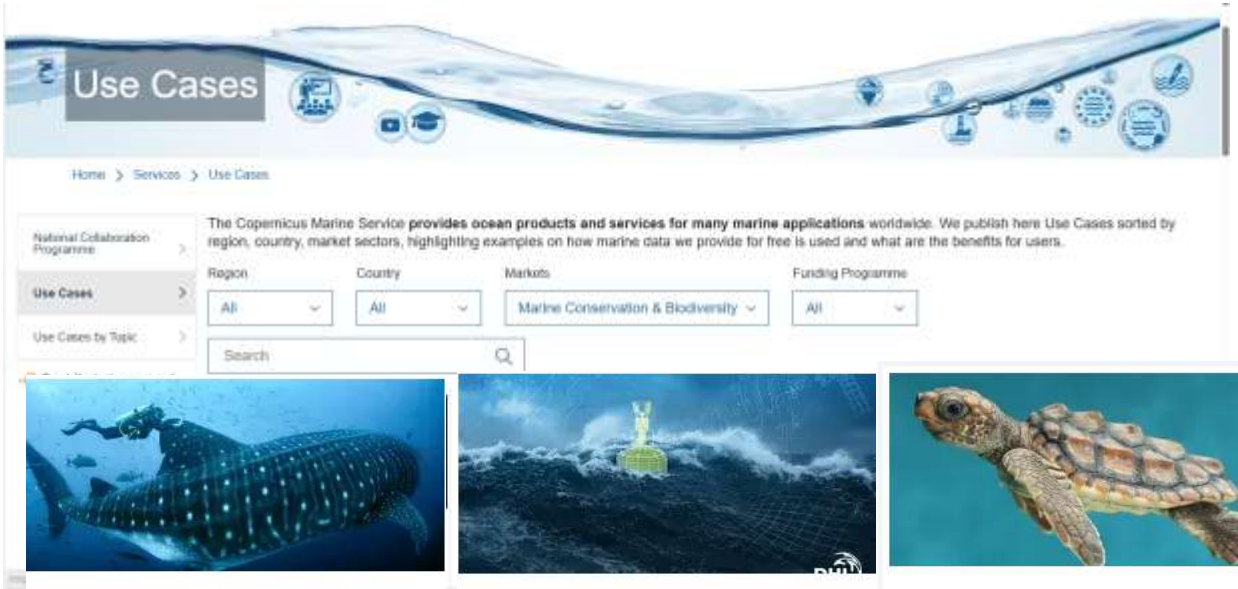
Copernicus Marine BGC products User Uptake

	Apr2024-Mar2025	Apr2025-Mar2026	
Users / IPs Total audience reach across all BGC products	Previous 12 months 97,067	Latest 12 months 170,573	YoY growth +75.7% +73,506 vs previous period
Registered users Total registered accounts engaging with BGC products	Previous 12 months 6,721	Latest 12 months 9,874	YoY growth +46.9% +3,153 vs previous period

Users / IP *: Anonymous - Pair IP address/Download method*
Registered Users *: Users who have submitted the registration form*

Users of Copernicus Marine Service BGC products

Environment policies (eg Marine Strategy Directive, Green Deal), Climate and Carbon, Ocean Health (eutrophication, acidification), Protection of endangered marine species, Fishery and Aquaculture management



Real-time assessment of MPAs with marine megafauna movements and bio-physical ocean variables

Oxygen depletion events in Danish seas

TURTLES: Effects of swimming behaviour and oceanography on sea turtle hatchling dispersal

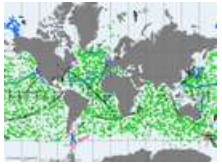
Supporting the JRC and EU with the Common Fisheries Policy (CFP)

Supporting Aquaculture and Fishing in the Adriatic Sea

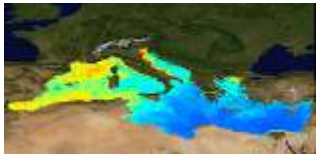
https://marine.copernicus.eu/services/use-cases/

Use of BGC Argo in the Copernicus Marine Service

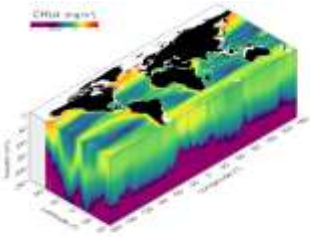
- ✓ The main source of in-situ observations for O2, Nitrate, Chl-a

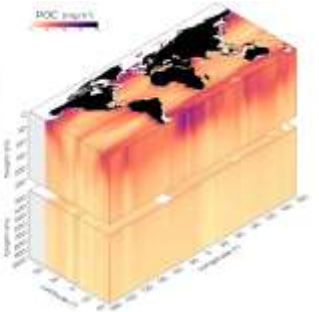


- ✓ Improvement and validation of satellite Chl-a products

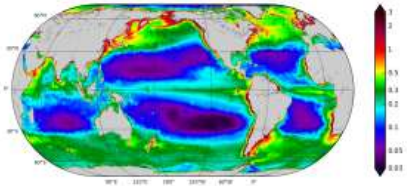


- ✓ High level ocean products derived from BGC Argo data (ML/NN)
  - Nutrient and carbon profiles derived T, S, O2 profiles
  - Global 4D fields of Chl a, bbp, PAR, and POC (SOCA)



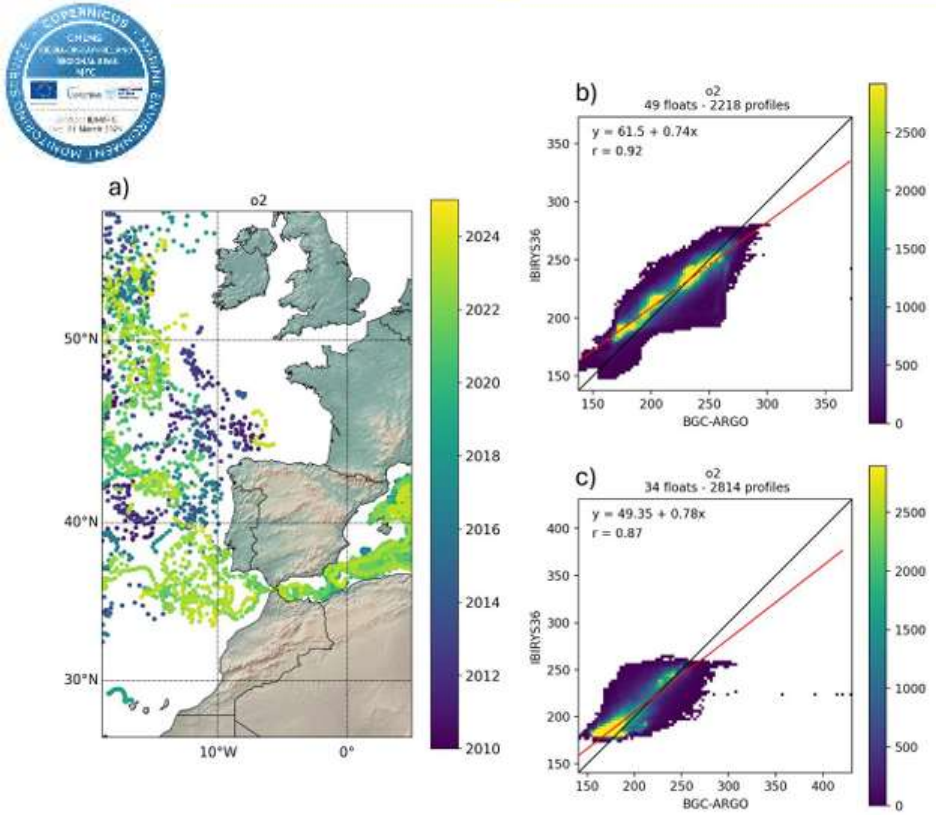


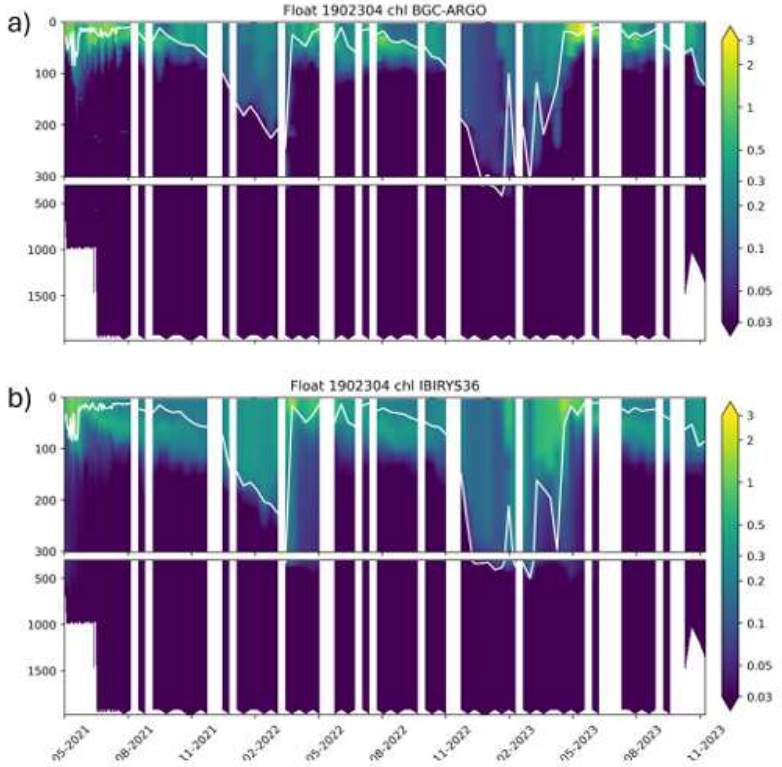
- ✓ Global and Regional Monitoring and Forecasting Centers
  - ✓ Validation
  - ✓ Model improvements
  - ✓ Data assimilation



Use of BGC Argo data to validate BGC models

QUID for IBI MFC Products IBI_MULTIYEAR_BGC_005_003	Ref: Date: Issue:	CMEMS-IBI-QUID-005-003 28 May 2025 5.0

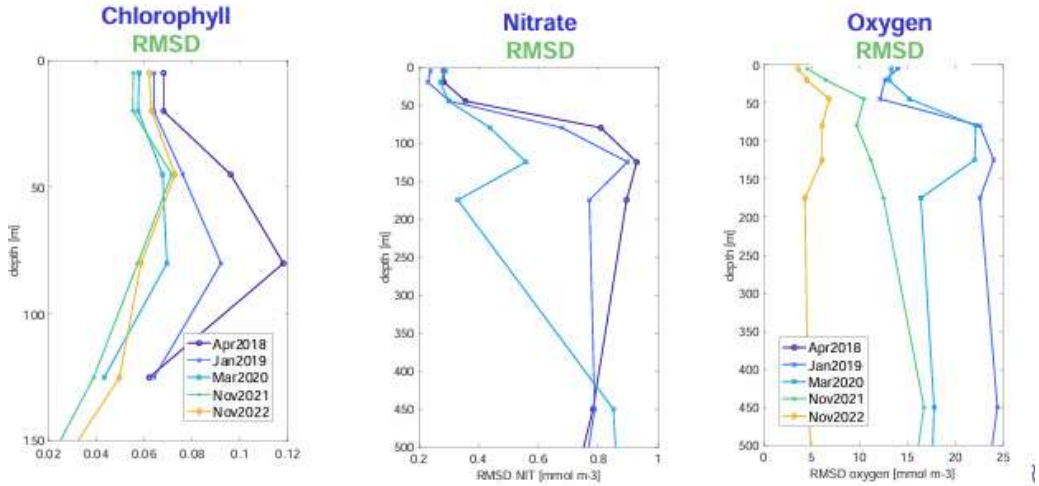




Use of BGC Argo data for assimilation

Mediterranean Monitoring and Forecasting Center (Cossarini et al., 2022)

OGSTM-BFM-3DVarBio assimilates OC since 2013 and BGC-Argo starting from 2020



BGC Argo assimilation impact:

⇒ improving vertical and seasonal dynamics of phytoplankton and oxygen in euphotic layer

⇒ correcting biases of nitrate and oxygen below nitracline and in deep layers

Teruzzi et al. 2021

Use of BGC Argo data to improve BGC models

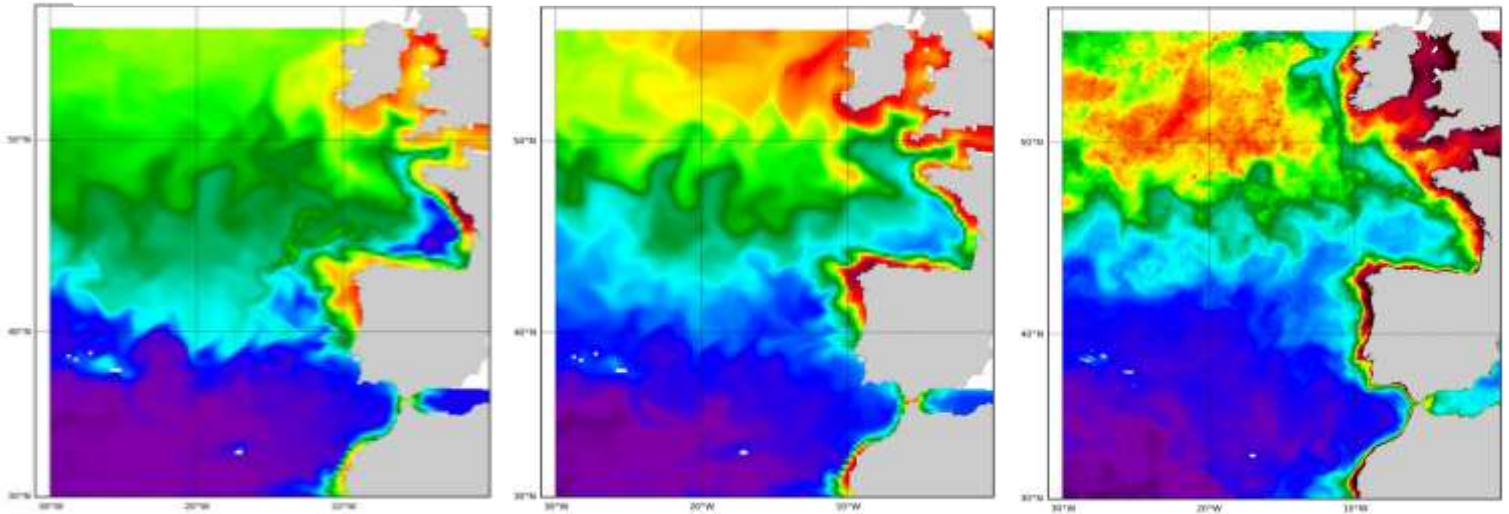
Optimization of the BioGeoChemical PISCES model parameters with Argo observations

Chlorophyll-a - September 2018

global model
initial parameters

global model with
Optimised parameters

Satellite Observations

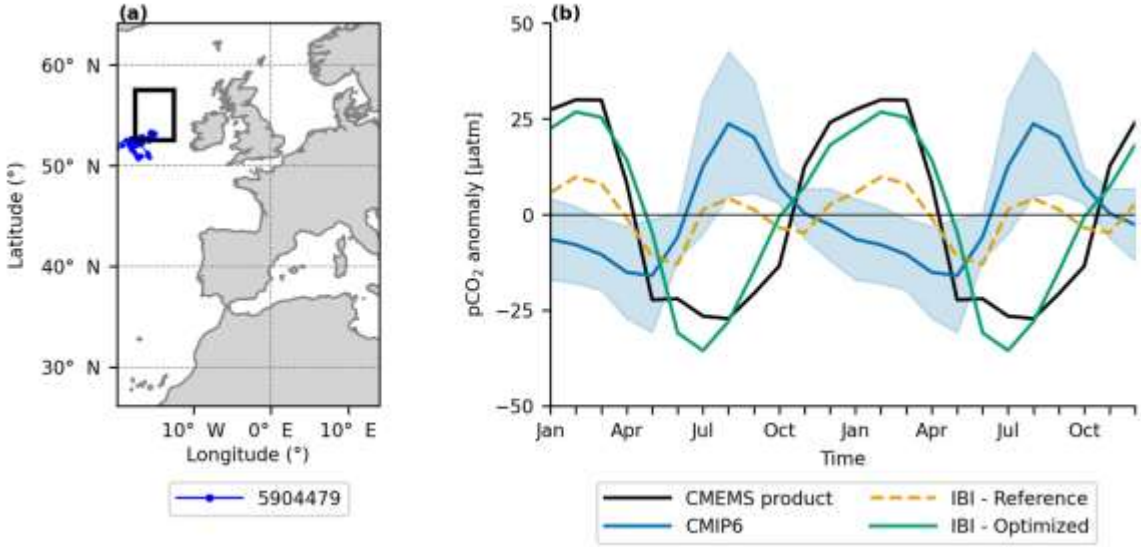


Improved representation of the North Atlantic bloom compared to satellite observations with the optimized model parameters:

- Better representation on the South-North Chlorophyll-a gradient
- Reduction of the normalized BIAS by 30 % and the RMSE by 10%.

Hyvernat et al. , 2026a

Use of BGC Argo to improve BGC models



PISCES biogeochemical parameter set optimized against BGC-Argo observations **corrects the seasonal pCO_2 bias in the subpolar North Atlantic** when applied to the Copernicus Marine IBI regional model at 1/36° resolution (Hyvernat et al., 2026b)

Copernicus Marine Service evolution and links with the EU Digital Twin Ocean

BLUE OCEAN
Currents, temperature, waves, sea level, ...

WHITE OCEAN
Ice coverage, velocity, concentration, Icebergs ...

GREEN OCEAN
CO2, nutrients, oxygen, primary production, ...

Copernicus Marine Service in COPERNICUS 2 (2021-2028):

Regular incremental improvements to the current Offer

+ a series of major evolutions

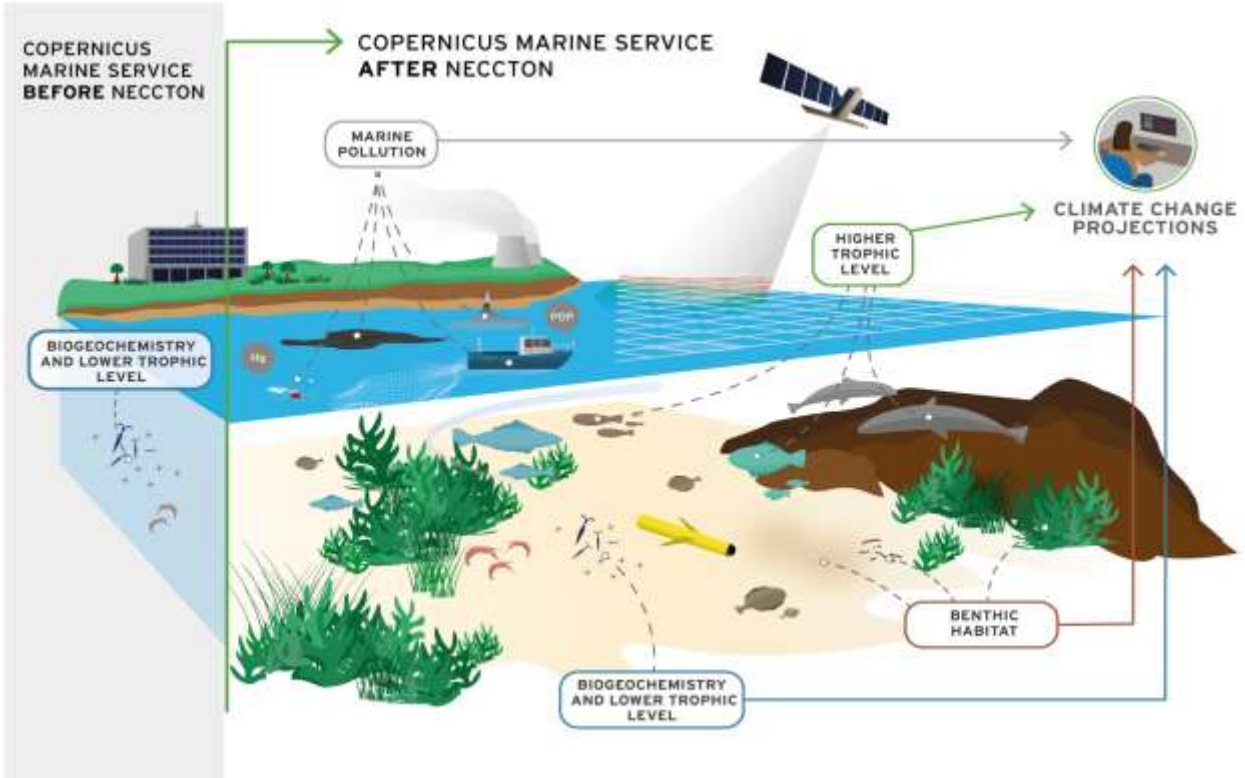
NECCTON: Preparing future Copernicus Marine Offer

Horizon Europe

NECCTON

NEW COPERNICUS CAPABILITY FOR TROPHIC OCEAN NETWORKS

Overall objective: Enable Copernicus Marine to deliver products that better inform marine biodiversity conservation and food resources management



Period: 2023-2026 (lead: MOi)

https://www.neccton.eu

New products, case studies and stakeholders engagement

NECCTON
NEW COPERNICUS CAPABILITY FOR TROPHIC OCEAN NETWORKS

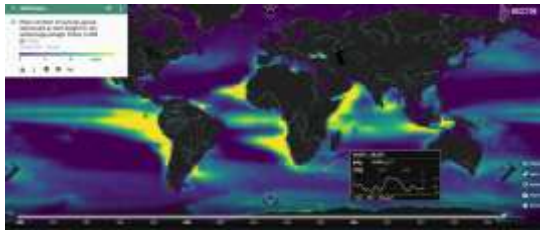
NECCTON outputs – 27 thematic variables

Biodiversity conservation

- Natura 2000 marine protected areas in the Adriatic Sea
- Biodiversity conservation in the North West Black Sea
- Climate-smart Marine Protected Area planning in the North West European Shelf
- Monitoring plankton diversity and dynamics in the Parc Naturel Marin d'Iroise (PNMI)
- Monitoring pollution of marine protected areas surrounding Svalbard
- Marine protected area monitoring and assessment in the Baltic Sea
- Monitoring marine mammals in the Azores region

Fisheries management

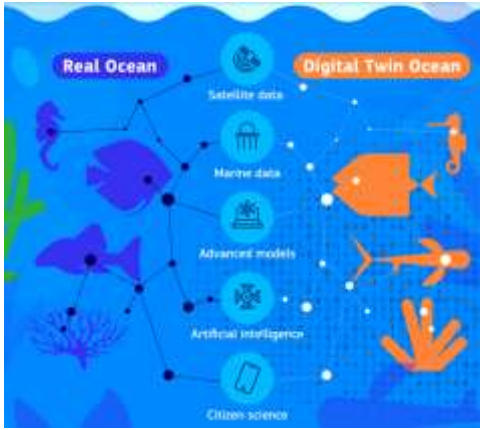
- Ensemble of species distribution models to determine hot spots of aggregation
- Mapping sources of pollutants transported towards Mediterranean aquaculture farm areas
- Small pelagic fish in the Bay of Biscay
- Modelling and projecting fisheries potential in the arctic Atlantic Ocean
- Spatial Management of Tuna Stocks and Fisheries under Climate Change
- Forecasting climate change impact on potential catches of open ocean large pelagic fish



https://data.neccton.eu

Evolution of digital services: the EU Digital Twin of the Ocean

EU DTO brings together Copernicus Marine and EMODnet. Acces to **data, models, artificial intelligence** and other tools, to allow the replication of the properties and behaviours of marine systems and their interaction



Use of **real-time and historical observation data** to represent the past and present, **initialize prediction models** and **improve models** to simulate future / what-if scenarios

Observations are the cornerstone of DTOs, serving key functions such as calibrating, optimizing (e.g., parameter estimation) and initializing models, training machine learning tools, or assessing and evaluating information provided by DTOs.

Summary

- The EU Copernicus Marine has been providing an operational monitoring of the global ocean and European seas for the last 10 years.
- Strong user uptake incl. for the green ocean offer.
- User driven, continusouly evolving to benefit from science and technology advances.
- The EU Digital Twin Ocean (DTO) now brings additional services (collaborative platform, scenarios, user interaction).
- Advancing Copernicus Marine / DTO green offer is a major objective for the years to come (e.g. BBNJ, MPAs, Carbon, mCDR).
- BGC Argo data play a major role (satellite and model validation, data assimilation, model improvements). Full implementation needed.