Copernicus Marine Service: achievements, future challenges and long-term evolution

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with contributions from MOi and CMEMS teams

EGU, May 8, 2020

Marine Monitoring

European Commission | Copernicus Europe's eyes on Earth

Implemented by MERCATOR OCEAN INTERNATIONAL

Marine Monitoring

Outline

- *Copernicus Marine Service : status*
- *The essential role of R&D activities*
- *The Copernicus Marine Service in Copernicus 2*
- *Conclusions*

The Copernicus Marine Service: status

Marine Monitoring

European Commission
Copernicus Europe's eyes on Earth
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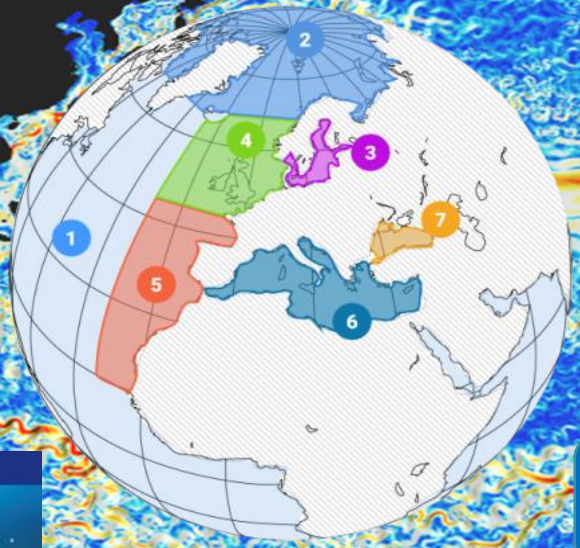
The Copernicus Marine Service
Monitoring and forecasting the ocean

MULTI-YEAR
10 to 45 years

REAL-TIME
Daily, hourly

FORECAST
2 to 10 days



ESSENTIAL MARINE VARIABLES

- **Blue** (Physics)
- **White** (Sea Ice)
- **Green** (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

Open and Free access

Copernicus Marine Service Ocean State Reports

Marine Monitoring

Scientific knowledge & expertise

+

Data Products

Von Schuckmann et al.

Ocean State Report

Summary for policy makers

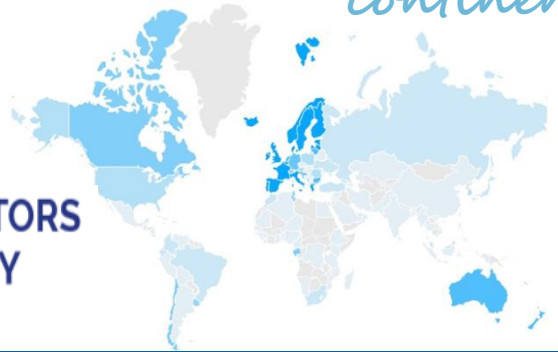
Ocean Monitoring Indicator framework

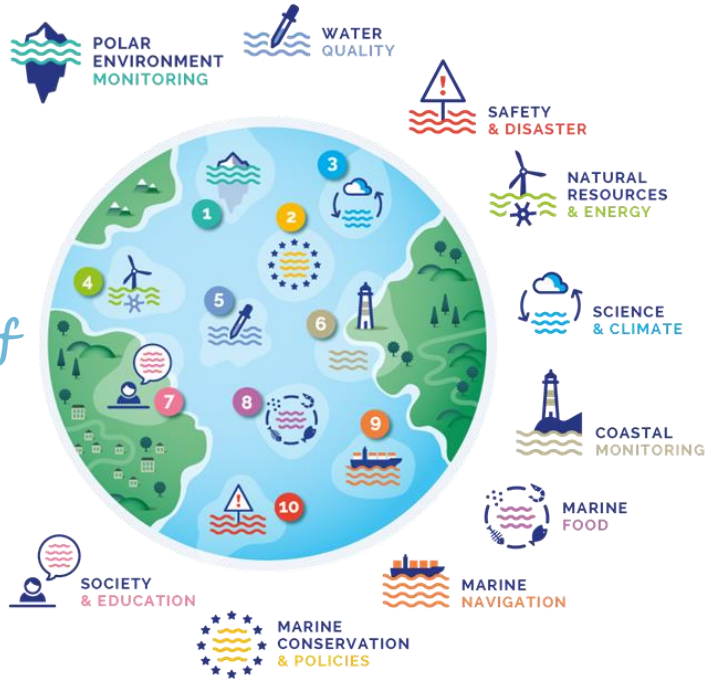
Marine Monitoring

From producers to markets and users

hundreds of producers co-operating in Europe

to feed thousands of users on all continents





WE SUPPORT ALL SECTORS OF THE BLUE ECONOMY

for a wide range of markets and to support environmental and climate policies

More than 22 000 subscribers

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The Copernicus Marine Service entering its 6th year of operations

Marine Monitoring

Today

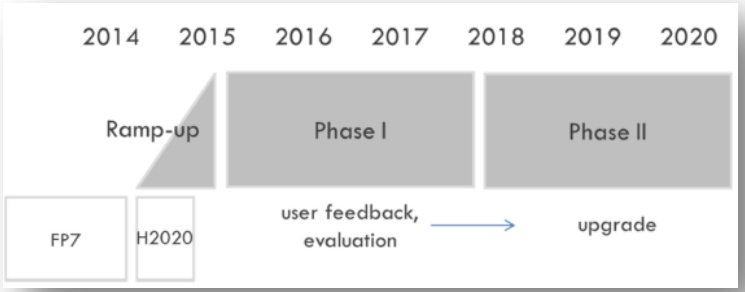
2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2028

CMEMS Implementation

1st year of operations | 2nd year of operations | 3rd year of operations | 4th year of operations | 5th year of operations

CMEMS operations

Phase 1 | Phase 2



CMEMS is doing very well. Very good KPI in service availability, product quality and user satisfaction, a constant growth in user uptake, and regular updates of the service offer.

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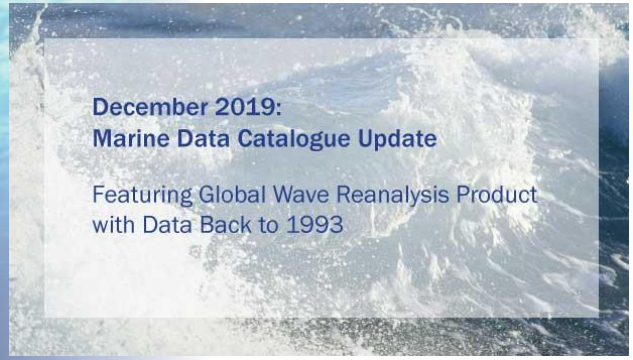
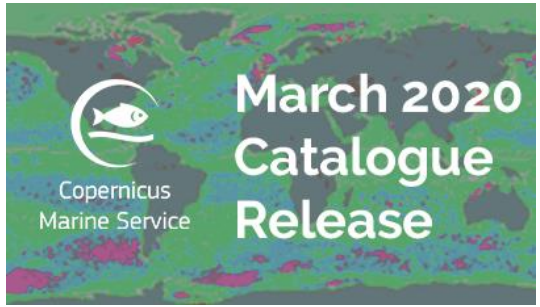
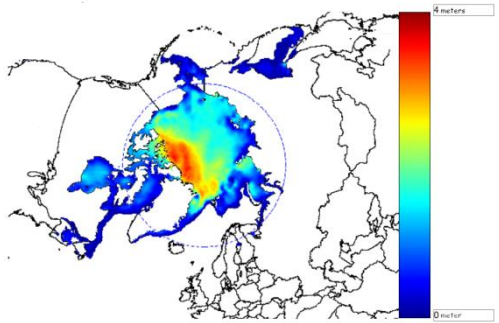
Regular improvements of CMEMS Blue/Green/White catalogue

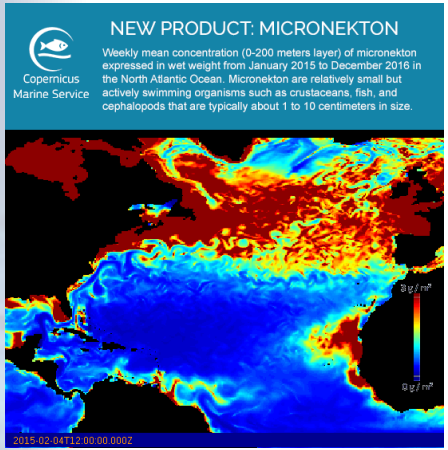
Marine Monitoring







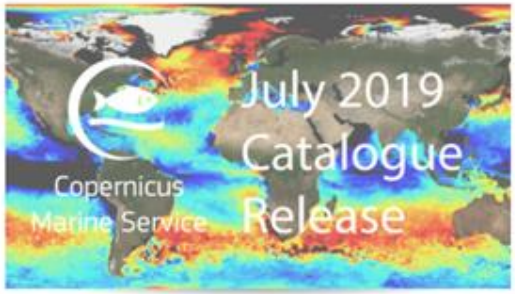
Real-time **sea ice thickness** product (CRYOSAT-2 and SMOS)



09/07/2019

JULY CATALOGUE RELEASE: IMPROVED MONITORING OF THE GREEN AND WHITE OCEAN

Our new July release of products and updates support the Blue Market segments such as Marine Food, Water Quality, Science & Climate, Polar Environment Monitoring, Safety & Disaster, and Marine Navigation and provide data and information to better monitor **the green (biogeochemical) and white ocean (sea ice)**. A focus is made on a new and much awaited global model-based **zooplankton and micronekton** product and a global **ocean biogeochemistry model** to forecast marine ecosystems.



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USER UPTAKE: UPWARD TREND FROM 2018 TO 2019

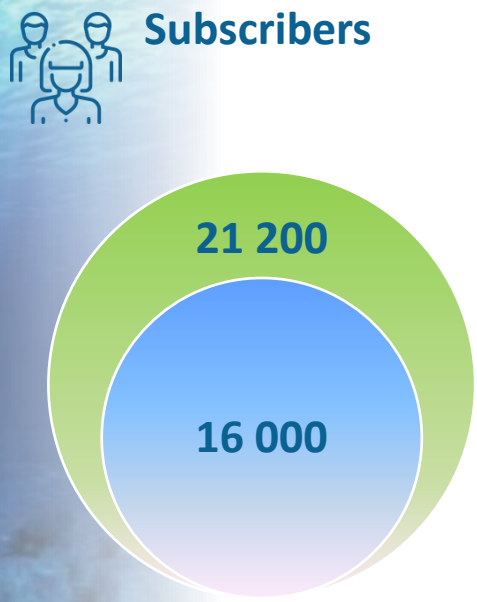
Marine Monitoring

> 22 000 Subscribers in 2020

USER SATISFACTION KPI 2019

4,7/5

Subscribers



+32%

Downloads

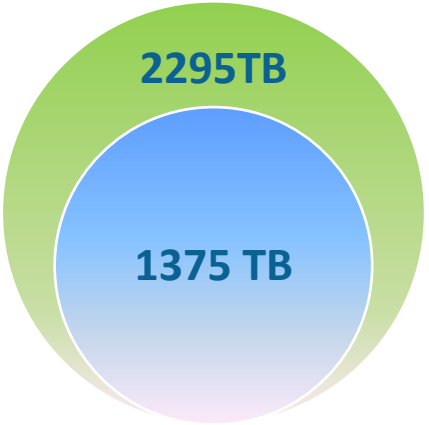
i.e. 1 Download = 1 user/dataset/day

+34%

2018 2019

Size downloaded

i.e. Size of files downloaded per year in TB



+67%

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Use cases : Environment/Society/Economy

MARKETS

Copernicus Marine Service supports all sectors of the blue economy

http://marine.copernicus.eu/markets/

1. SEA ICE MONITORING
2. MARINE CONSERVATION & POLICIES
3. SCIENCE & CLIMATE
4. NATURAL RESOURCES & ENERGY
5. WATER QUALITY
6. COASTAL MONITORING
7. SOCIETY & EDUCATION
8. MARINE FOOD
9. MARINE NAVIGATION
10. SAFETY & DISASTER

how Copernicus Marine service data is used:

Use cases page (200 use cases)

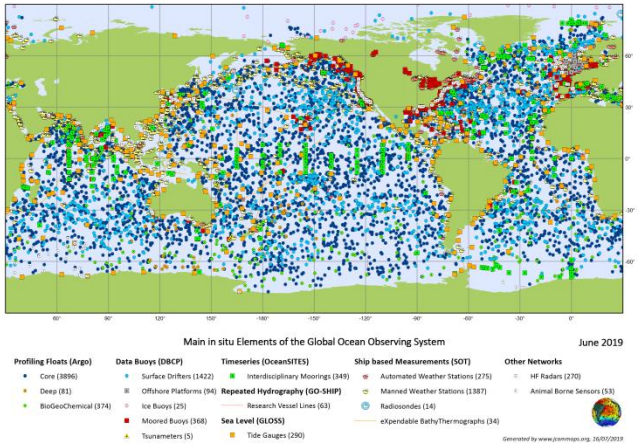
Use cases books

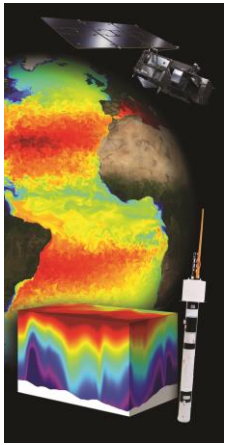
Use cases demo page

Marine Monitoring

The essential role of observing systems

The Copernicus Marine Service is highly dependent on the satellite and in-situ observing capabilities.





Role of Copernicus Marine Service wrt observing systems: requirements, design, impact assessment & advocacy

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Sentinels data integration in CMEMS

Marine Monitoring

S1A S2A S3A S1B S2B S3B S6

2015 2016 2017 2018 2019 2020 2021

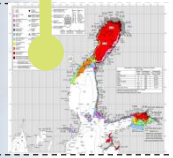
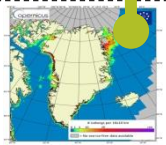
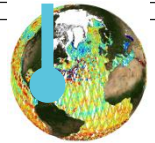
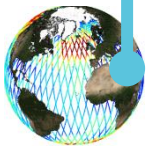
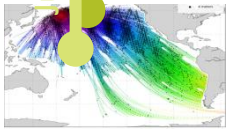
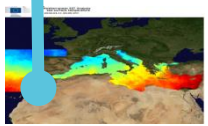
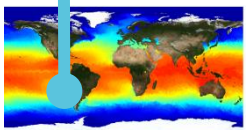
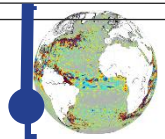
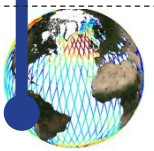
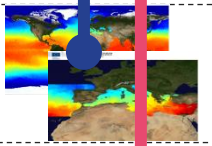
SEA LEVEL

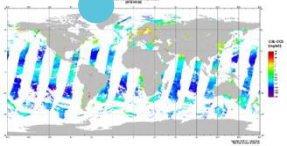
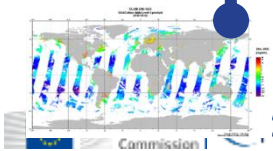
WAVE

SST

Sea Ice

Ocean Colour


Evolution of CMEMS product quality

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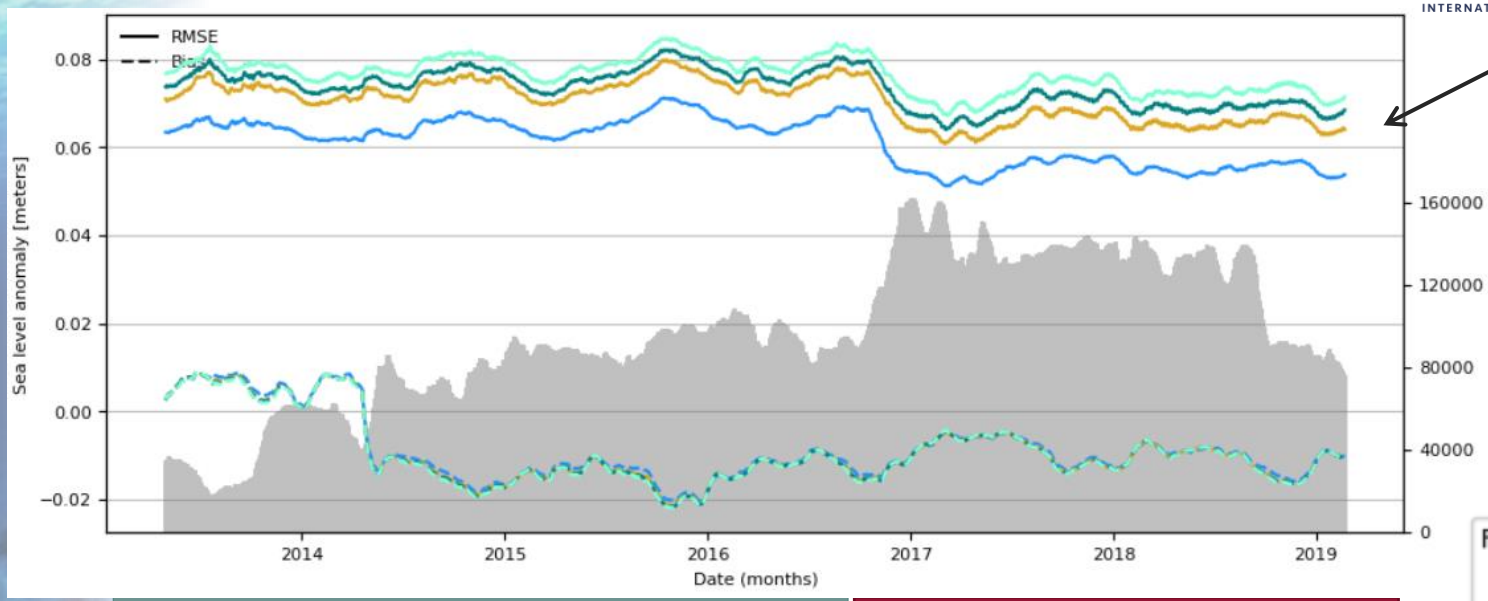
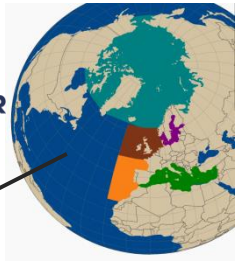
Global 1/12° MFC : RMS difference SLA **obs – analysis/forecast**

http://marine.copernicus.eu/services-portfolio/scientific-quality/

Impact of Sentinel 3 altimeter data assimilation





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Version 2013->2016
1/12° analyses and forecasts, assimilation of SLA, SST, T/S profiles, Sea Ice conc.

Version 2016->2019
+ Sentinel 3 and improvement of SLA assimilation

Y. Drillet, M. Drevillon et al.

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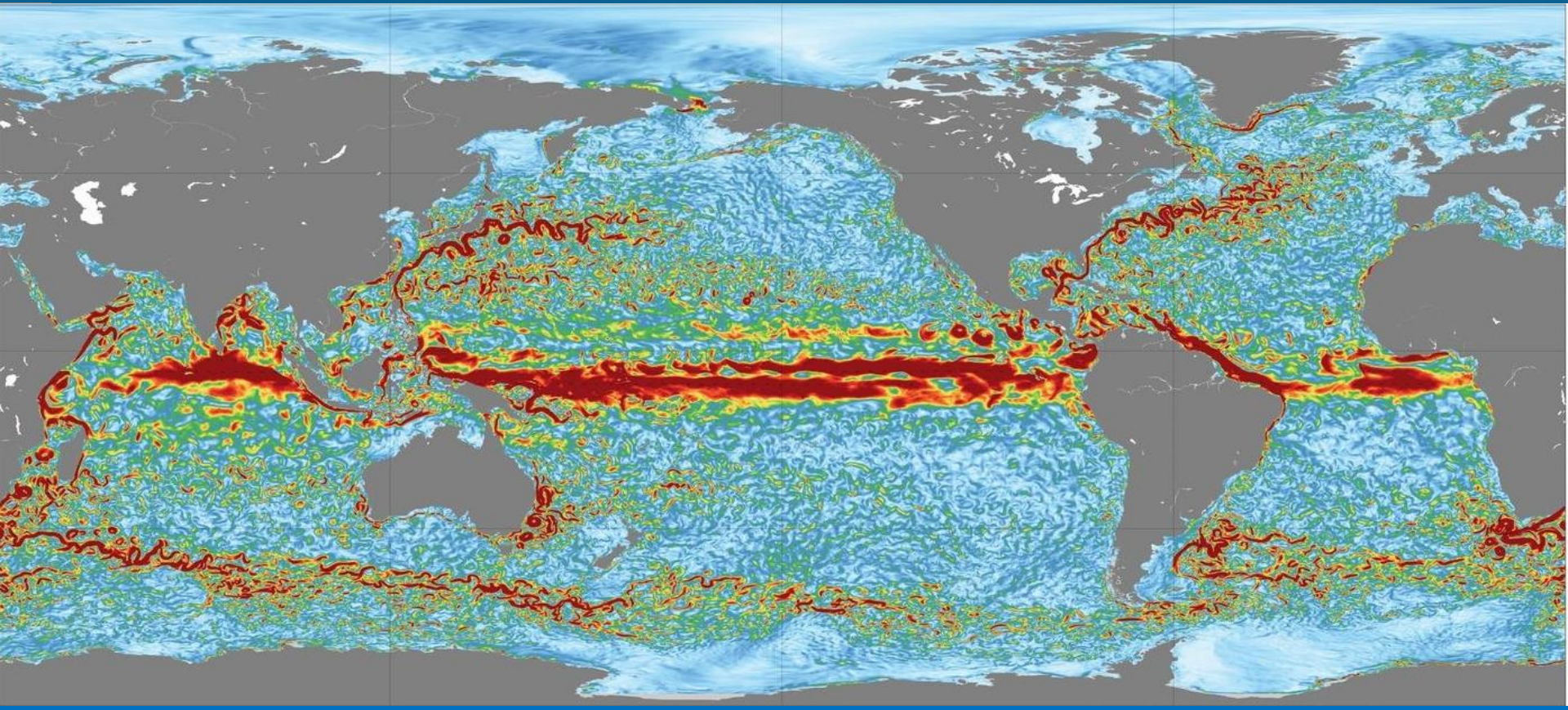
Existing capabilities : global high resolution ocean forecasts



Surface currents -7 day forecast - Mercator Ocean 1/12° system - May 10, 2020

Assimilated data sets : altimeters, satellite SSTs, in-situ (Argo, moorings, gliders, ships, marine mammals)

Serving users - **from physics …**

Global/Regional/Coastal – Fully operational

Large scale

Copernicus Marine service

Ocean & wave forecasts

Observations (satellite, in-situ)

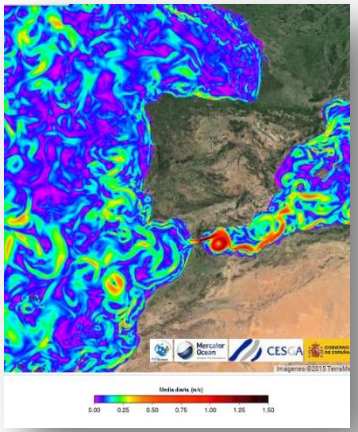
Coastal and port scale

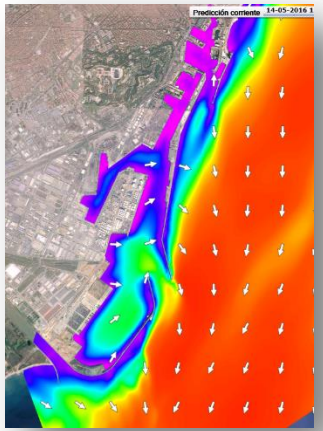
Puertos del Estados

Coastal models, observations

Ports

Infrastructures, Piloting, environmental issues, etc..





Puertos del Estado

GOBIERNO DE ESPAÑA MINISTERIO DE FOMENTO

E. Alvarez et al.

Serving users - from physics to biogeochemistry …

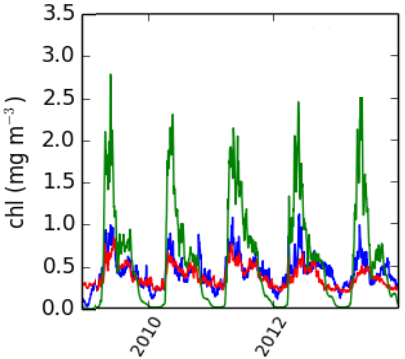
Satellite chlorophyll assimilation in the European NW Shelf system (reanalysis)

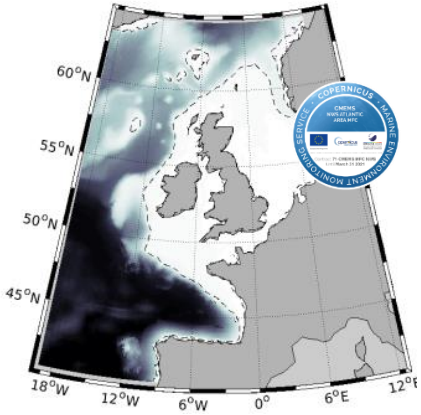
Time series of domain-average daily chlorophyll

without chl DA

with chl DA

satellite

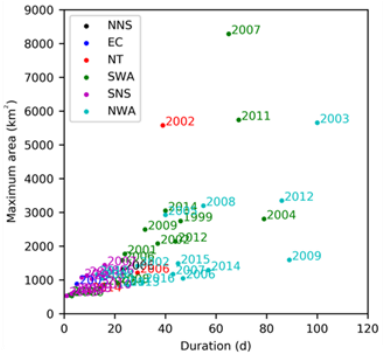




…enabling new societally-relevant products

Duration (x-axis) and extent (y-axis) of low bottom oxygen conditions for different years, regions.

Clark et al.

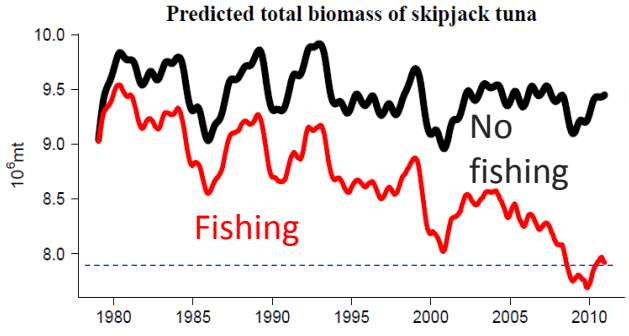


Met Office

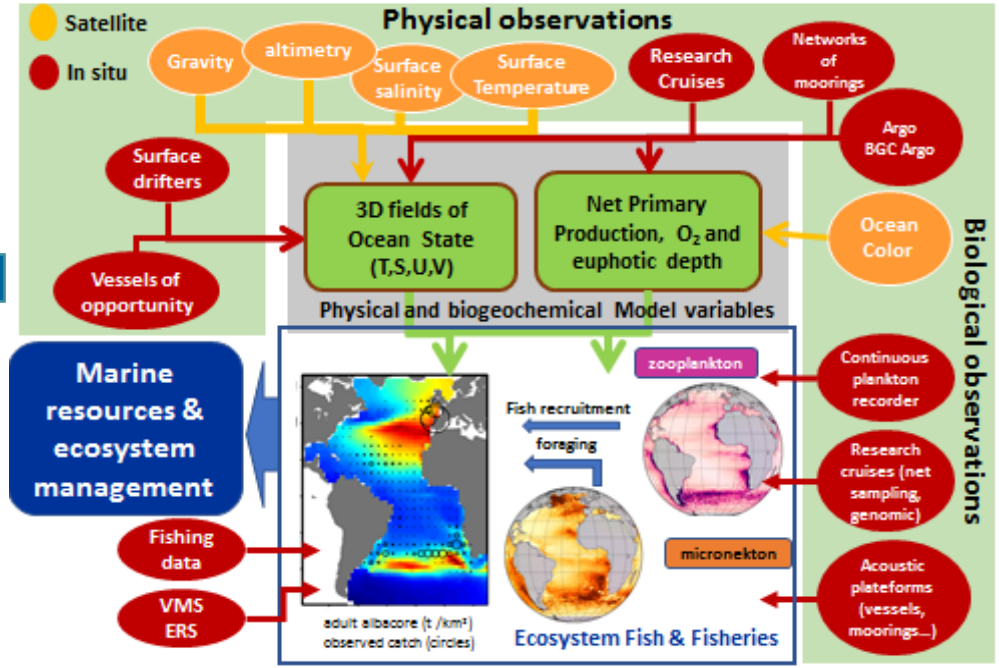
PML Plymouth Marine Laboratory

Serving users - from physics to biogeochemistry **and biology**

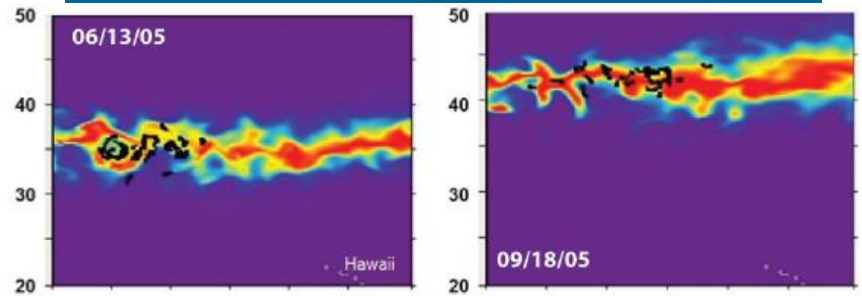
Fishery management



Monitoring and forecasting up to high trophic levels



Marine ecology: marine habitats (e.g. turtles, cetaceans) and marine biodiversity protection



Loggerhead turtle predicted habitat index (color scale) overlaid with portions of tracks (Abecassis et al., 2013)

Lehodey et al (2010, 2015)

The Copernicus Marine Service: the essential role of R&D activities

Marine Monitoring

European Commission

Copernicus
Europe's eyes on Earth

Implemented by

MERCATOR OCEAN INTERNATIONAL

Copernicus Marine Service Evolution – Principles

Users are explicitly and transparently involved:

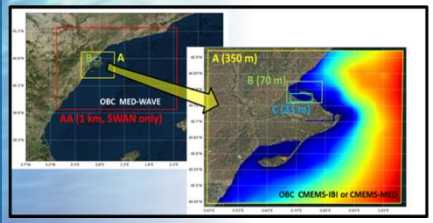
- Users needs drive service evolution,
- User feedbacks and needs are regularly monitored and collected,
- Work to translate user requirements into achievable service evolution objectives.

- **Scientific** (satellite and in-situ observations, modelling, data assimilation, AI) **and technological** (e.g. computing capabilities, information systems & big data) **advances** relevant for the CMEMS are fully taken into account.
- Need to maintain **competitiveness** wrt international actors.
- **Innovation capacity** required to attract new users.
- **Delineation with downstream activities**:
  - The core service focuses on activities best performed at pan-European scale.

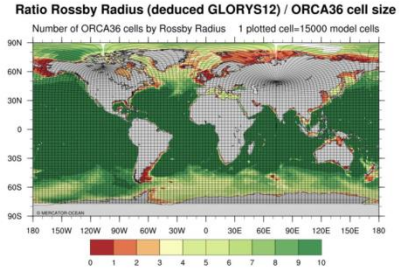
User Pull and Science & Technology Push

Themes of innovation and research (R&D needs) to respond to evolving user needs

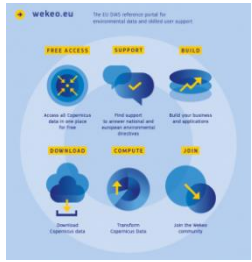
Marine Monitoring



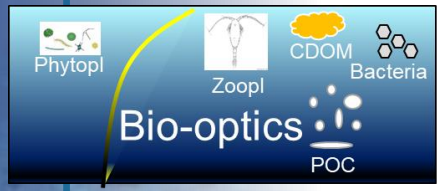
Coastal ocean
Coupling with open ocean & hydrology

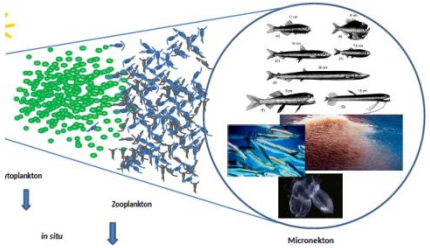


New generation of ocean models,
HPC infrastructure



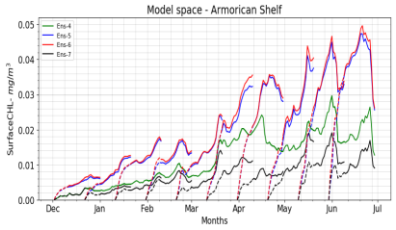
Cloud, Big Data
and AI





Improved BGC modelling & assimilation capabilities,
high trophic levels

Ocean/Wave/Atmosphere
interactions & coupling



Data assimilation
Impact of observations

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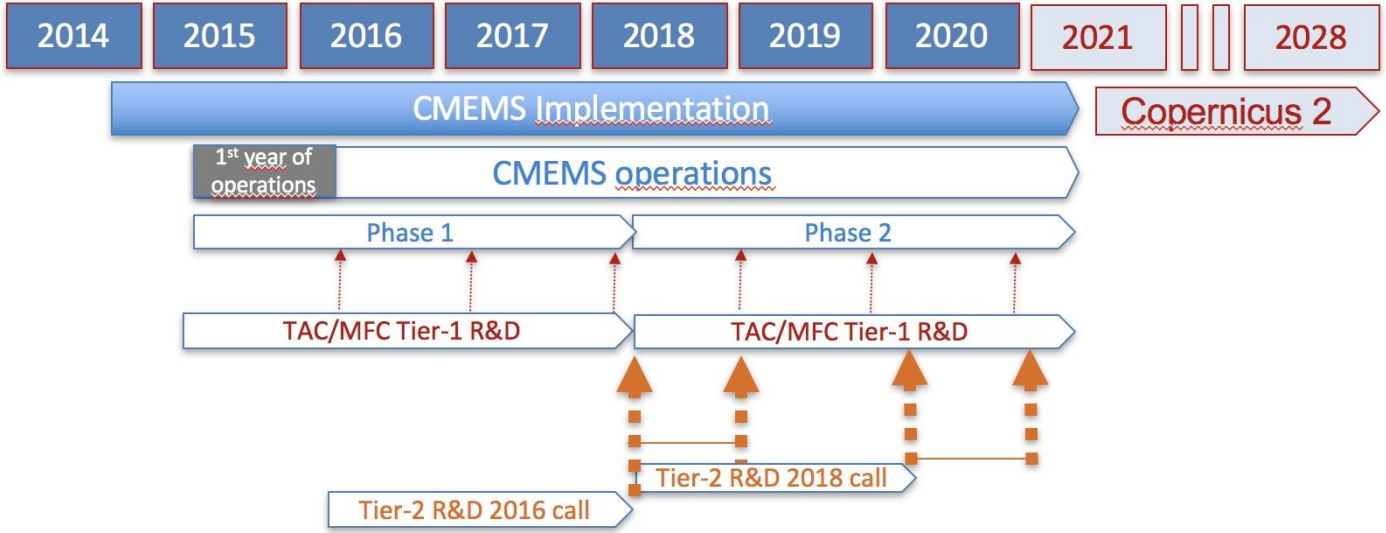
CMEMS Service Evolution - Roadmap



Tier 1 R&D (1 year) managed by CMEMS as part of the Production Centers activities (TACs and MFCs)

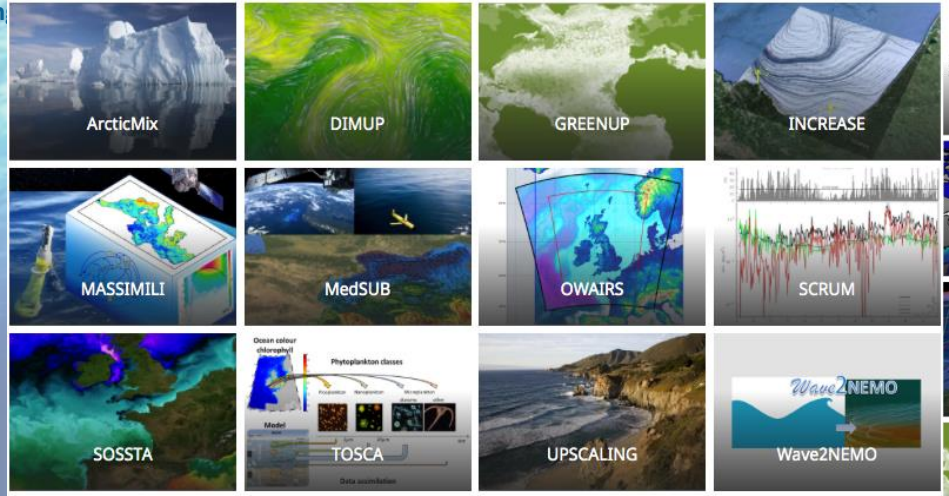
Tier 2 R&D (1-2 years) – managed by CMEMS through call for Tenders "Studies shall lead to significant results in less than 2 years and have the potential of improving the operational service in < 3 yrs"

Tier 3 R&D (3 years and +) - not managed by CMEMS but CMEMS provides guidance

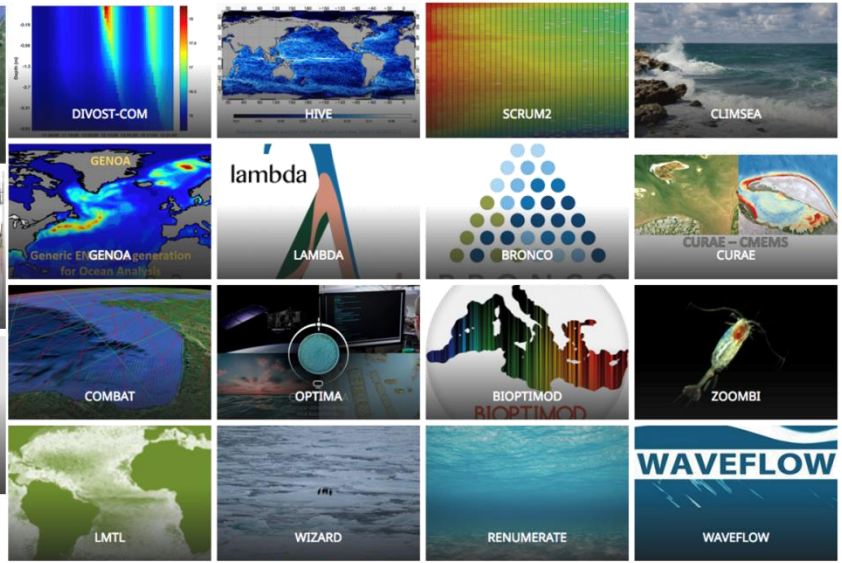
CMEMS Service Evolution R&D projects

Marine Monitorin

First call (2016-2018) – 12 projects



Second call (2018-2020) – 18 projects



Keywords: biology, high res., coupling, ensemble, ocean & climate, waves, sea ice, coastal, rivers

A. Melet

Together with H2020 projects (e.g. Ceaseless, IMMERSE), SE R&D projects pave the way for the development of future versions of the Copernicus Marine Service

http://www.mercator-ocean.fr/mercator-ocean/copernicus/service-evolution/

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immerse
IMPROVING OCEAN MODELS FOR THE COPERNICUS PROGRAMME

European Commission

IMMERSE project demonstrators

Demonstrating impact on CMEMS systems

IMMERSE : objectives and structure

Specific project objectives

1. Develop a new, efficient, stable and scalable NEMO reference code with improved performances adapted to exploit future HPC technologies in the context of CMEMS systems
2. Develop NEMO for the challenges of delivering ocean state estimates and forecasts describing ocean dynamics and biogeochemistry at kilometric scale with improved accuracy
3. Prepare the exploitation of the next generation of high resolution observing networks within CMEMS systems and in detailed, downstream modelling systems.
4. Develop a flexible and generic software tools series for interfacing CMEMS observation and model-based products and detailed, downstream modelling systems
5. Provide proven model code and software tools with assessments suitable for rapid deployment in CMEMS

Next generation numerical kernel for NEMO — **WP3**

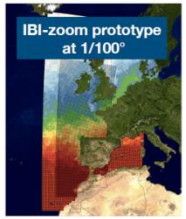
Preparing CMEMS to future HPC infrastructures — **WP4**

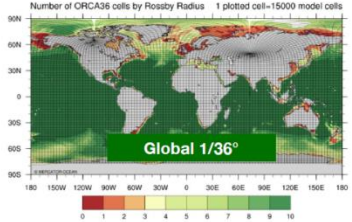
Modelling key processes at kilometric scales — **WP5**

Integrating model-based products and observations — **WP6**

Demonstrating impact on CMEMS systems — **WP7**

Assessing impact on downstream systems — **WP8**





H2020 EU project

https://immerse-ocean.eu

Project coordinator: J. Le Sommer

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Copernicus Marine Service Plans for Copernicus 2 *(under discussion)*

Arctic / Coastal / Biology / Climate / Digital

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Main drivers guiding CMEMS long term evolutions

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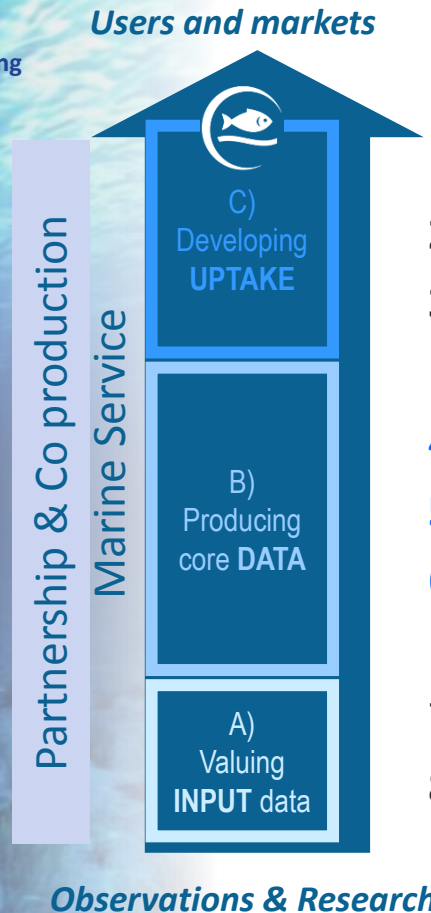

1. The Ocean higher than ever on the **political agenda**
2. **Markets** responding well to our sectoral approach
3. **Coastal, Arctic, Marine Biology & Climate** calling for more

4. Users calling for a consistent **BLUE / WHITE / GREEN** ocean
5. **Better** accuracy, **higher** resolution, **longer** reanalysis period
6. Integration of WEkEO/**Cloud based** digital approaches

7. New space observations (Sentinel evolution, polar missions)
8. New in situ int. observation effort (BioGeoChemical Argo, …)

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Strategy of service

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Consolidate the positioning of Copernicus Marine Service as a world-leading reference source of information in the marine domain

Maintaining the excellence of a cutting-edge service capacity, reinforcing a pan-European network of highly-skilled providers of data and information:

- ⇒ **Focus on service uptake and sustained engagement of users, and intensify training activities**
- ⇒ **Re-enforce the «marine identity» to reach downstream service operators (Private/Public) beyond the known community,**
- ⇒ **High space/time resolution integrated blue-green-white ocean monitoring and forecasting system (real time, reanalyses)**
- ⇒ **Offer state-of-the-art cloud-based services to marine users**
- ⇒ **Enhance operational interfaces with other Copernicus Services (e.g. climate, land, emergency, CO2) and EMODnet to foster cross-fertilization**

SEA ICE MONITORING
MARINE FOOD
WATER QUALITY
NATURAL RESOURCES & ENERGY
COASTAL MONITORING
SAFETY & DISASTER
MARINE NAVIGATION
SCIENCE & CLIMATE
SOCIETY & EDUCATION
MARINE CONSERVATION & POLICIES

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Post 2021 Service Evolution priorities: needs and responses

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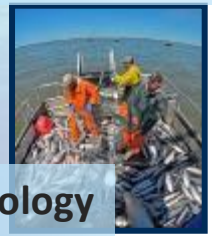

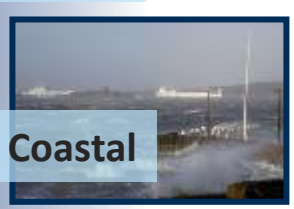

- **Marine Safety and maritime transport** : global high resolution, ocean and sea ice, increased product accuracy, increased operational data access and user support. Uptake of future Sentinel missions.
- **Marine Resources**: reach for biology the level of excellence CMEMS has now for "Marine Physics" : better support fisheries management, development of sustainable aquaculture and living resources protection. Harmful Algae Blooms. Higher trophic levels in CMEMS BGC models.
- **Marine & coastal environment**: Coastal Zone Monitoring (satellite) and Coastal Zone Forecasting (co-design & co-production between MS services and a re-enforced EU Marine Service) incl. coupling with land (rivers).
- **Climate :** Transform the high level CMEMS expertise on the ocean into a strong assessment capacity on the ocean climate and CO2 ocean uptake, develop new capabilities for long term projection & scenarios for the evolution of the coastal ocean and marine ecosystems.

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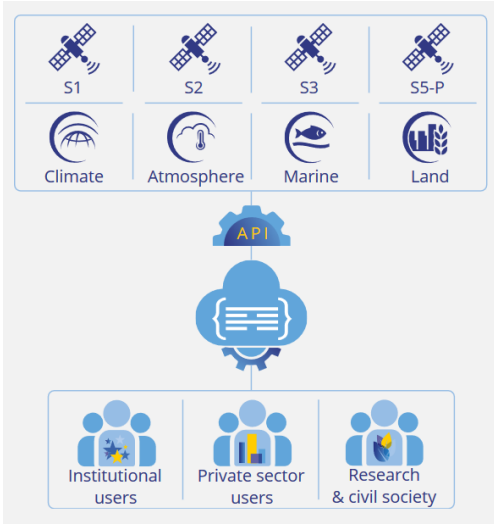
Integration with WEkEO cloud services

- CMEMS is managed to be fully compliant with the DIAS service layer.
- CMEMS transitioned in 2018 to a cloud technology for a better efficiency, scalability and flexibility of the system.
- MOI/EUMETSAT/ECMWF operate jointly WEkEO, a Copernicus data and services access platform, that offers cloud based services to process the data.

⇒ Perspective : Take benefit of WEkEO to extend the product & service portfolio for Marine Users (access to all Level 1&2 Sentinel data, other marine products eg Emodnet, on line processing capabilities).

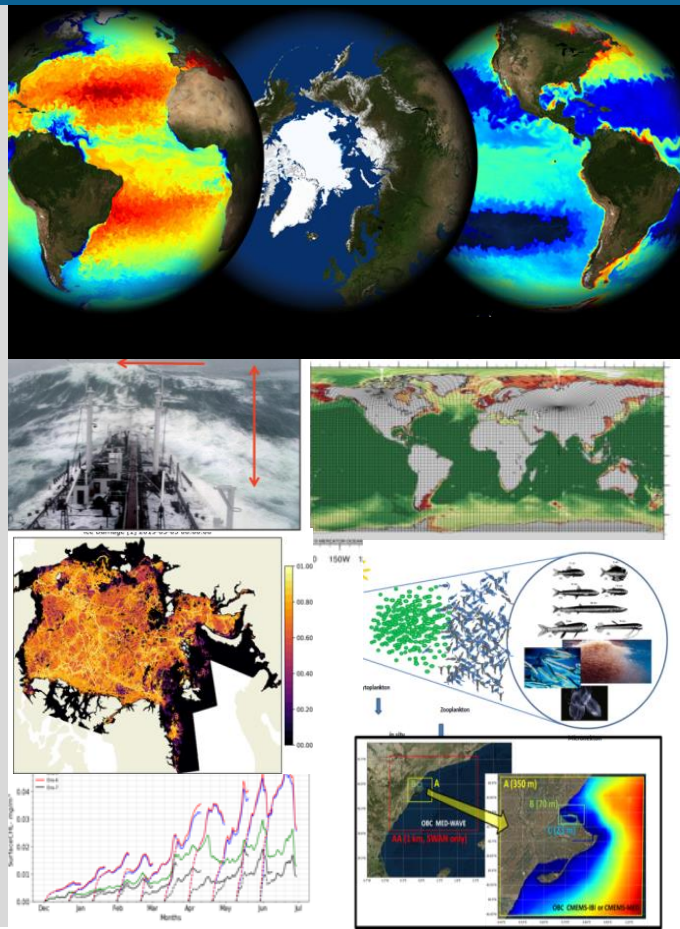


Conclusions

- ✓ **The Copernicus Marine Service in Copernicus 1**: major achievements (operational service, user interaction and user uptake, R&D and service evolution)

- ✓ **Plans for Copernicus 2**:
  - ❑ Remain a marine reference worldwide
  - ❑ Implement the next generation of forecasting systems: higher resolution, coupled approaches, ensemble methods
  - ❑ Expansion of products/service portfolios for Arctic, Coastal, Biology & Climate incl. advances in digital services

- ✓ **Strong partnership with research community** will remain key. Essential role of R&D to maintain a state-of-the-art Copernicus Marine Service responsive to user needs



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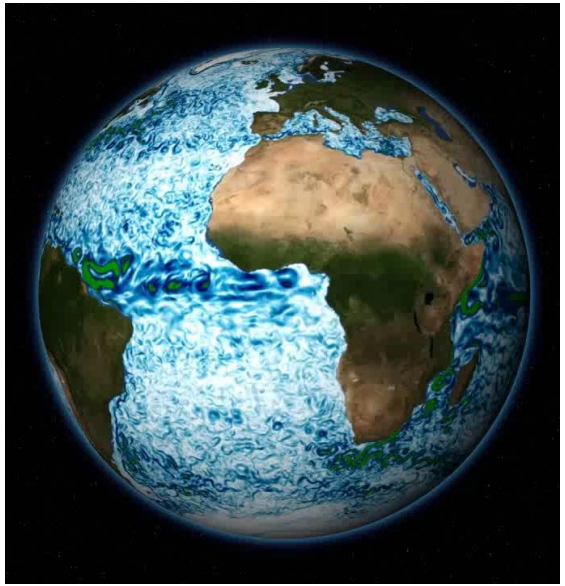
THANK YOU



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