

Open Science principles applied to SOCIB's Research Infrastructure ocean observing activities and data

(Marine Research Infrastructures ideal environment for Open Science development and implementation)

Joaquín Tintoré and all SOCIB & IMEDEA Team
jtintore@socib.es

Scientific Excellence with Impact on Society

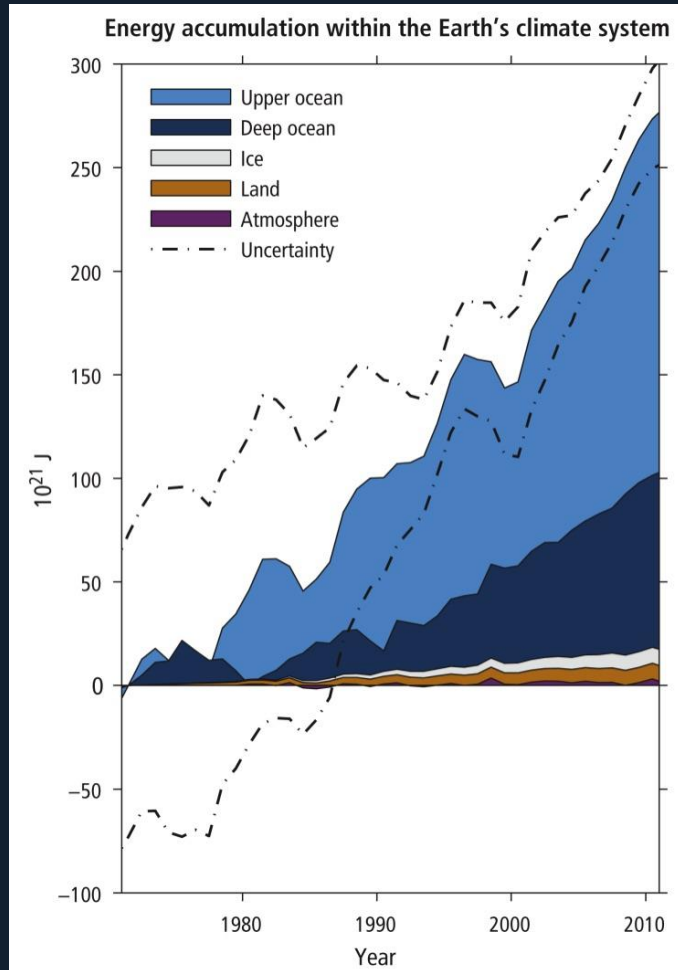


OUTLINE

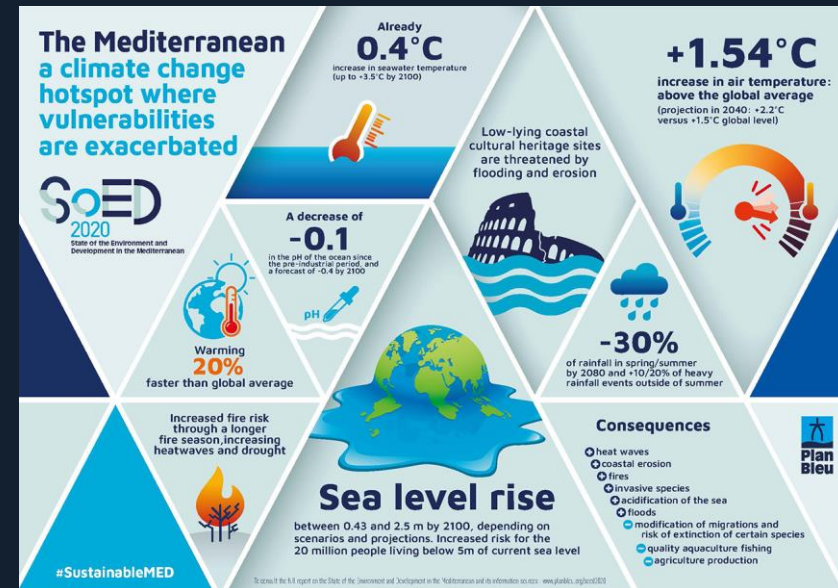
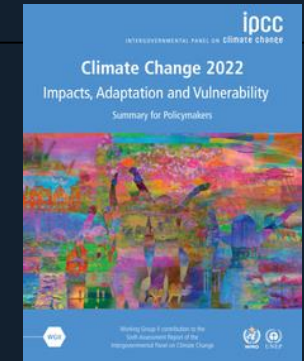
1. Planet Ocean, Ocean Scales, Changes in our Planet, in Technology, Science, Society, ...
2. New Ocean Observing Systems: connecting the pieces of an N dimensional puzzle: the relevance of data & resources, beyond data...
3. Transformative changes: Ocean Integration, the right time for the Ocean, Research Infrastructures & Open Science

Topics for discussion: Are we ready for these changes ? Do we have the capacities, the framework and right structures to get all the benefits from these changes ?

OUR MAIN GOAL TODAY: Climate Change, global warming is ocean warming –



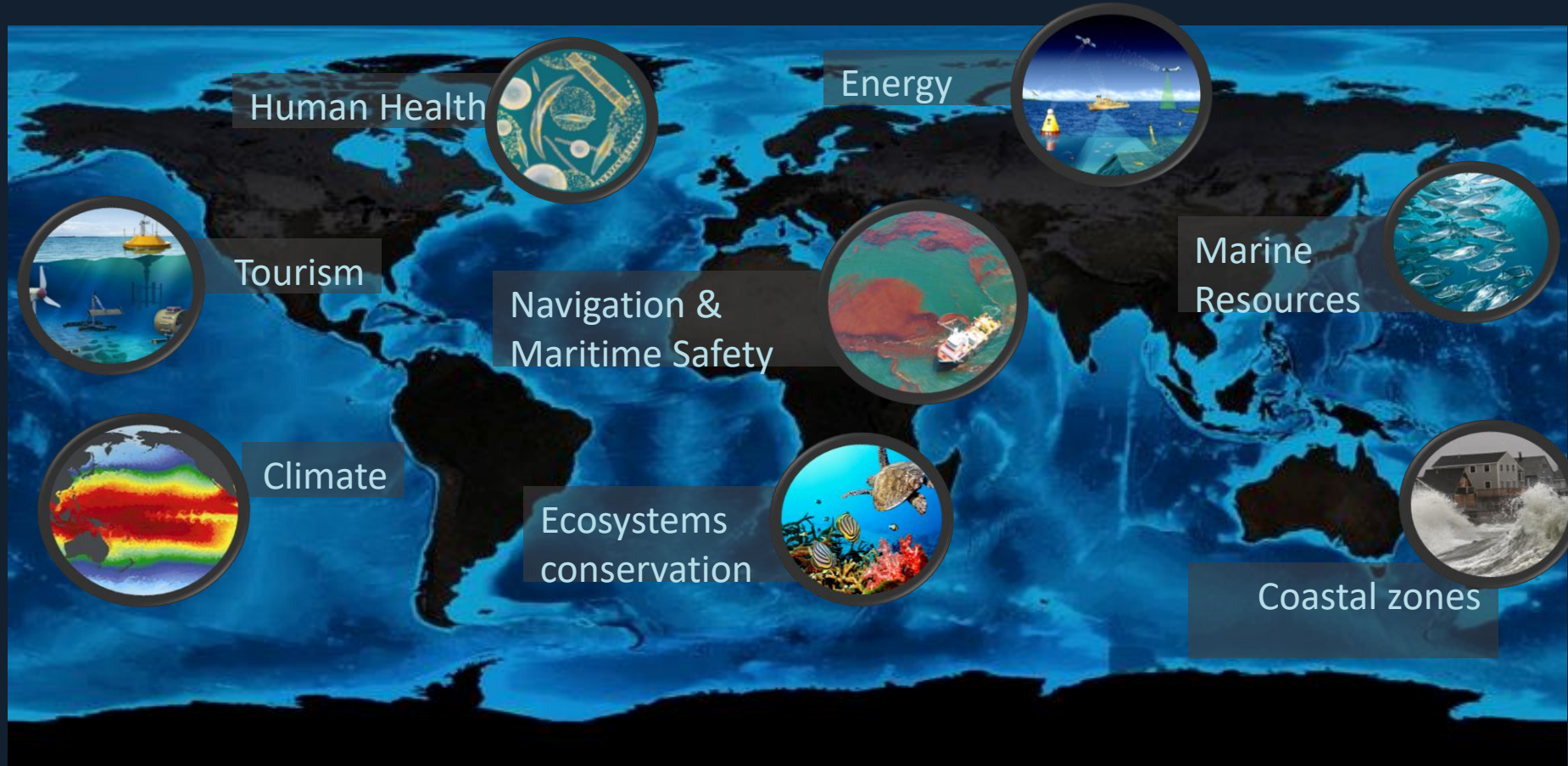
IPCC - Special Report Ocean & Cryosphere, 2019



Waite et al., COP25, 2022

Emergency situation: action and transformation required

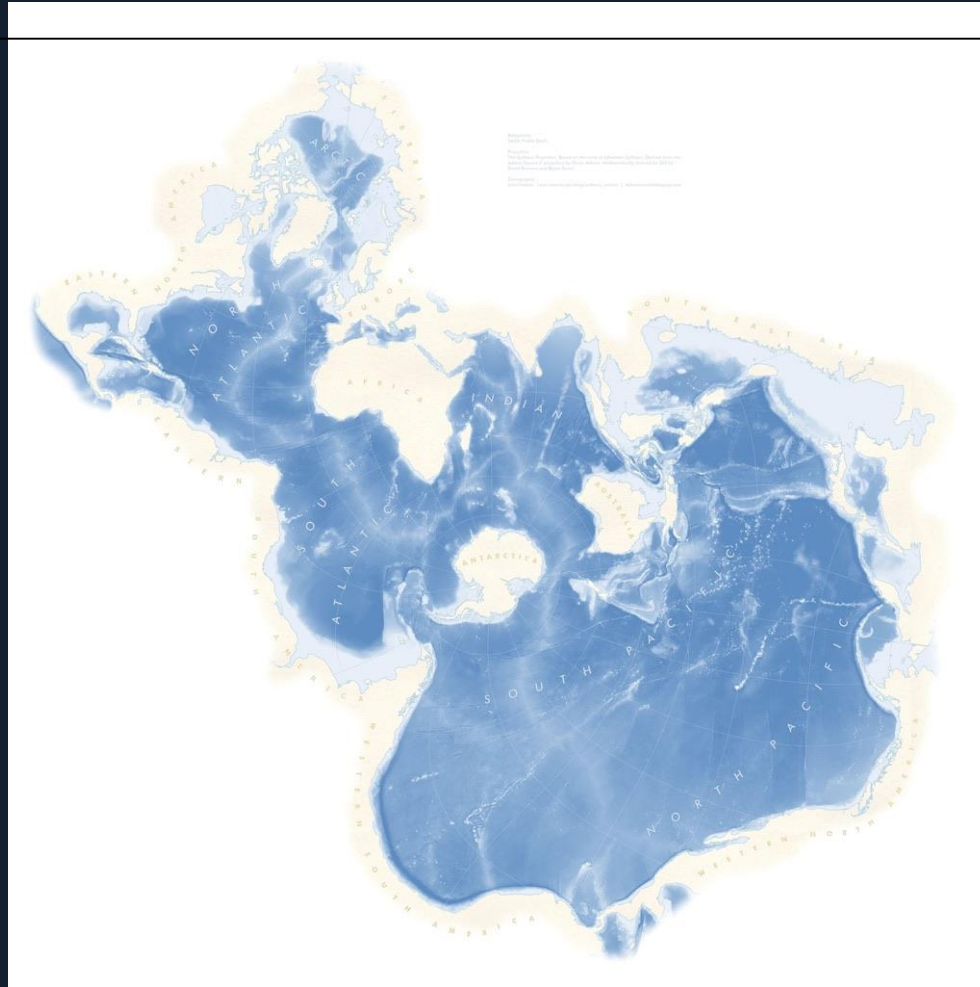
WHY IS THE OCEAN IMPORTANT



Adapted from Future Ocean · Kiel Marine Science

The Ocean provides 50 % O₂, absorbs 90% excess heat generated & 1/3 of CO₂

ONE OCEAN – ONE PLANET



Spilhaus map - ESRI

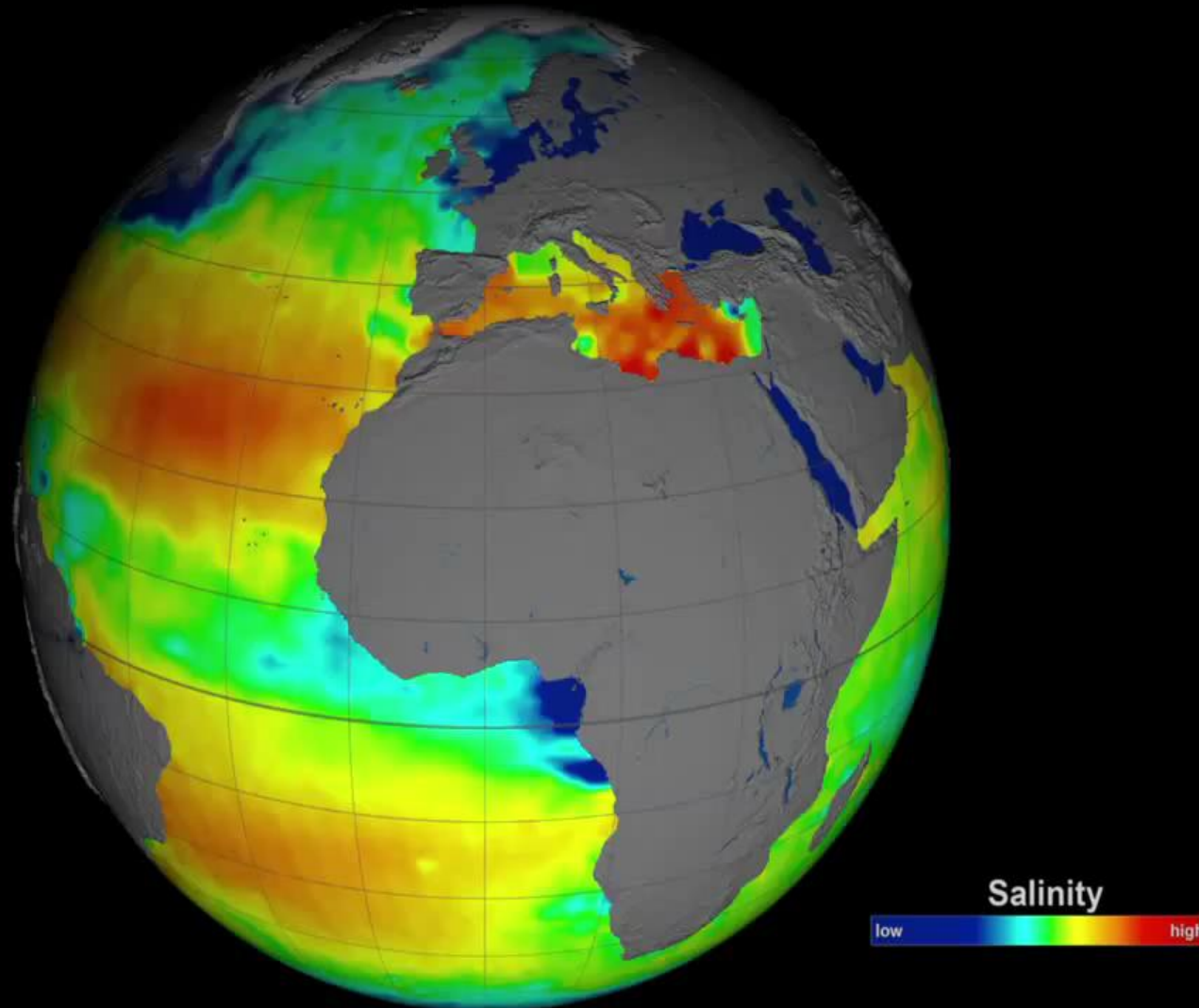
Connectivity, Scales, Limits, Sustainability

We need to characterise Ocean State AND VARIABILITY at Different Scales (basin, sub-basin, local & coastal interactions)

We need:

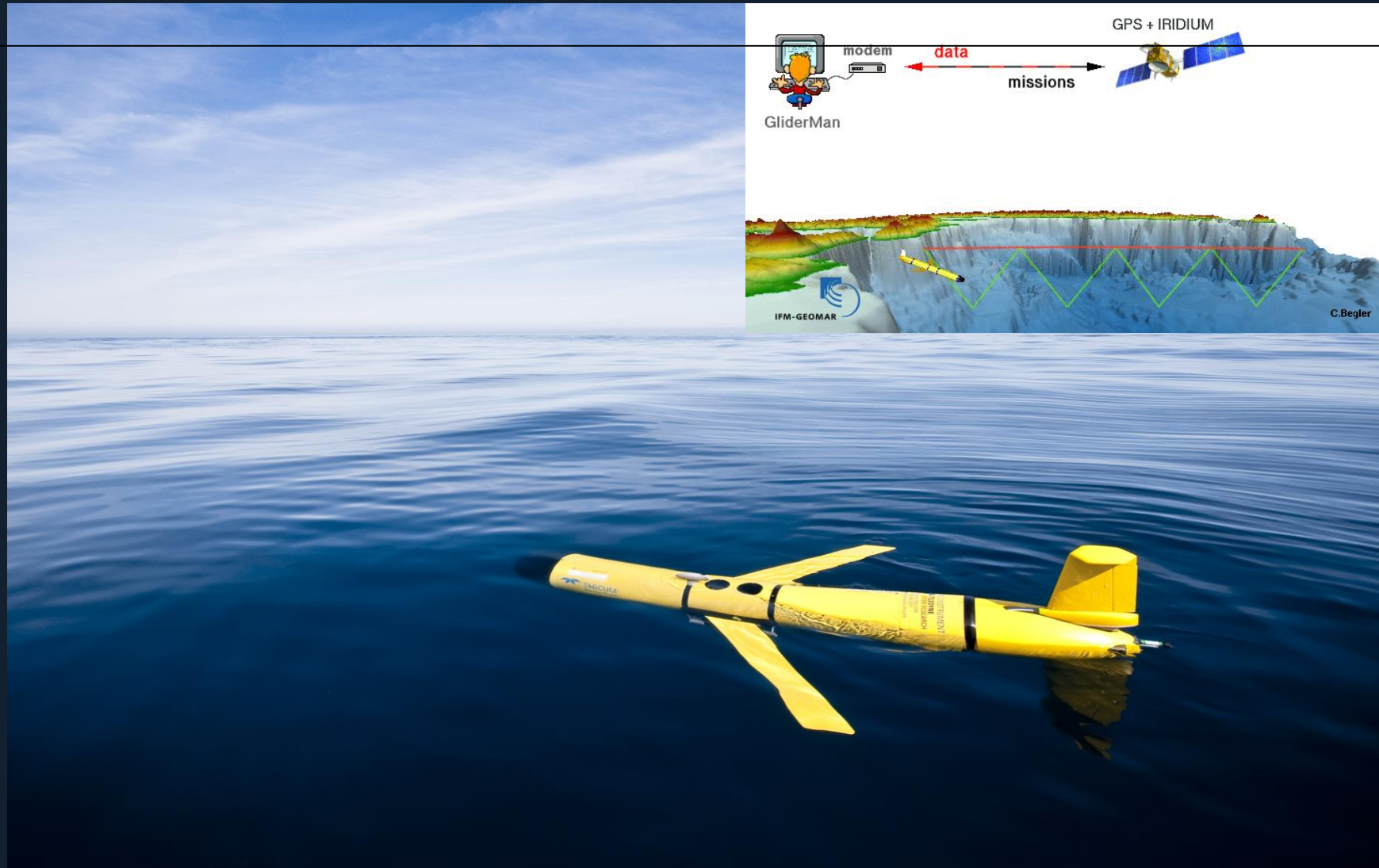
- Long time series
- Synoptic data

But... we need more than
“just data”



NASA's Aquarius salinity, from December 2011 through December 2012

CHANGES IN TECHNOLOGIES: drivers of change...



Gliders, ... “the quiet revolution” (Emma Heslop)

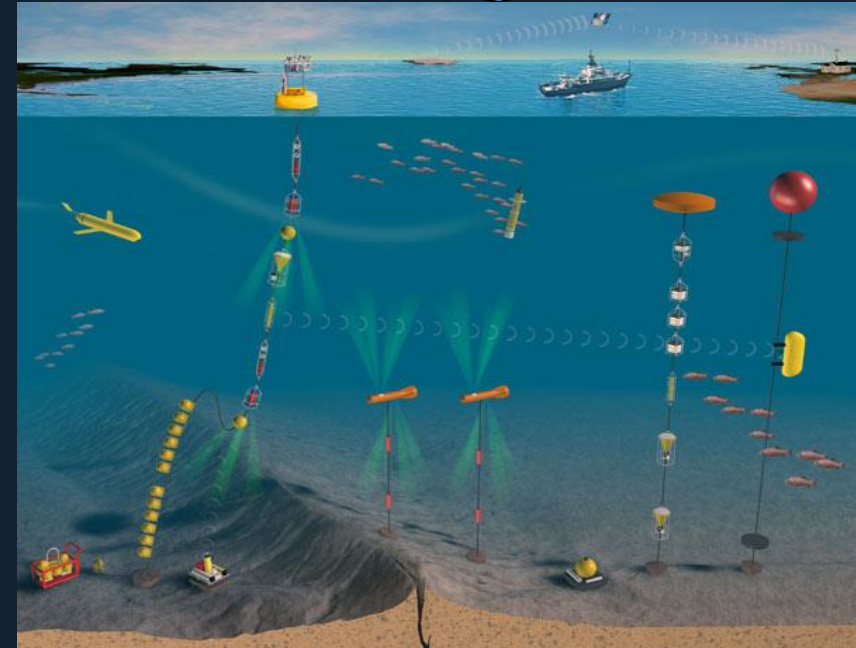
CHANGES IN SCIENCE: OCEAN OBSERVATION AND DATA AVAILABILITY → PARADIGM SHIFT

From: Single Platform - Ship based observation

To: Multi-platform observing systems

Platform-centric
Systems

Network - distributed
Systems



(Adapted from Steve Chien, JPL-NASA)

“A single ship can only be in one place at one time. We need to be present in multiple places in multiple times.” ([John Delaney, Nature, Sept. 25, 2013](#))

→ ... DISCOVERING ELEMENTS OF THE OCEAN VARIABILITY AT DIFFERENT SCALES: THE MEDITERRANEAN SEA



NASA. Ocean current flows in the Mediterranean - 16 Feb 2005 through 16 January 2006.

Ocean variability, from the coast to the open ocean,
and from events to climate

CHANGES IN CONCEPTS:...

Blurred distinction

The idea of research excellence is ubiquitous, but what it means depends on the context.

Excellence is everywhere in science. Or that seems to be the plan: to make excellence ubiquitous in research. This month, the University of the West Indies in Kingston, Jamaica, became the latest academic institution to encourage its scientists to excel, setting up a Regional Centre for Research Excellence in the Caribbean.

To be good is no longer enough — excellence, by definition, must go beyond that.

And for those who achieve it — from individual researchers and

22 FEBRUARY 2018 | VOL 554 | NATURE | 403

“Some funders are starting to place more importance on the societal impact and relevance of research.”

Redefining Scientific Excellence

Fewer numbers, better science

Scientific quality is hard to define, and numbers are easy to look at. But bibliometrics are warping science — encouraging quantity over quality. Leaders at two research institutions describe how they do things differently.

REDEFINE EXCELLENCE

Fix incentives to fix science

Rinze Benedictus and Frank Miedema

An obsession with metrics pervades science. Our institution, the University Medical Center Utrecht in the Netherlands, is not exempt. On our website, we proudly declare that we

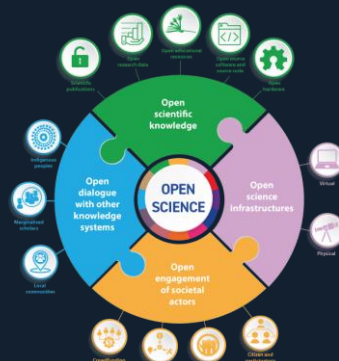
publish about 2,500 peer-reviewed scientific publications per year, with higher than average citation rates.

A few years ago, an evaluation committee spent hours discussing which of several faculty members to promote, only to settle on the two who had already been awarded particularly prestigious grants. Meanwhile, faculty members who spent time crafting policy advice had a hard time explaining how this added to their scientific output, even when it affected clinical decisions across the country.

Publications that directly influenced patient care were weighted no higher in evaluations than any other paper, and ▶

27 OCTOBER 2016 | VOL 538 | NATURE | 453

CHANGES IN SOCIETY & INTERNATIONAL FRAME



“The **Blue Economy** is a knowledge based economy looking to the sea, not really for extraction of natural goods but for data to address societal challenges and inspire solutions” R. Spinrad, NOAA - 2016.

WHAT IS SOCIB?: a Research Infrastructure, a multi-platform observing & forecasting system, from nearshore to open sea & from events to climate

3 DRIVERS

- Science priorities
- Technology Development
- Society Needs

-> SYSTEMATIC & SUSTAINED OBSERVING

-> OPEN DATA ACCESS

- Free/open data
- Endurance lines
- Competitive Open Access

COLLABORATIVE

- CSIC, CSIC/IEO, UIB

INTERNATIONAL EVALUATION

- Every 4 years



Tintoré et al., 2013; 2019

www.socib.es

Timeline:

- Proposal 2006 & approved in 2009
- Designed & built 2010-2013
- Included in Large Scale RI Map, 2014
- Regional Digital Twin, 2024-2030

KPI Scientific Production:

- > 200 papers, 2011 - 2023
- 20 EU projects, 2014 – 2023
- 8 contracts private sector
- 8 agreements public sector
- External funding: > 6 M€
- Building trust and partnership through collaboration

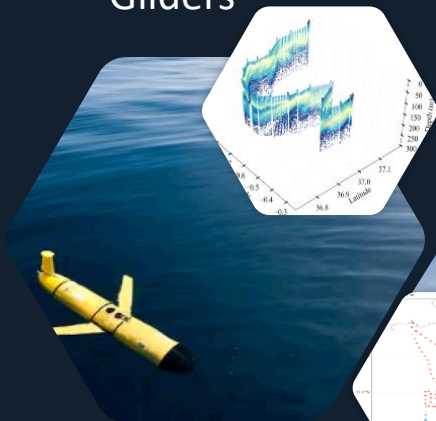
National, Collaborative Research Infrastructure

Leadership – Partnership – Principles

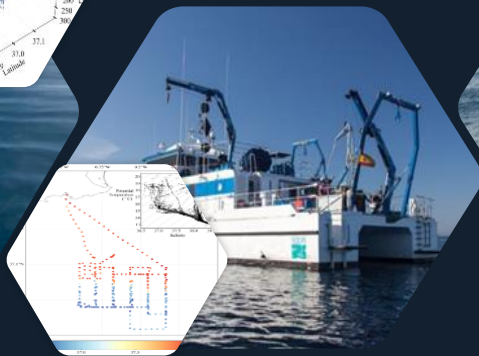
(close to Open Science, “but we did not know”!)

WHAT IS SOCIB?: a Research Infrastructure, a multi-platform observing & forecasting system, from nearshore to open sea & from events to climate

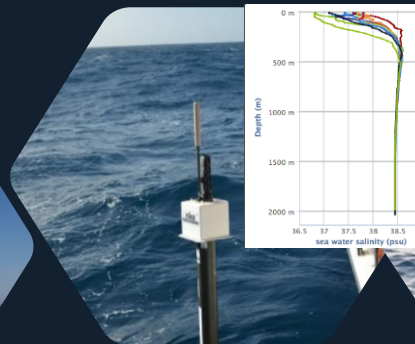
Gliders



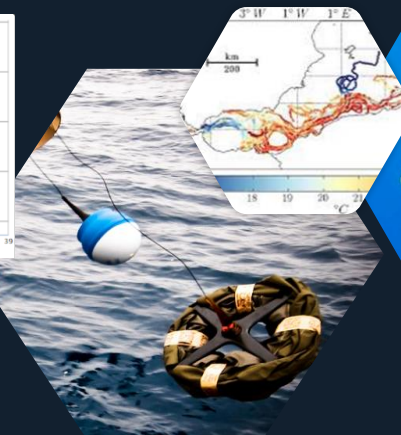
Research and opportunity vessels



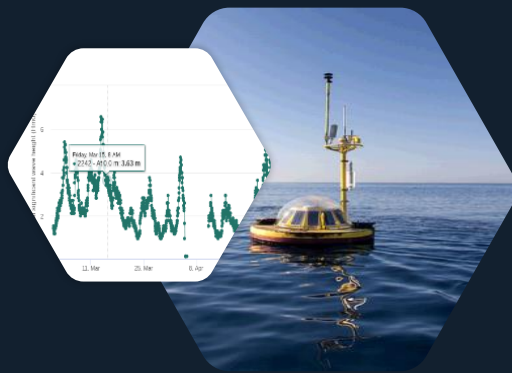
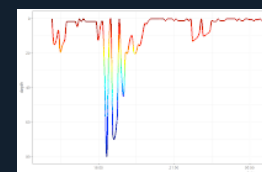
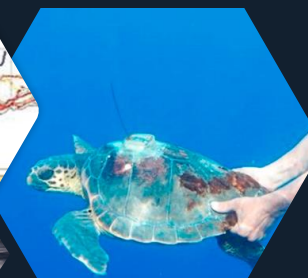
ARGO floats profilers



Drifting buoys



Marine animal tracking



Moorings



Tide Gauges

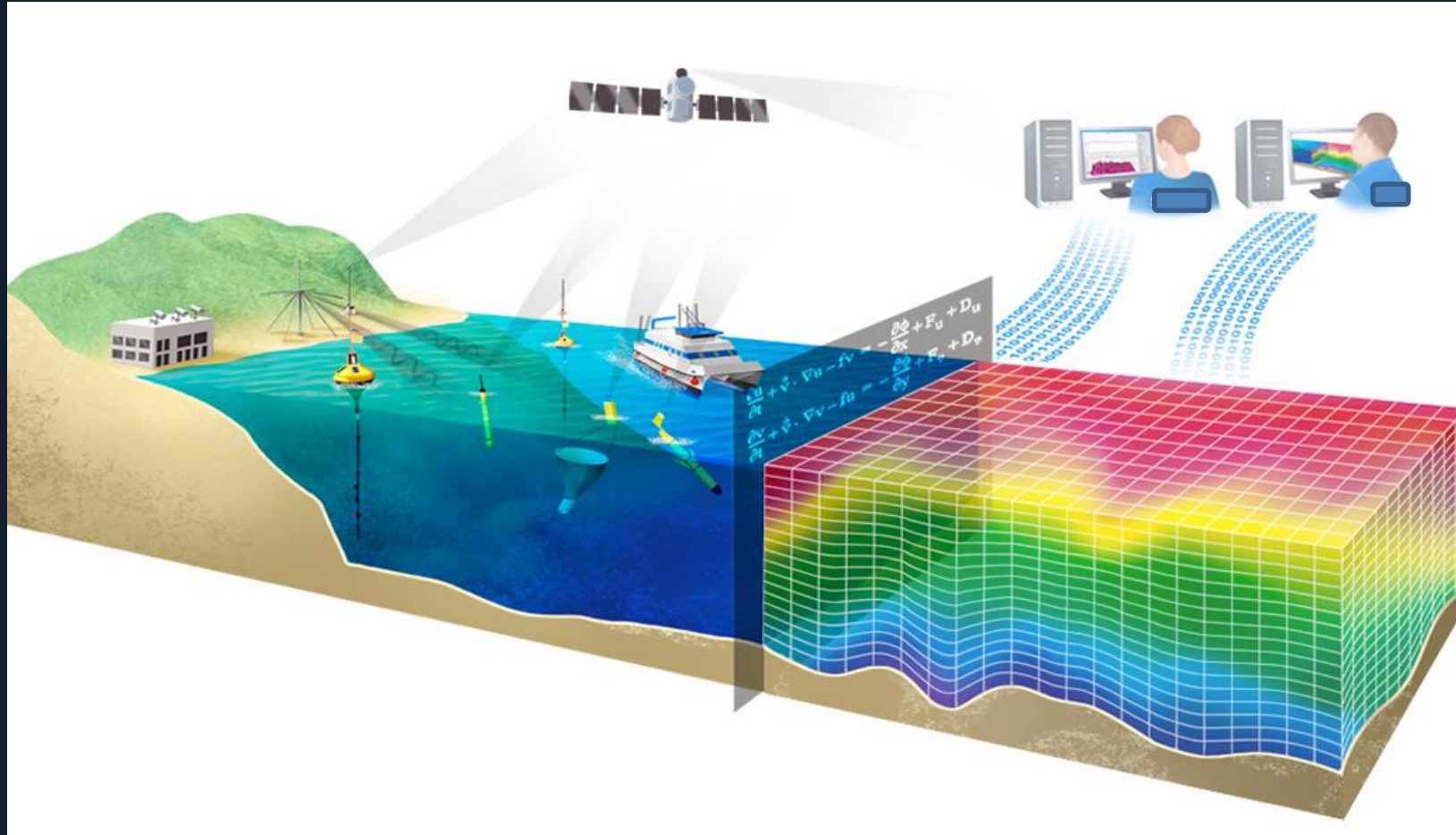


HF radars



Beach Monitoring

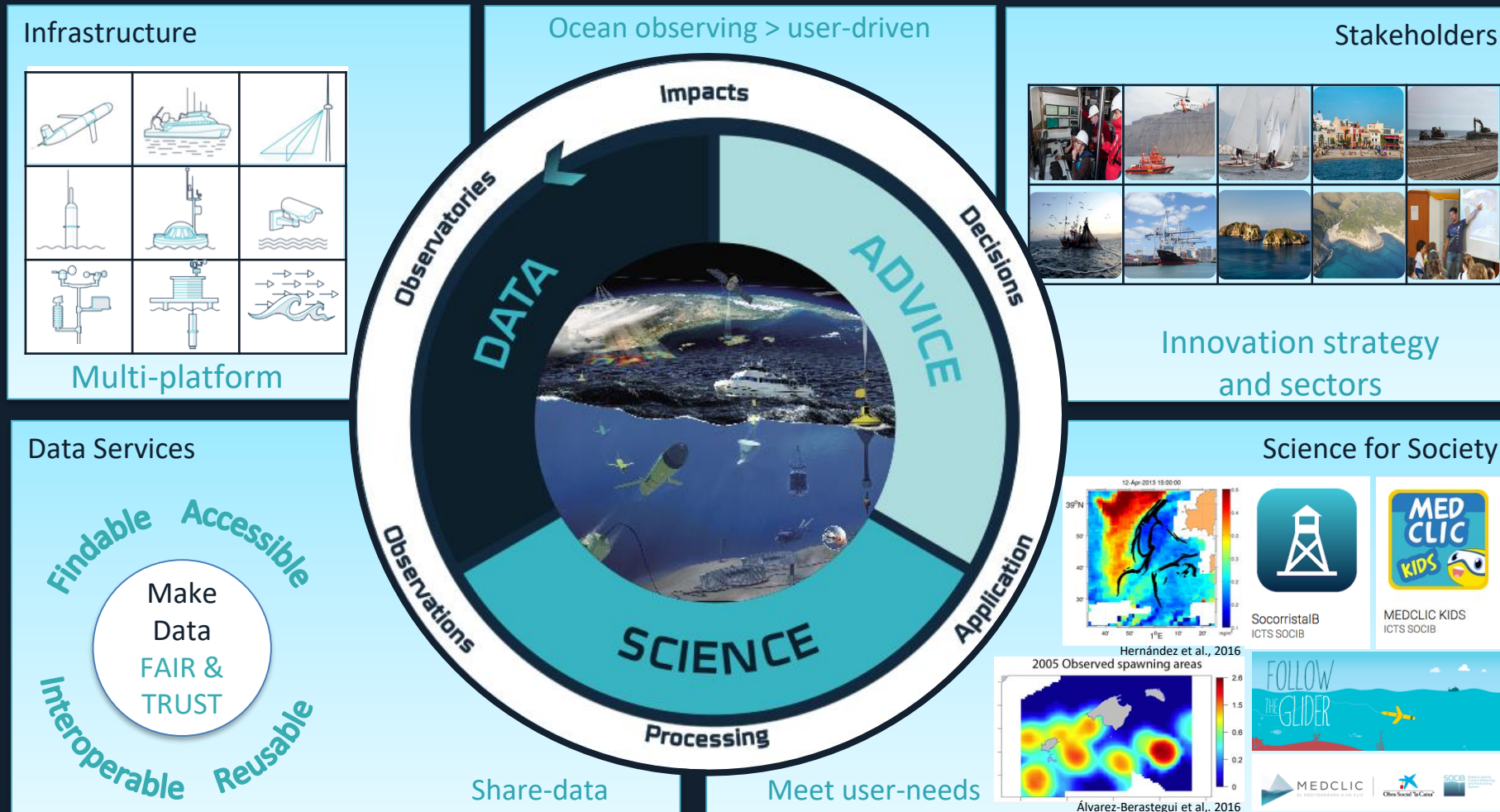
SOCIB INTEGRATED APPROACH TO OCEAN OBSERVING



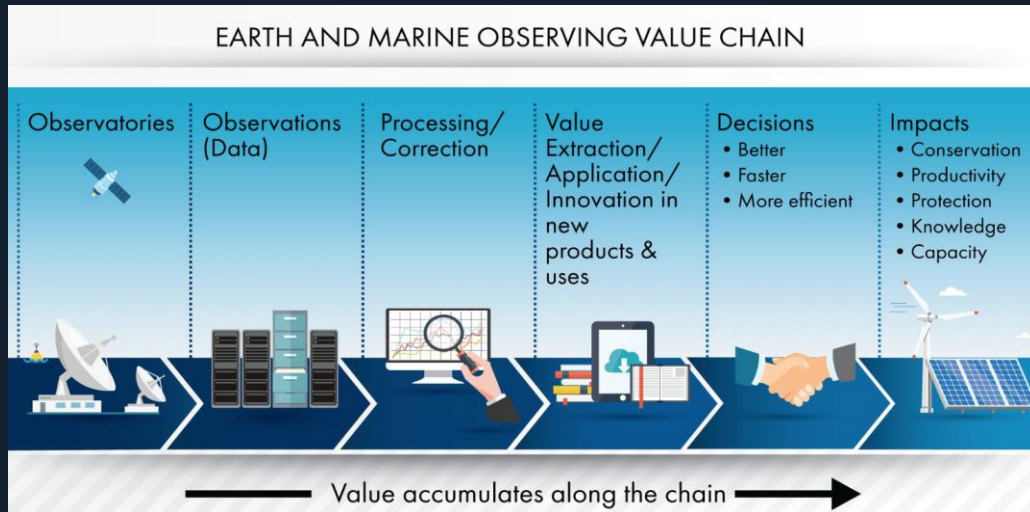
Data Reliability: FAIR data and TRUST repositories

Access to Resources (tools, software, methods,...) & Metrics; Trans-National & Virtual

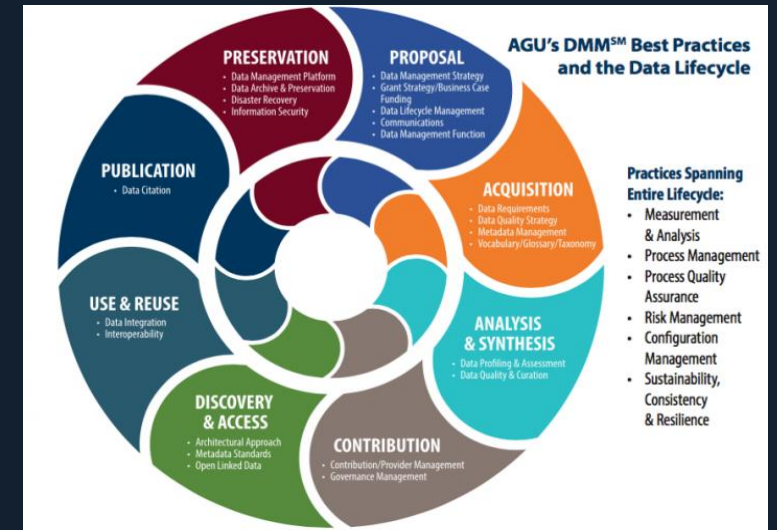
SOCIB: A PUBLIC LARGE SCALE RESEARCH INFRASTRUCTURE. A STORY THAT STARTED IN 2009, OPERATIONAL 2014 AND TODAY ...



DATA & OCEAN OBSERVING VALUE CHAIN: THE DATA DELUGE !

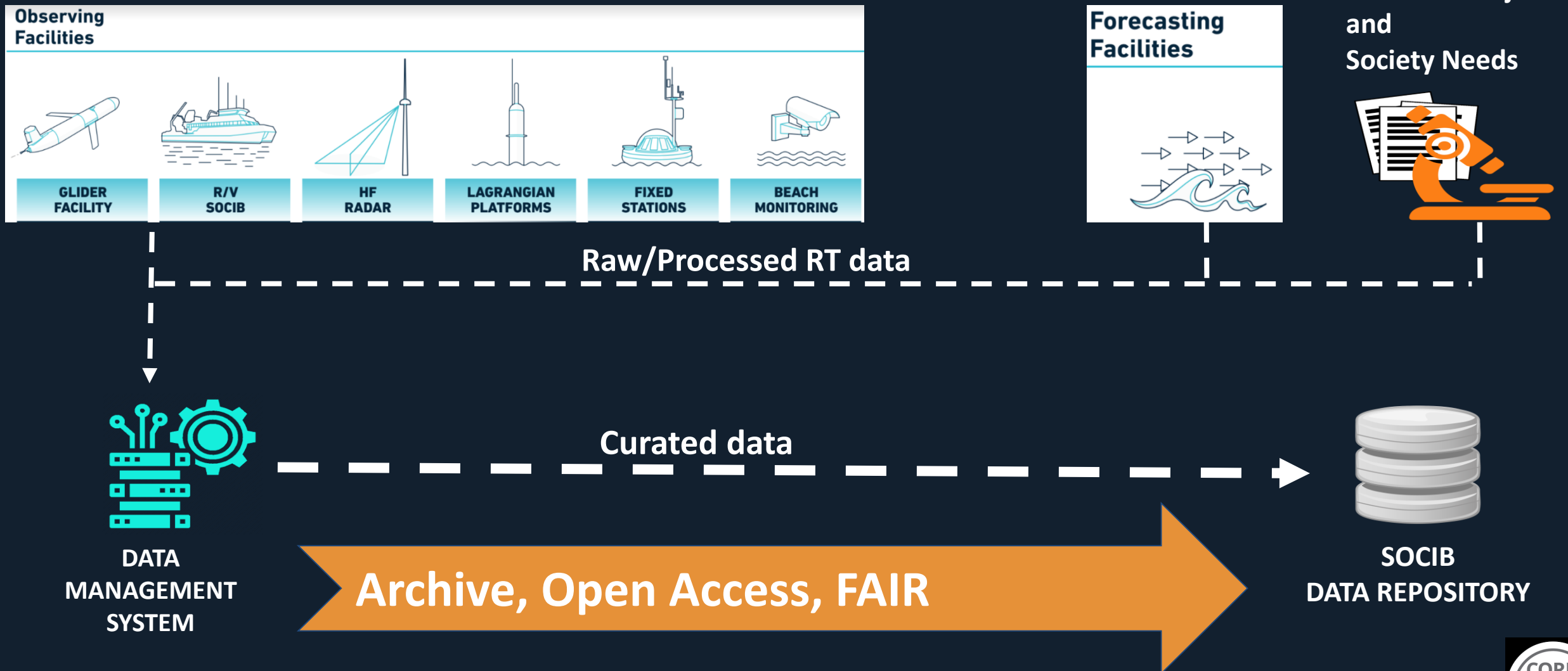


(Hodgson-Johnston, 2016)



Marine observation data has potential for huge innovation through data collection, analysis & application

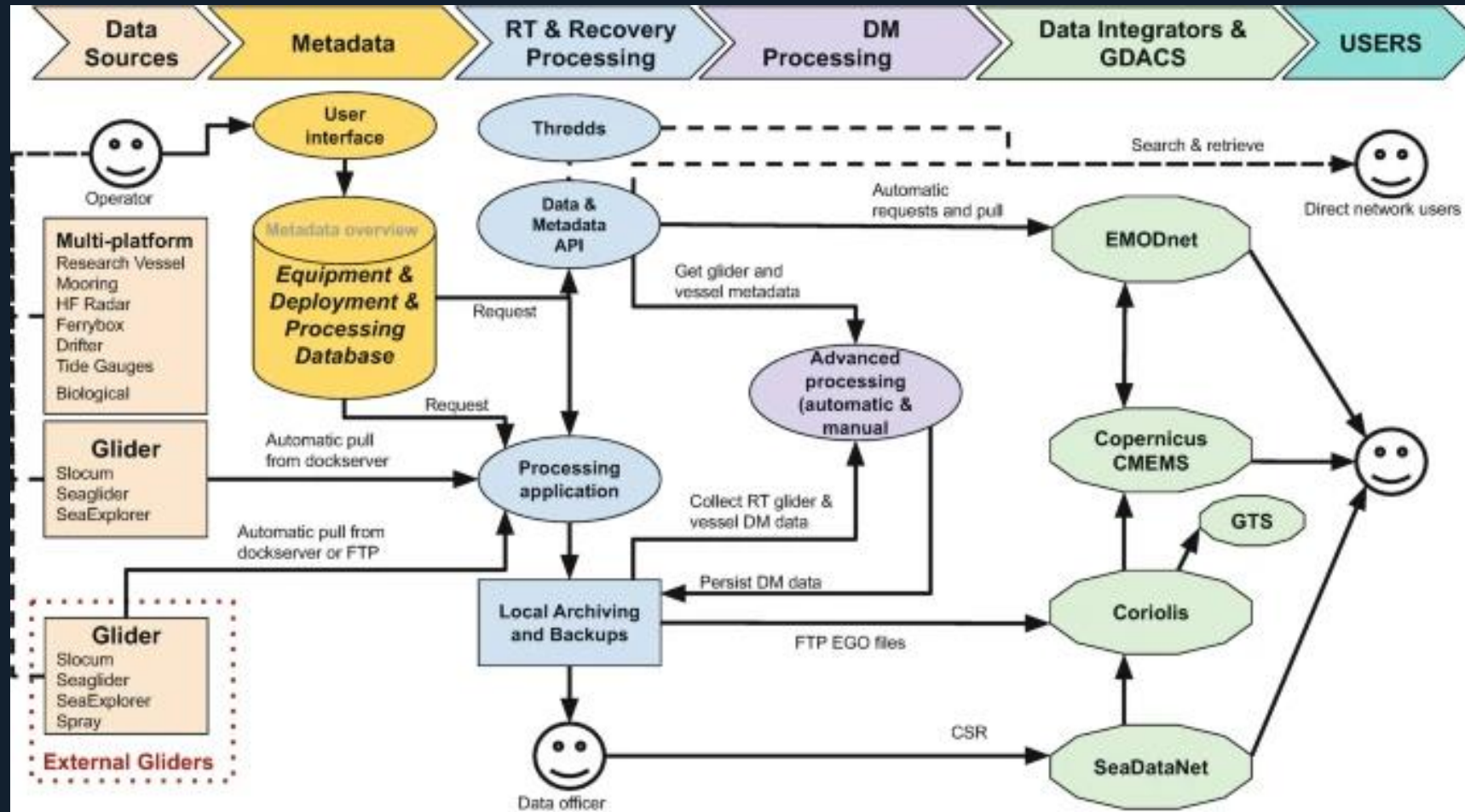
SOCIB Data Management Framework



Ocean data has potential for innovation through data collection, analysis & application



SOCIB GLIDER DATA WORKFLOW



FAIR by construction ...

SOCIB Data Repository: data dissemination & user interfaces

Operational data

thredds.socib.es

Data server: the structure and organization of the data responds to operational criteria. It also offers access through standard services (OPeNDAP, WMS).



Catalog <http://thredds.socib.es/thredds/catalog.html>

The SOCIB Thredds Data Server allows downloading and accessing the SOCIB Data Repository through a variety of standard protocols such as OPeNDAP and WMS. The present catalog structure responds to operations and therefore it might result complex for average users. Please visit SOCIB Data Catalog instead for a more friendly interface in this regard.

Dataset	Size	Last Modified
SOCIB DATA		
observational		
mooring/		
drifter/		
sw/		
bf_radar/		
research_vessel/		
aggregated_data/		
operational_model/		
oceanographical		
hydrodynamics		
wmp/		

Data Catalog

apps.socib.es/data-catalog

Catalog of data products: operational data in the best available quality, packaged according to scientific criteria. Data products have a DOI.



SOCIB DATA CATALOG

SOCIB Data Catalog is a browser-like application built on top of the SOCIB API services that enables a friendly discovery, visualization and download of the data available at SOCIB Data Repository. Both the SOCIB Data Catalog and SOCIB API serve as the most significant demonstration of the SOCIB Research Infrastructure commitment toward the user data.

SOCIB Data Catalog is the recommended point of entry for non-operational users that are interested in the oceanographic data produced by the observing facilities of the Balearic Islands Coastal Observing and Forecasting System (COFIS). Operational users are encouraged to continue the application as a third time of SOCIB API, the actual service to be used for accessing data in an operational way.

SEARCH FILTERS

SEARCH RESULTS

- ALBUFERA DE BELLISERVA
- ALBUFERA DE BELLISERVA
- ALBUFERA DE BELLISERVA

API M2M

api.socib.es

Machine-to-machine interface REST API to access repository data and metadata.



SOCIB API

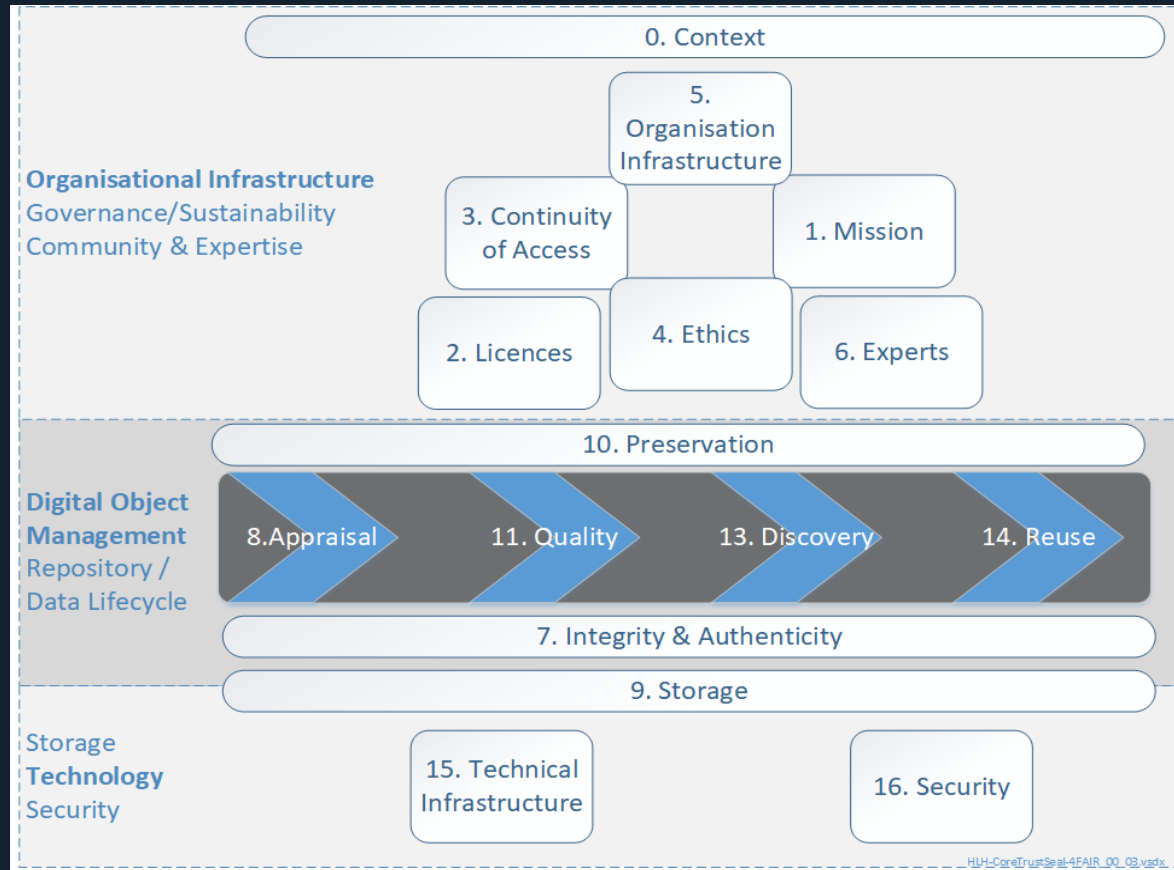
The SOCIB API lets you discover in a fast and easy way what products are made available by SOCIB and access the data related to them, where each product is a combination of related data sources by a virtual relation, both in a catalog or project. The data sources can come from observational platforms (e.g., oceanographical buoy, coastal stations, weather stations, autonomous underwater vehicles, drifter buoys, ...) and in later versions from forecasting models, images and more.

REST ENDPOINTS

- `GET /data-products/` Provides a list of products matching the requirements given by the query parameters.
- `GET /data-products/{id}/` Retrieves a specific product given by its ID.
- `GET /data-products/{id}/metadata` Retrieves metadata of a specific product given by its ID. Currently only data products with a DOI (DOI 1.0) following standard schema.
- `GET /platforms/` This endpoint allows listing all platforms with indexed datasets. Optionally can be filtered by platform type.
- `GET /platforms/{id}/` Retrieves a specific platform given by its ID.

3 user interfaces to support different use cases

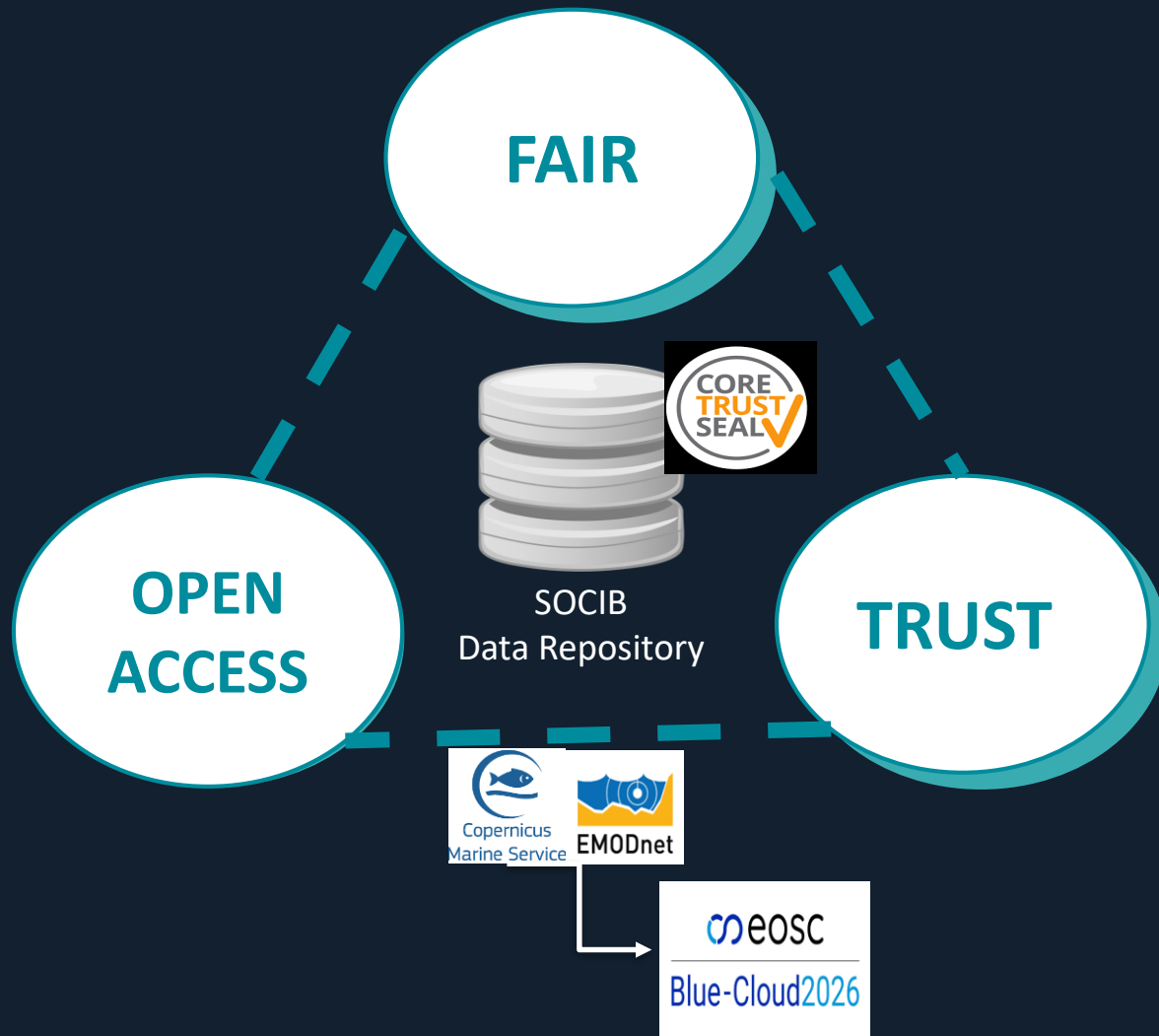
CORE TRUST SEAL and FAIR AT SOCIB



The best way to make your data FAIR is to make use of a data repository that is FAIR-aligned and complies with international data repository standards such as [CoreTrustSeal](https://www.fosteropenscience.eu)

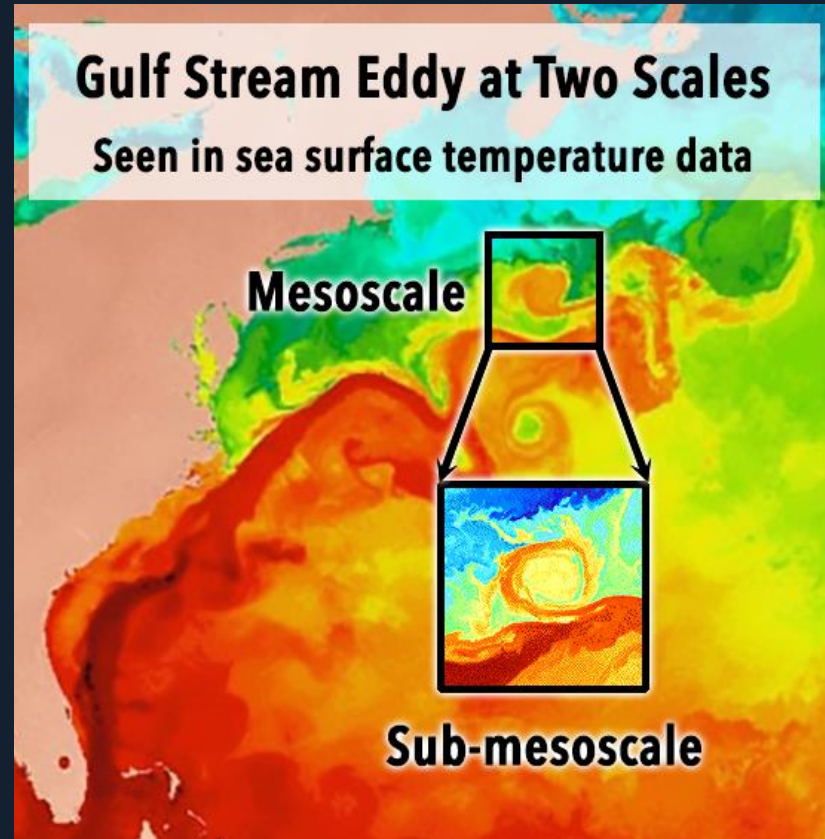


SOCIB DATA REPOSITORY: supporting Open Science



Accessible scientific research and data, open to all citizens

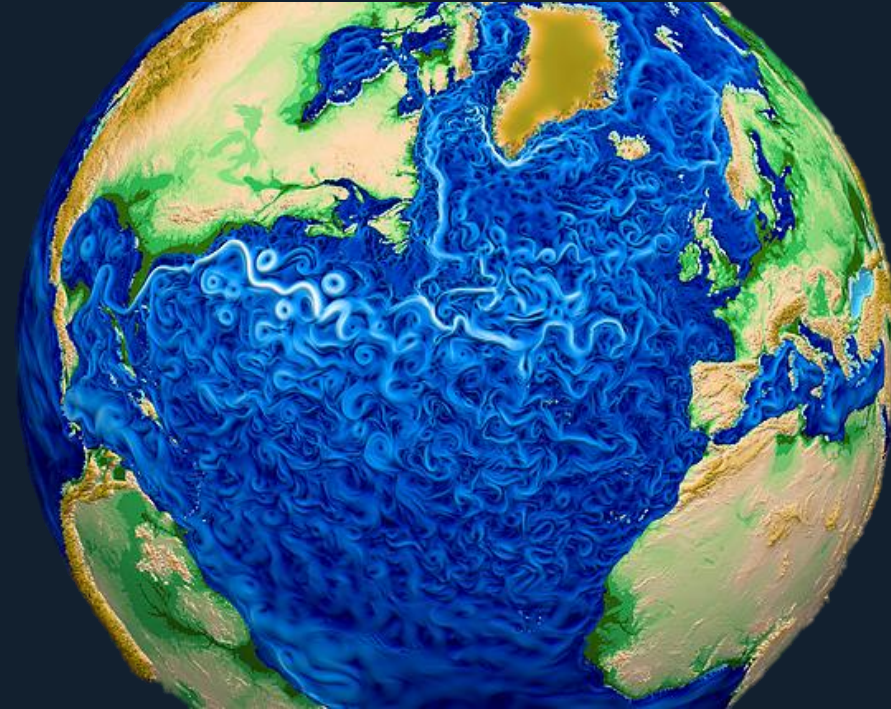
OCEAN CURRENTS AND VARIABILITY: eddies & instabilities: the mesoscale & sub-mesoscale, the 'ocean weather'



NASA SWOT

Theory and observations have shown a maximum energy at the mesoscale/fronts & eddies ~10-100km

Vertical motions in ocean eddies: from, 10 m/day to up to 2.000 m/day !!!



Todd Ringler Journal of Physical Oceanography

- Ocean eddies** contain the major part of ocean kinetic energy:
- Key to understand **climate** (heat transport, vertical exchanges),
 - **Ocean health** and ecosystem variability (nutrients, spawning areas),
 - **Operational response** (SAR, oil spills, plastics).

HIGHLIGHTS: SCIENCE → CALYPSO PROGRAM

KPIs:

US-ONR Funded DRI in Spanish waters (Alborán & Balearic Sea); 2017-2024.

Funding: > 30 M\$ and + 10 outstanding US Teams involved; WHOI, MIT, Harvard, Scripps, UW, etc.

CSIC/IMEDEA & SOCIB leadership

At the fore-front of international science questions and discoveries

Open Access, Open Data, Collaboration, Integration,... 1st steps!

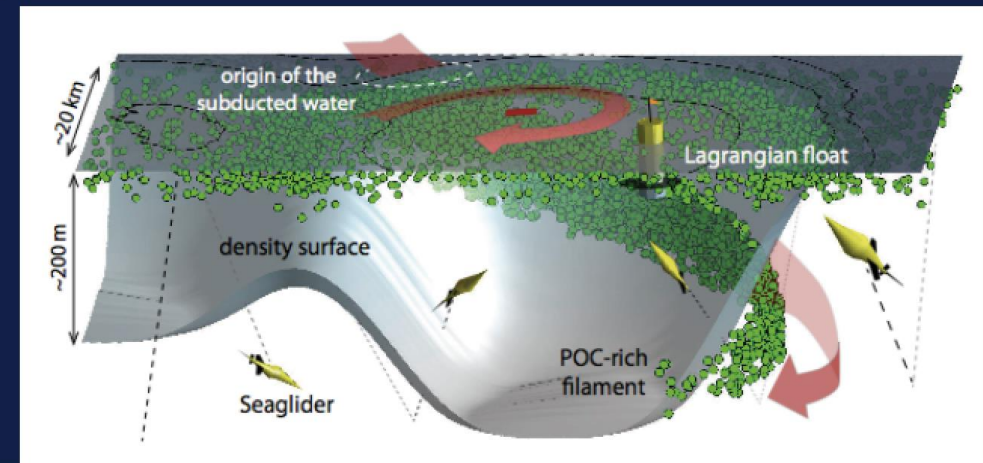
Mahadevan et al., 2020: BAMS

CALYPSO
Coherent Lagrangian Pathways from the Surface Ocean to Interior

Goal:
Unravel the three-dimensional coherent pathways by which water carrying tracers and drifting objects is transported from the surface ocean to depths below the mixed layer.

Approach

- Multiple observing platforms - ship, swarm of autonomous gliders, floats and water-following instruments that will track the water and gather data.
- Natural biological tracers that have implications for the ecosystem.
- Mathematical modeling - Unravel underlying physics for coherent pathways to subduction.
- Gain predictive capability for tracing pathways - targeted and adaptive sampling.



BAMS
In Box

Coherent Pathways for Vertical Transport
from the Surface Ocean to Interior

Amala Mahadevan, Ananda Pascual, Daniel L. Rudnick, Simón Ruiz,
Joaquín Tintoré, and Eric D'Asaro

HIGHLIGHTS: MISSION DRIVEN INNOVATION STRATEGIES, & BLUE ECONOMY

Today: SOCIB is providing data, resources, knowledge & advice to 10 sectors of society

SOCIB DECISION SUPPORT TOOLS EXEMPLARS:

- Rip-currents App for lifeguards & beach safety
- Sea level rise Balearic coasts & IPCC Scenarios
- Bluefin tuna spawning & ICCAT indices
- Meteo-Tsunami early warning
- Oil spill forecasting & coastal response
- Environmental Sensitivity Index web application
- Marine Heat Waves web tool
- ...



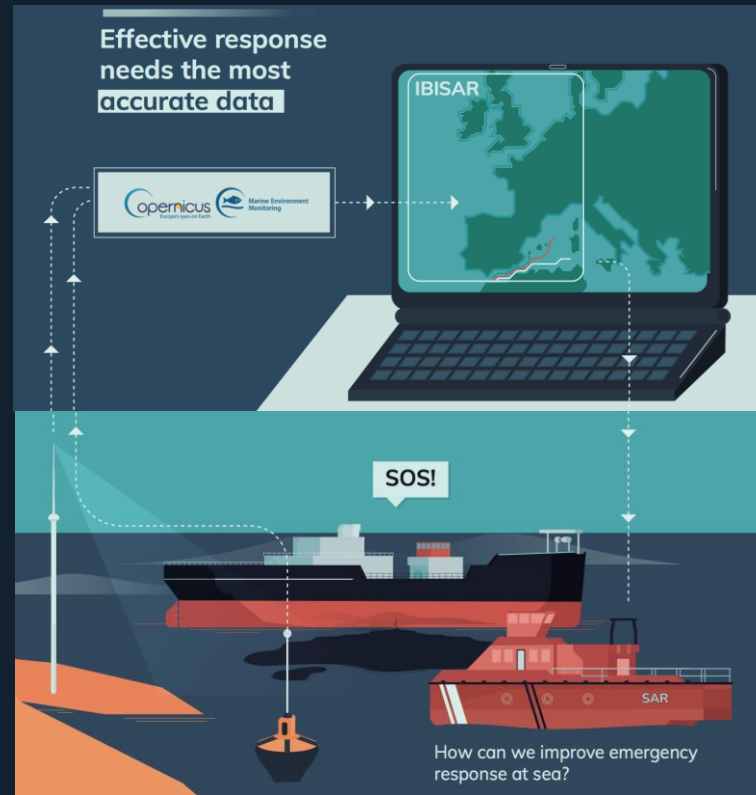
From Science to Society: a well defined Mission oriented Innovation Strategy, responding to society needs from solid scientific grounds

HIGHLIGHTS: SCIENCE, OPERATIONAL RESPONSE & SOCIETY, BUILDING TRUST - SASEMAR

PI: Dr. Emma Reyes, SOCIB



IBISAR: real-time data ranking in the IBI area for emergency and SAR operators



KPIs:

*Revelard et al., 2021:
Front. Mar. Sc.*



IBISAR service

Provides real-time information of the most accurate ocean current forecast in the IBI area

Facilitates decision-making to SAR operators and emergency responders

End-users needs

Reliable current observations and forecasting are essential

Easily interpretable metrics

User-friendly automated skill assessment

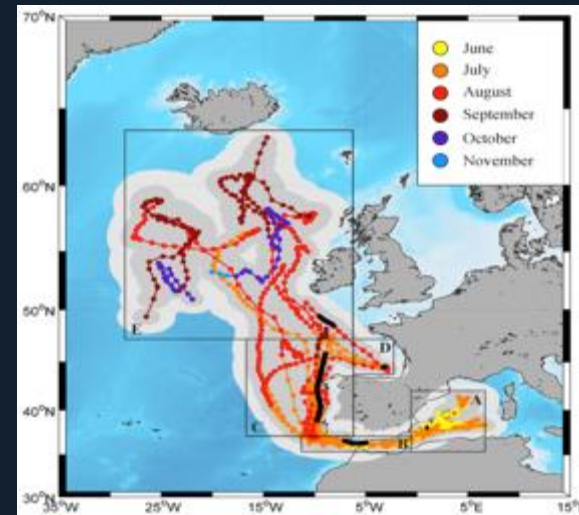
HIGHLIGHTS: Bluefin Tuna, linking ocean variability & species ecology to improve population stock assessment



Alvarez-Berastegui D.

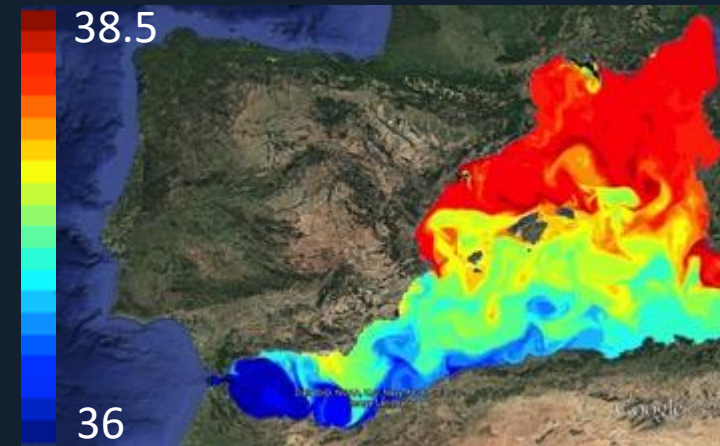


Migration patterns along the year (Eastern Stock)



Aranda et al, Pone 2013

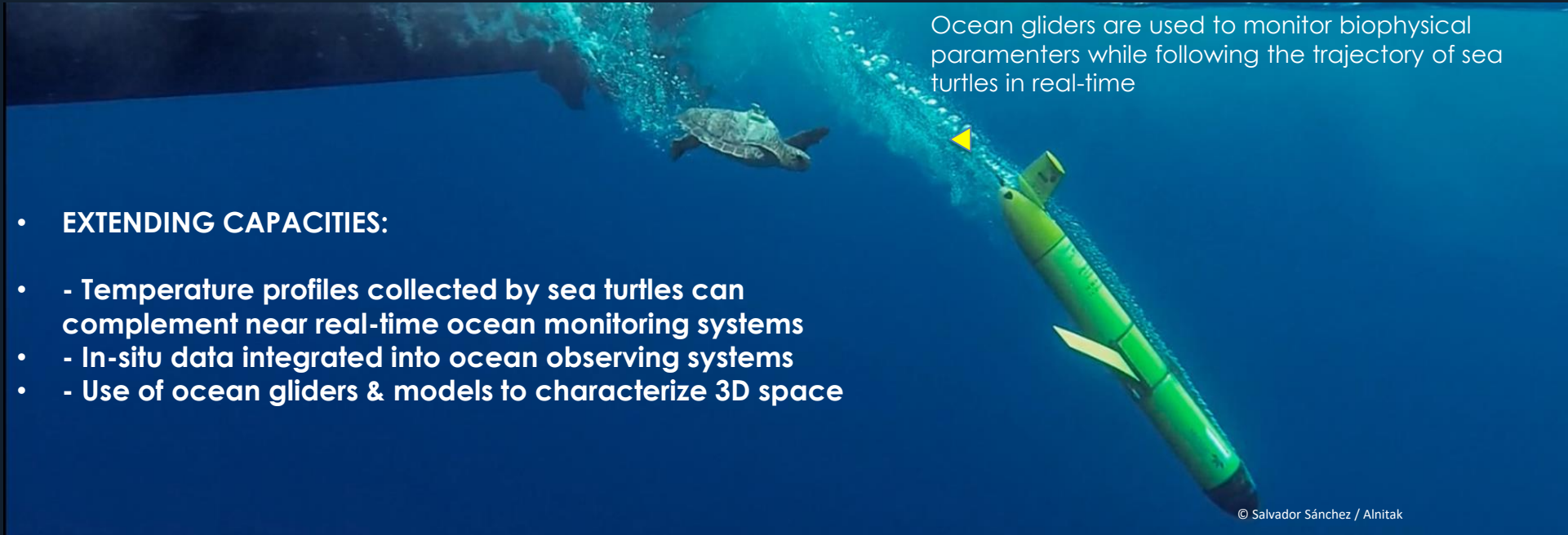
Sea Surface salinity (06/2016)



Alvarez-Berastegui et al. (ICES JMSc. 2016)



HIGHLIGHTS: NEW OBSERVING SYSTEMS, ANIMAL BORNE INSTRUMENTS



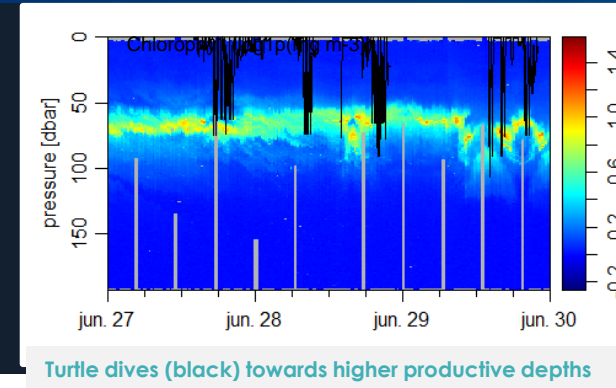
Ocean gliders are used to monitor biophysical parameters while following the trajectory of sea turtles in real-time

- **EXTENDING CAPACITIES:**
 - Temperature profiles collected by sea turtles can complement near real-time ocean monitoring systems
 - In-situ data integrated into ocean observing systems
 - Use of ocean gliders & models to characterize 3D space

© Salvador Sánchez / Alnitak

KPIs:

- AniBOOS



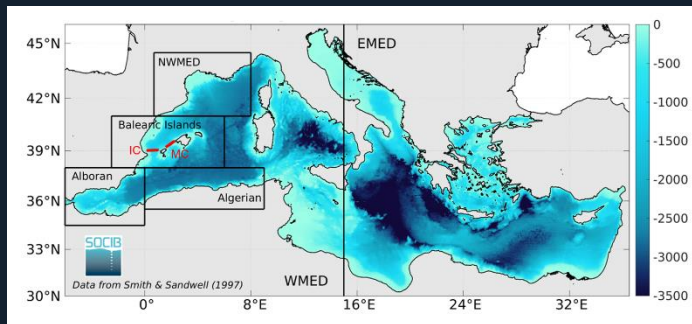
HIGHLIGHTS TOOLS: Sub-regional Mediterranean Sea Indicators, from event detection to climate change

SUB-REGIONAL MEDITERRANEAN SEA INDICATORS
From event detection to climate change

Surface ocean: Ocean temperature, Ocean health, Ocean currents, Sea level, Winds

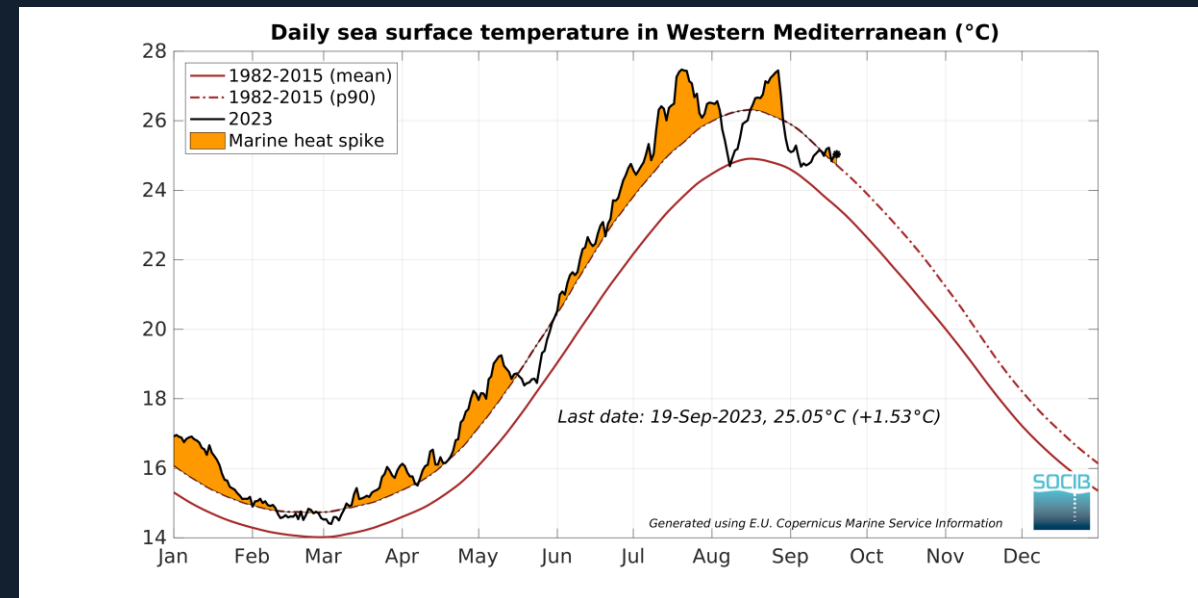
Integrated ocean: Heat & salt contents, Mixed layer, Transports

<https://apps.socib.es/subregmed-indicators>
(updated daily)



Juza & Tintoré (2021)
<https://doi.org/10.3389/fmars.2021.610589>

Mediterranean Marine Heat Waves



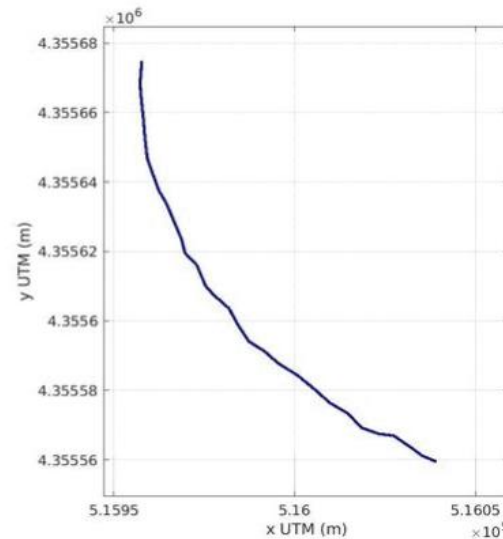
<https://apps.socib.es/subregmed-marine-heatwaves>

From event detection (marine heat wave) to long-term variations (ocean warming, sea level rise)

HIGHLIGHTS: NEW Citizen Science in beaches, CoastSnap



21-Jul-2022



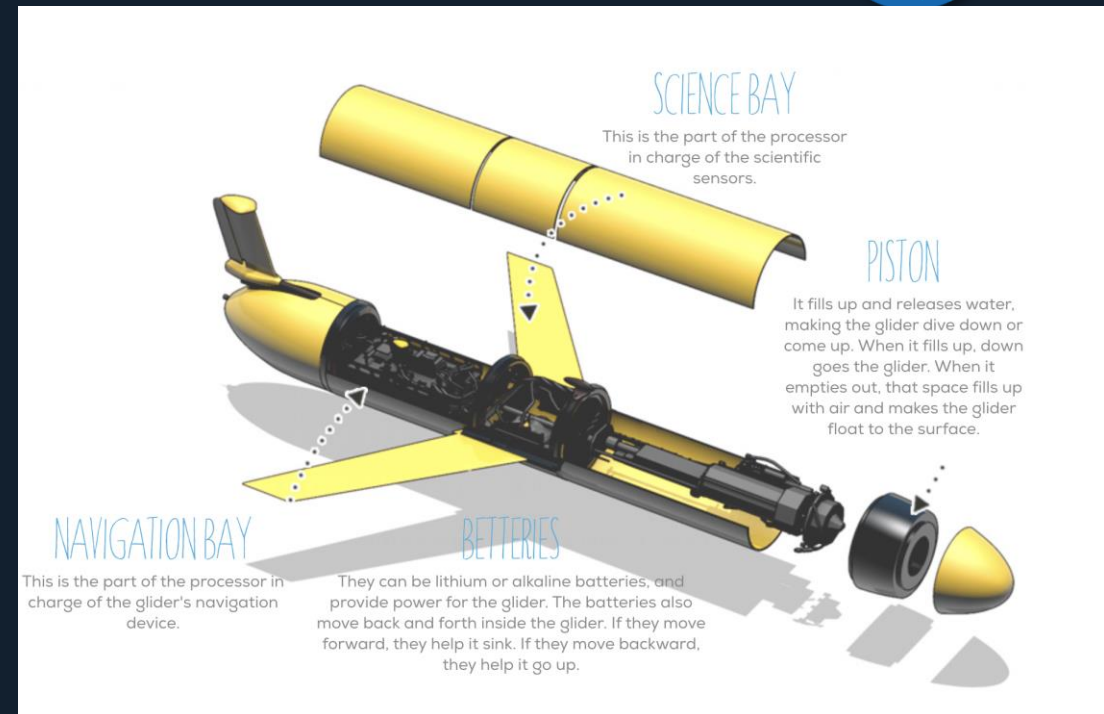
CoastSnap Balears: S'Amarador beach evolution



HIGHLIGHTS: Science with and for Society, bi-directional Transfer of Knowledge, RRI



“In the end we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught”, Baba Dioum 1968.



“We are entering a new phase of community engagement in which scientists and society, educators, are encouraged to use the data, provide feedback on data access ease and quality and in the process, expand our knowledge on the oceans” — Fulweiler, Gawarkiewicz, Davis, OOI, EOS, August 1st, pag. 9, 2016)

HIGHLIGHTS: SOCIB and Society



We carry out
events and trainings
On-site and
Online activities
for all audiences

83 events & activities

285.645 assistants



We organize
contests
Online
activities for
all audiences

4 national contests

3.494 participants



We design
resources
Focussing on
the educational
community

76 resources & materials

3 languages



We communicate
Radio, TV, Social
Media
Research results,
products, data,
services and
activities

1.314 news

SOCIB promotes ocean literacy with activities to discover, learn, generate awareness, inspire, and empower citizens and stakeholders towards protecting OUR OCEAN.

SOCIB and OPEN SCIENCE



Research infrastructures, physical and virtual: ideal structures / ecosystems for effective implementation of open science

BUT...



**We need real transformation in ocean observation,
we need a real change: “*ocean integration*”
for enhanced science and responding to
society challenges**



INTEGRATION



Riccardo Muti

“The diversity in the orchestra is to be combined with the need of integration to reach an overall common goal above each one of the elements”

“The harmony on top of the different component”

“From egosystems to ecosystems”

Gerd Leonhard &
Xavier Ferras

+



Cristiana Figueres

“Optimism , which actually means courage, hope, trust, solidarity... the belief that we can work together...injecting optimism into the system”

OCEAN INTEGRATION: a call for transformative organizational changes

Build a collective impact organisation

- Agreeing on a common agenda & principles
- Connecting the diverse communities
- Redesigning a robust governance structure
- Establishing clear design & implementation plan

Reach sustainability

- Elaborating mission-based funding strategies
- Efficiently communicating the value of ocean observing
- Facilitating the transition from research to operations

Promote a culture shift: OPEN SCIENCE...

- Redefining scientific "excellence"
- Fostering FAIR data, TRUST digital repositories & BPs

(Revelard et al., 2022)

frontiers
in Marine Science

POLICY AND PRACTICE REVIEWS
published: 25 January 2022
doi: 10.3389/fmars.2021.737671

Check for updates

Ocean Integration: The Needs and Challenges of Effective Coordination Within the Ocean Observing System

OPEN ACCESS

Edited by:
Sabrina Speich,
École Normale Supérieure, France

Reviewed by:
Antoine De Ramon N'Yeurt,
University of the South Pacific, Fiji
Molly McCammon,
Alaska Ocean Observing System,
United States

***Correspondence:**
Adèle Revelard^{1*}, Joaquín Tintoré^{1,2}, Jacques Verron³, Pierre Bahrel⁴, John A. Barth⁵, Mathieu Belbéoch⁶, Jérôme Benveniste⁷, Pascal Bonnefond⁸, Eric P. Chassignet⁹, Sophie Cravatte¹⁰, Fraser Davidson¹¹, Brad deYoung¹², Michelle Heupel¹³, Emma Heslop¹⁴, Cora Hörstmann¹⁵, Johannes Karstensen¹⁶, Pierre Yves Le Traon^{14,17}, Miguel Marques¹⁸, Craig McLean¹⁹, Raul Medina²⁰, Theresa Paluszkiwicz²¹, Ananda Pascual², Jay Pearlman²², George Petihakis²³, Nadia Pinaridj²⁴, Sylvie Pouliquen²⁵, Ralph Rayner²⁶, Iian Shepherd²⁷, Janet Sprintall²⁸, Toste Tanhua¹⁶, Pierre Testor²⁹, Jukka Seppälä³⁰, John Siddorn³¹, Soeren Thomsen²⁹, Luis Valdés³², Martin Visbeck^{15,33}, Anya M. Waite³⁴, Francisco Werner³⁵, John Wilkin³⁶ and Ben Williams³⁷

¹ Balearic Islands Coastal Observing and Forecasting System (SOCIB), Palma, Spain, ² Mediterranean Institute for Advanced Studies (IMEDEA) (CSIC-UIB), Esporles, Spain, ³ Ocean Next, Grenoble, France, ⁴ Mercator Ocean International, Ramonville-Saint-Agne, France, ⁵ College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis,

The ocean observing system needs organizational transformative changes, cultural, behavioral, management....

SUMMARY: THE RIGHT TIME FOR THE OCEAN & OCEAN OBSERVING SYSTEMS, & OPEN SCIENCE A CLEAR PATHWAY

- Changes in Science, Technologies, Science to Society relations, new opportunities: UN Ocean Decade, Digital Twins,...
- Regional & Coastal Ocean Observing Systems/Marine Research Infrastructures: key elements leading these changes because:
 - Critical mass, scientific excellence driven, and also...
 - Mission oriented, multi-disciplinary approach & Integration capabilities, leadership
 - Society Engagement, RRI

In other words: ...

Research Infrastructures provide the symbiotic ecosystem that allows “Scientific Excellence with Impact on Society”, effective synchronization elements, building trust and responding to a clear & well established common goal, fully aligned with Open Science. But ... we still need INTEGRATION... , leadership & transformation...

SOCIB TEAM

45



SOCIB PARTNERS; integrating science, technology and society



“We investigate the ocean. we share the future”

Thank you!