

# Routine monitoring and research with ARGO in the western Mediterranean Sea: SOCIB and IMEDEA

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# Contents

- Part 1: SOCIB and Argo
  - What is SOCIB?
  - Observing and Forecasting Network
  - Argo and Drifter Facility
  - SOCIB and IMEDEA
- Part 2: Heat Content and ongoing research with Argo
  - Seasonal heat content cycles and surface forcing
  - What next – IMEDEA/NOCS PhD Research Project

# What is SOCIB?

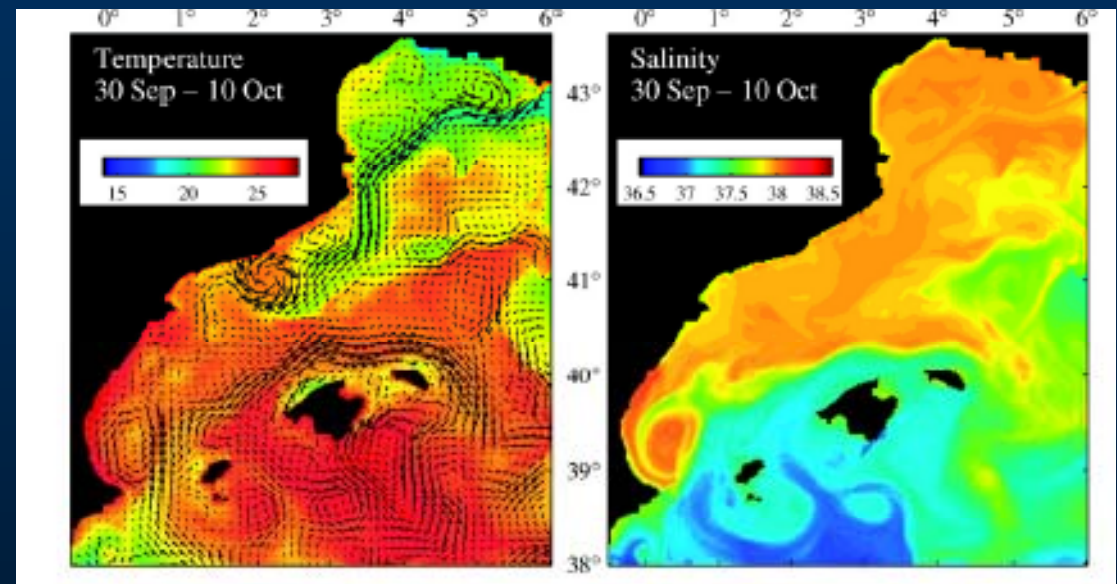
SOCIB is the new Coastal Ocean Observing and Forecasting System located in the Balearic Islands

- A multi-platform distributed and integrated system that will provide streams of oceanographic data and modeling services to support operational oceanography within a European and international framework. A new facility of facilities, open to international access
- Contributing to the needs of marine and coastal research in the context of global change
- Joint funded by the Spanish Government (MICINN) and the Balearic Islands Government to 2021, new approach, long term monitoring

# The Balearic Islands – strategic location

## SOCIB benefits from the Balearic Islands strategic location:

- Central in western Mediterranean
- Important transition area between Atlantic and Mediterranean waters
- Significant interactions between basin and sub-basin scale circulation, with mesoscale and submesoscale dynamics of particular relevance
- Local dependence on marine activities (maritime traffic, fishing, tourism)
- Marine reserves and other vulnerable marine ecosystems



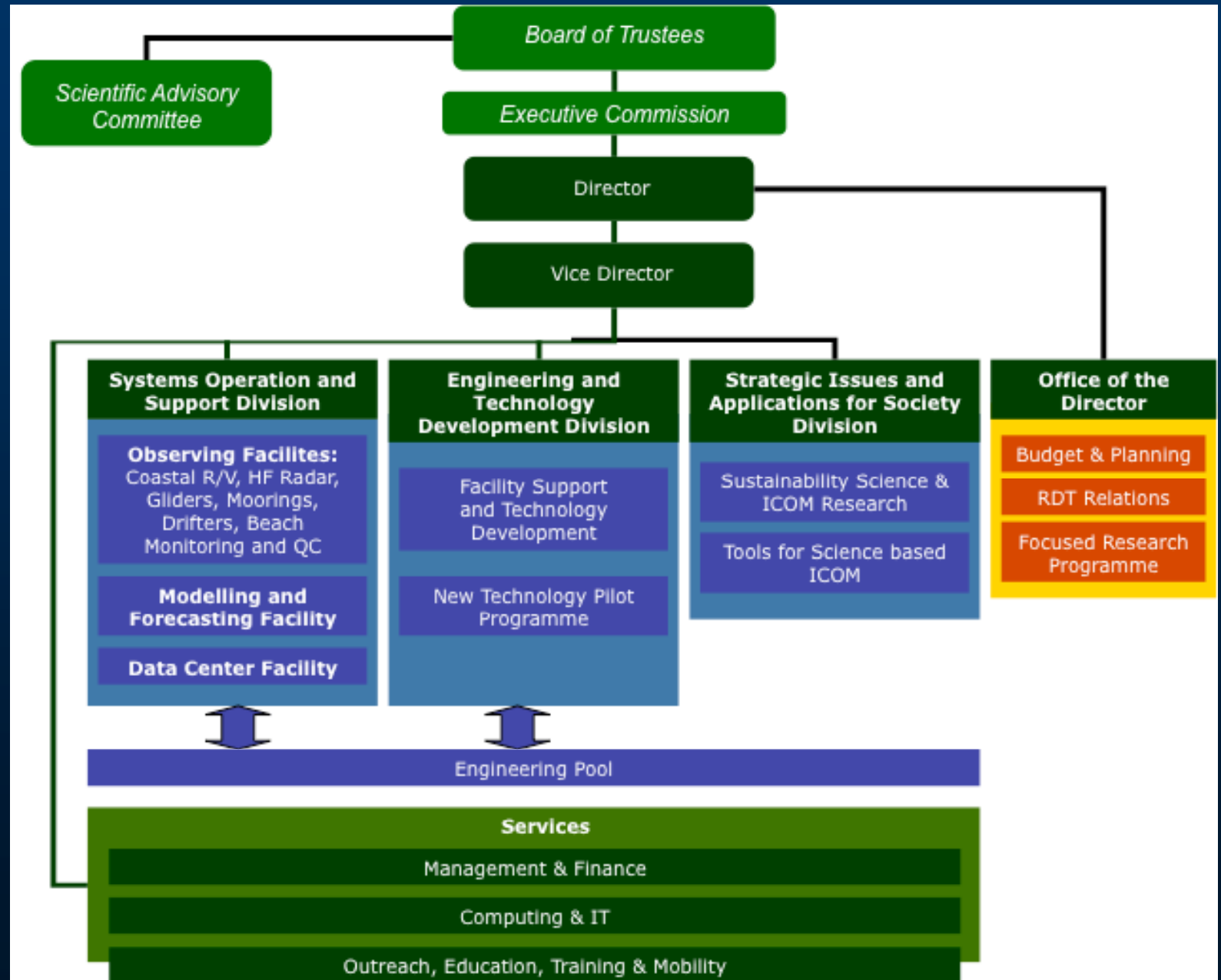
# SOCIB Mission

To develop a coastal ocean observing and forecasting system that will:

- provide free, open, quality controlled and timely streams of data
- support research and technology development on key internationally established topics
- consolidate operational oceanography and associated marine technology development in the Balearic Islands and in Spain
- support the strategic needs of society in the context of global change

# SOCIB Structure

Drivers are 3 fold:  
 - international scientific priorities,  
 - technology and  
 - the specific interests of society

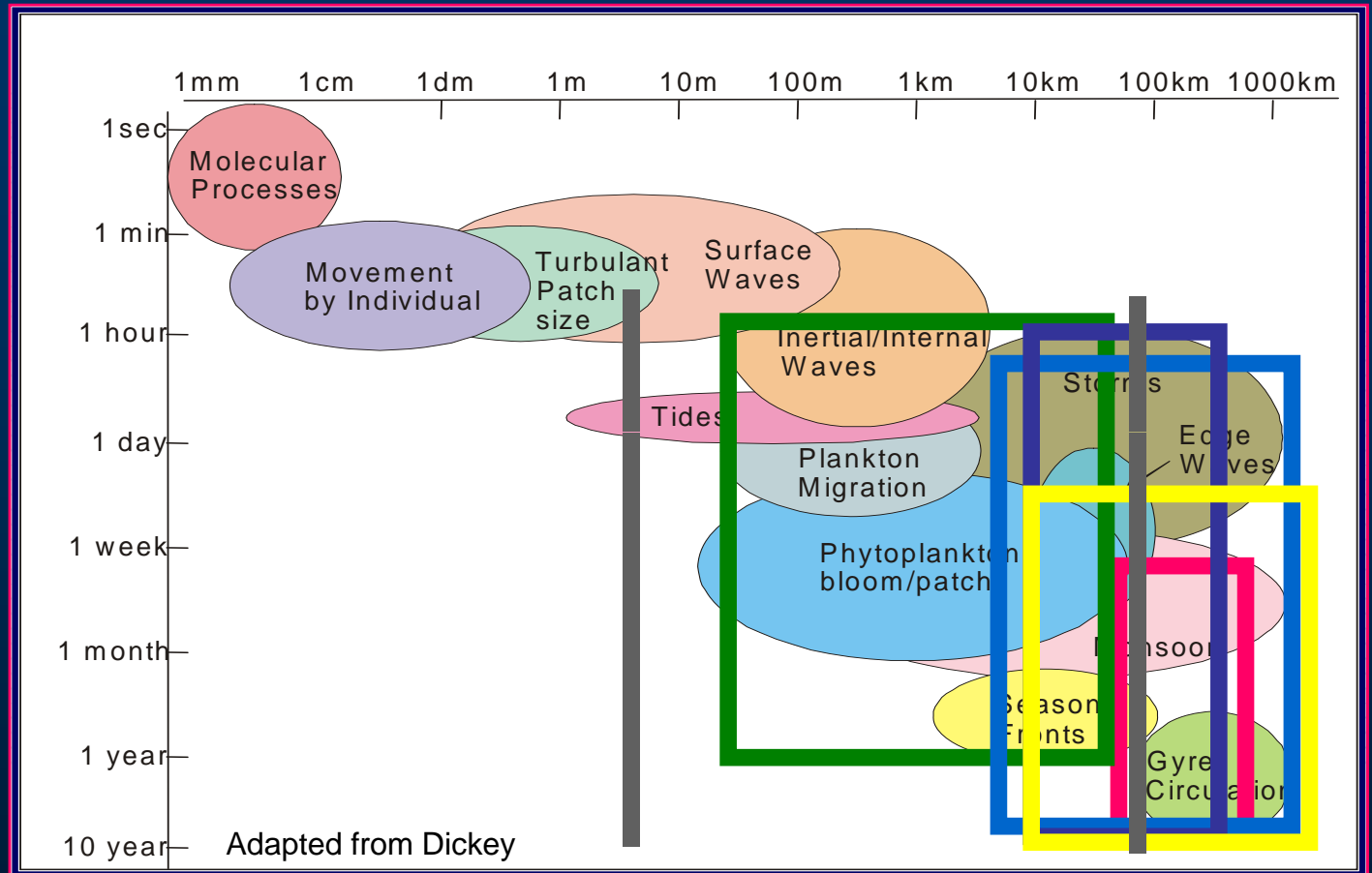


# Scale: monitor coastal to basin scales

Vision: to advance on the understanding of physical and multidisciplinary processes and their non linear interactions, to detect and quantify changes, understand the mechanisms and to forecast their evolution, under e.g. IPCC scenarios

Monitor: nearshore to coastal ocean regional variability, mesoscale, submesoscale, interactions and ecosystem response

Specifically: addressing the preservation and restoration of the coastal zone and its biodiversity



**ARGO**

**Gliders**

**HF radar**

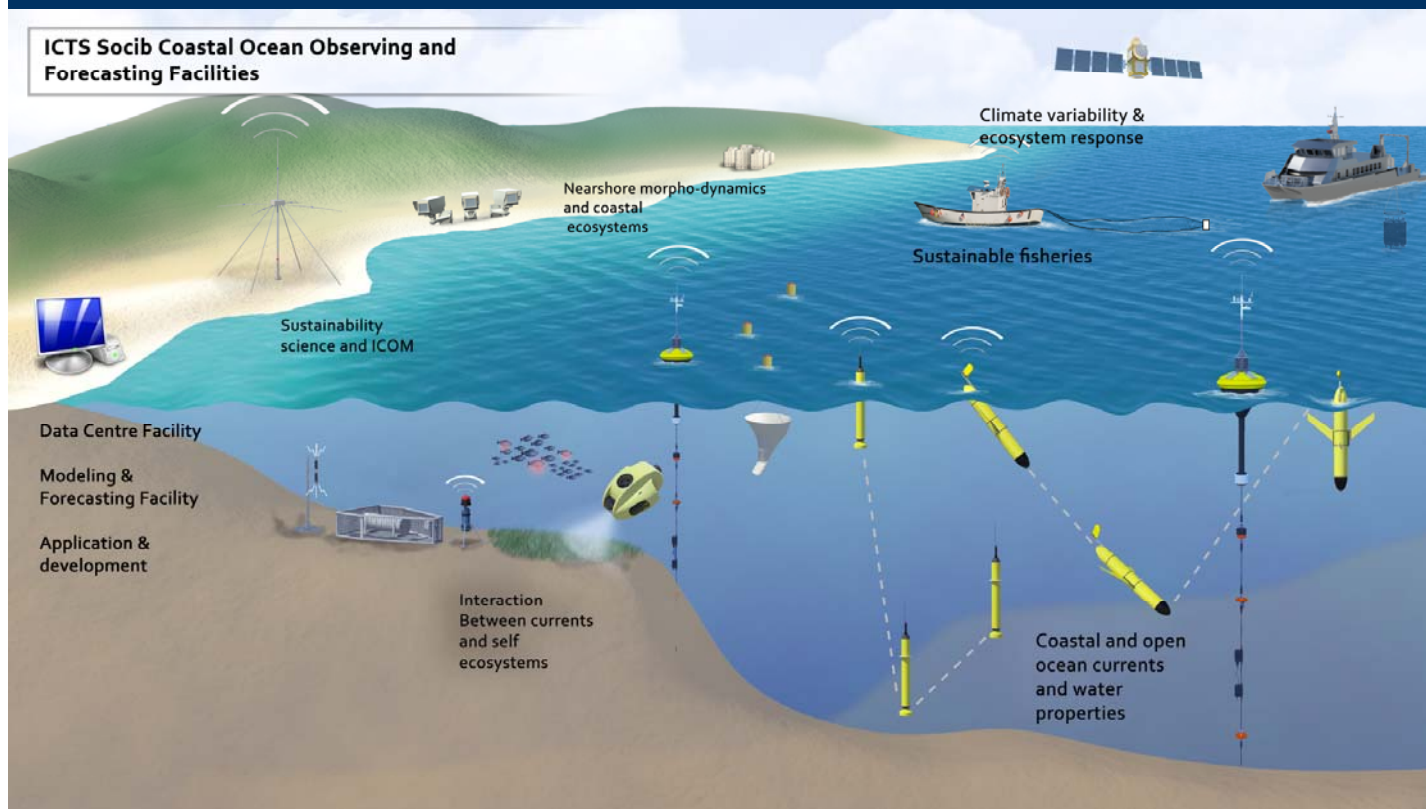
**Time series**

**AUV's**

**Spatial survey**

- finding new approaches and advancing a more science based sustainable management of ocean and coastal areas

# SOCIB Facilities



## Initial Observing Facilities:

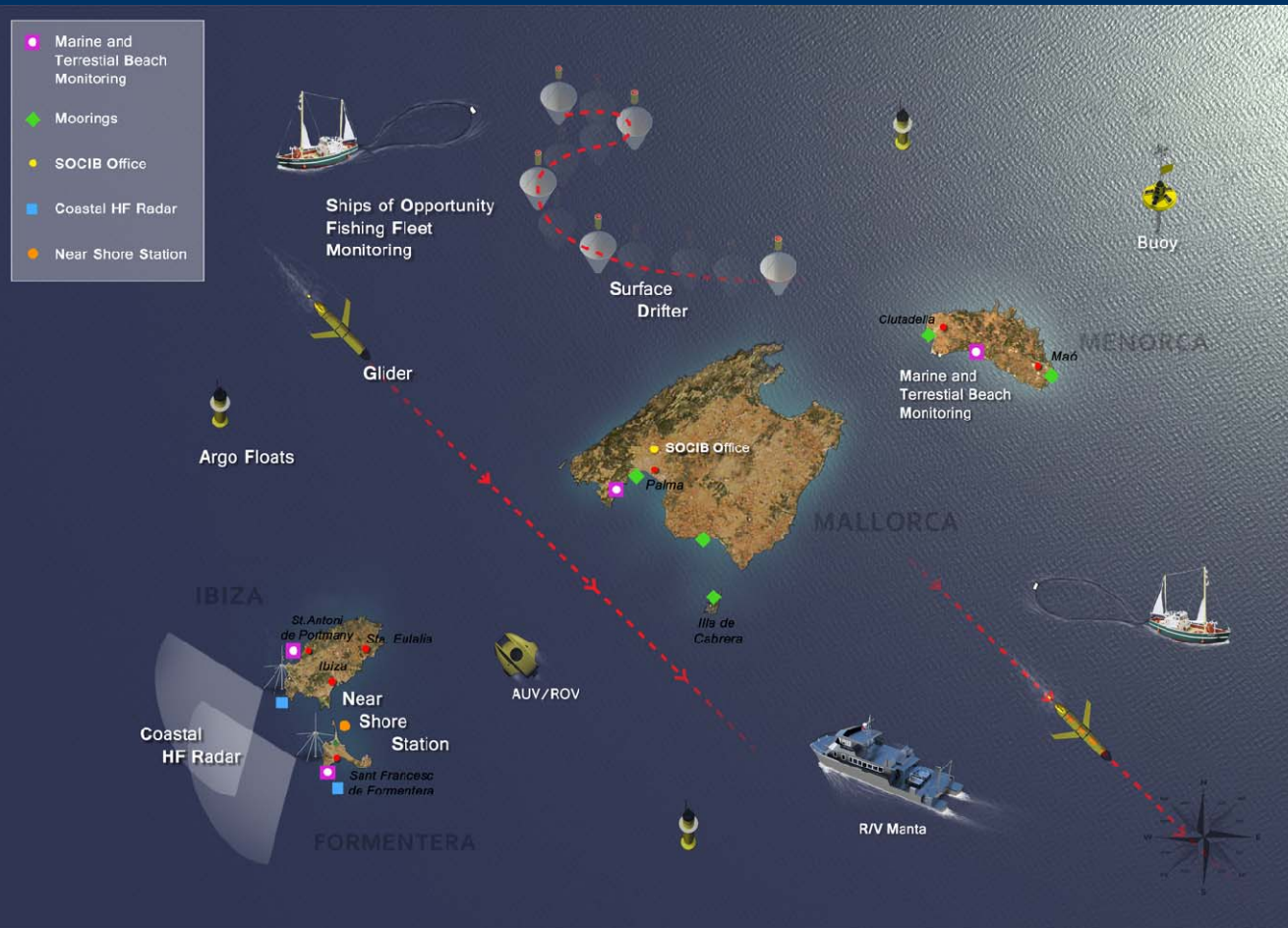
1. R/V (24m Catamaran)
2. Fixed coastal buoys
3. HF radar
4. Gliders
5. Argo floats & surface drifters
6. Beach monitoring system

Additional monitoring and visualisation technologies under development in ETD

Observational datasets are integrated to exploit the synergies between observed data per se and the observed and numerical modelling datasets. To enable real time monitoring of the state of the coastal zone and prediction of its spatial and temporal evolution.



# Observing and Forecasting Facilities



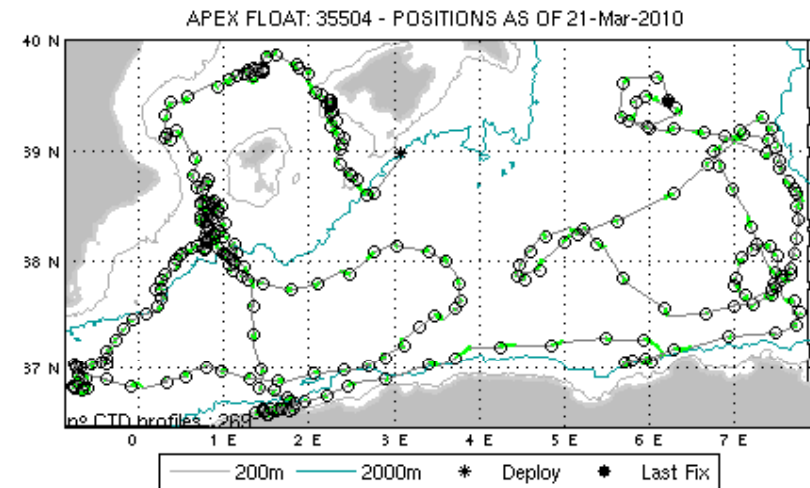
Forming a sustained, spatially distributed, heterogeneous, potentially re-locatable and dynamically adaptive observing network

With data streams from observing network open and free to international access and from 2012 onwards external, peer reviewed, access to the observing network will be enabled

Through monitoring, data integration, technology development and cooperation with research institution partners SOCIB aims to enable 1) advances in key topics of international interest and 2) application and transfer of knowledge to make advances of relevance to society, particularly in the area of ICOM

# SOCIB Argo and Drifter Facility

- Mostly centered in the western Mediterranean, with focus in the Balearic Islands and adjacent sub-basins, Algerian and Alborán
  - SOCIB aims to maintain an active fleet of 8 Argo floats and 16 Surface Drifters
  - Contributing to the Euro-Argo program (Pedro Vélez-Belchí, IEO, scientific coordinator)
- 
- Complex Mediterranean ocean dynamics mean aim for coverage at resolution  $2^\circ \times 2^\circ$



# SOCIB Euro-Argo Deployment

## Planned Deployments:

- 2010 – 4 Argo and 8 Drifters – location Balearic and Algerian basin
- 2011 - 4 Argo and 8 Drifters – location Balearic and Algerian basin\*
- 2012 - 2 Argo and 4 Drifters – location Balearic and Algerian basin\*
- 2013 - 2 Argo and 4 Drifters – location Balearic and Algerian basin\*

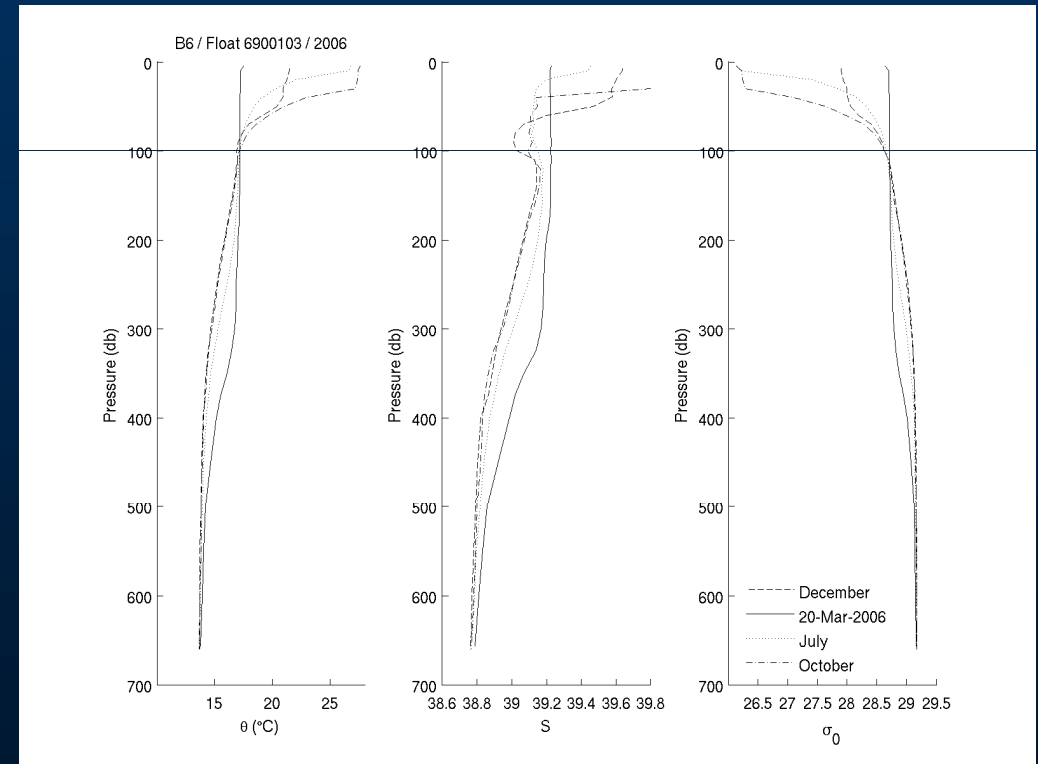
## Data stream assimilation :

- 2011 – Data assimilated into SOCIB web site
- 2012 – Integrated viewing tools available

\* to be reviewed each year within Euro-Argo frame and existing float density etc.

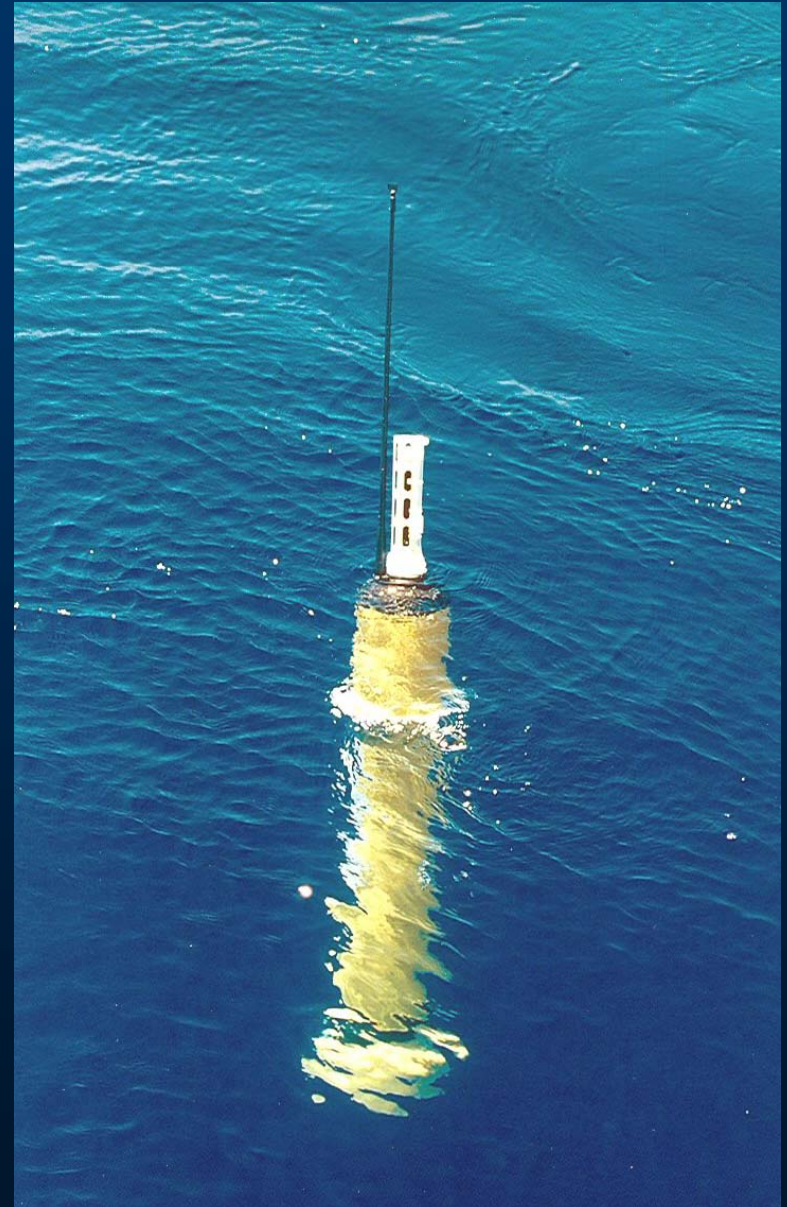
# SOCIB Argo Applications

- Real-time monitoring of broad scale ocean structure (T, S and deep currents), contributing to our understanding of deep and intermediate waters and the role of atmosphere and large scale circulation in Mediterranean
- Data assimilation into HOPS and ROMS to verify 3D current fields
- Integrated with other facility datasets in particular with glider data – blending large scale and mesoscale datasets to develop a new integrated view - available through SOCIB portal
- Specific research projects in collaboration with IMEDEA

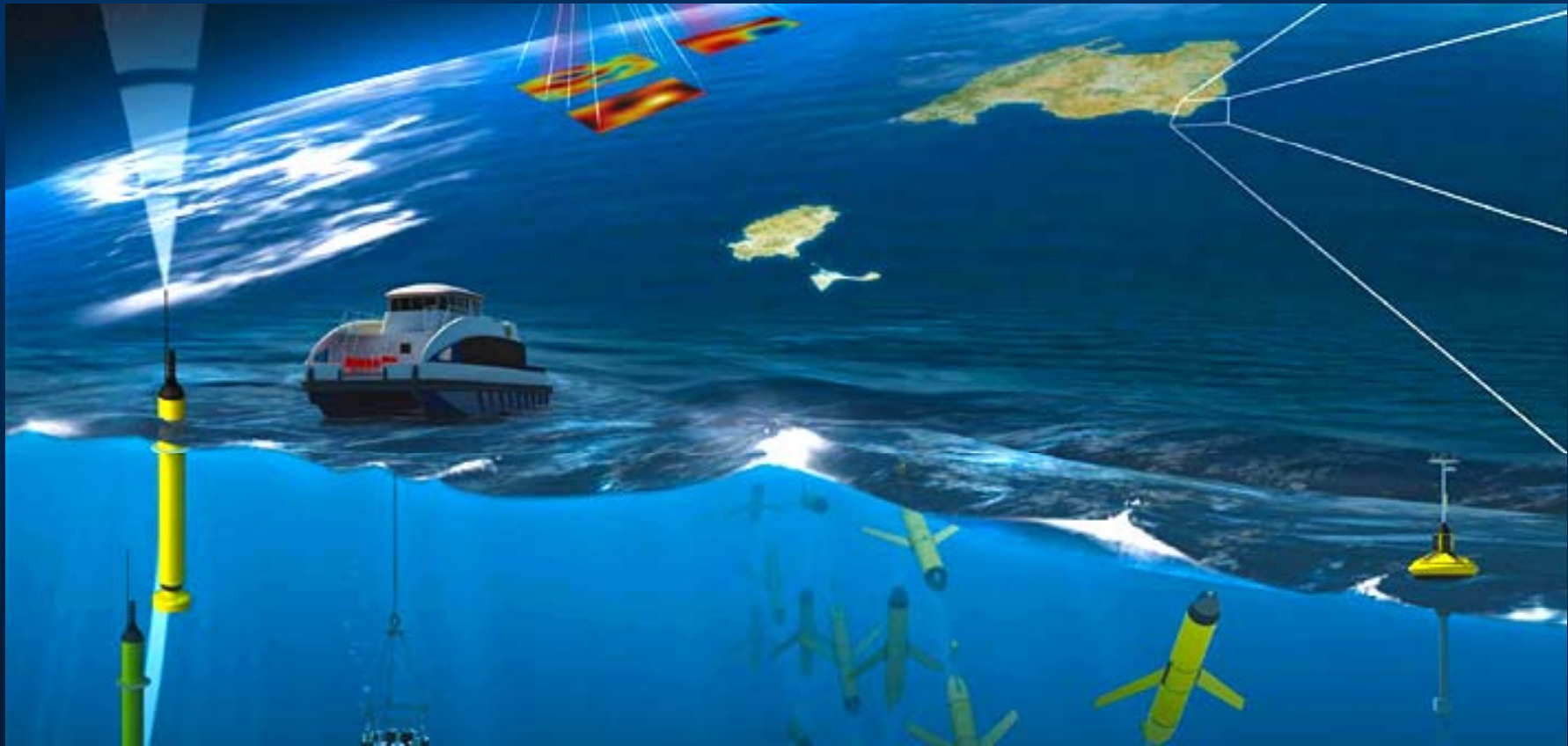


# SOCIB and IMEDEA

- With funding approved until 2021, SOCIB will undertake responsibility for routine monitoring, assimilation and forecasting in the Balearic Seas area
- The underlying scientific research will be carried out at IMEDEA and other research institution partners
- SOCIB developed from research initiatives in the Balearic Islands and remains closely integrated

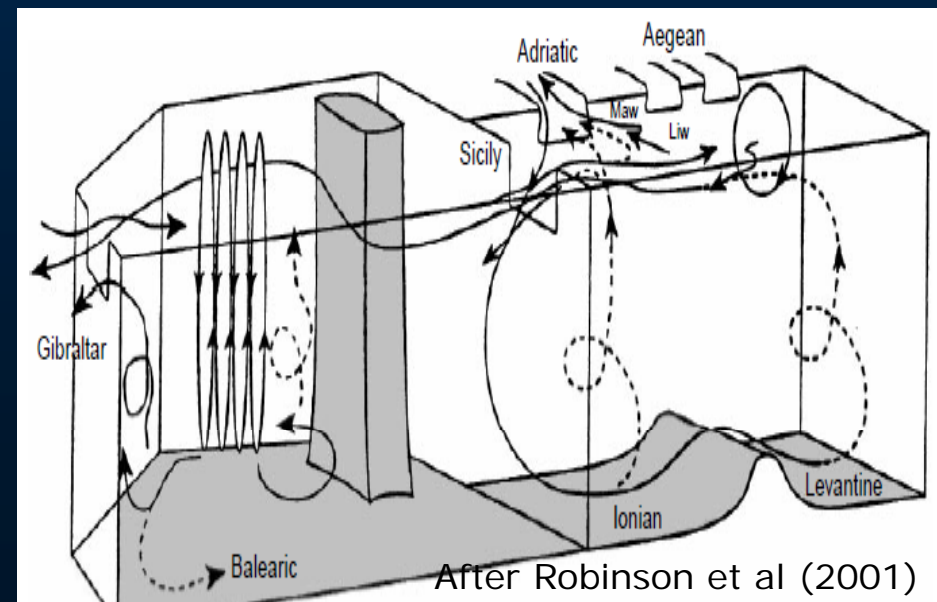


# From SOCIB monitoring to Argo research.....



# Heat Content Budgets and the Mediterranean Basin

- 2009 MSc Research Project: University of Southampton supervisor Prof. Harry Bryden
- Research question: Heat loss from the Mediterranean basin is measured at  $-5.2 \text{ Wm}^{-2}$  (Macdonald et al 1994), surface forcing from climatology datasets NCEP/NCAR indicates a gain of  $+2 \text{ Wm}^{-2}$  (Josey 2003) - this represents an unknown bias that may affect our understanding of surface forcing with reference to issues like DWF
- Hypothesis: Bias in NCEP visible in seasonal cycle heat content
- Two datasets:
  - In situ Argo T/S profiles
  - surface forcing NCEP/NCAR Reanalysis heat fluxes
- Gain insight through comparing:
  - heat content surface ocean (2004 – 2008)
  - anticipated from surface heat fluxes



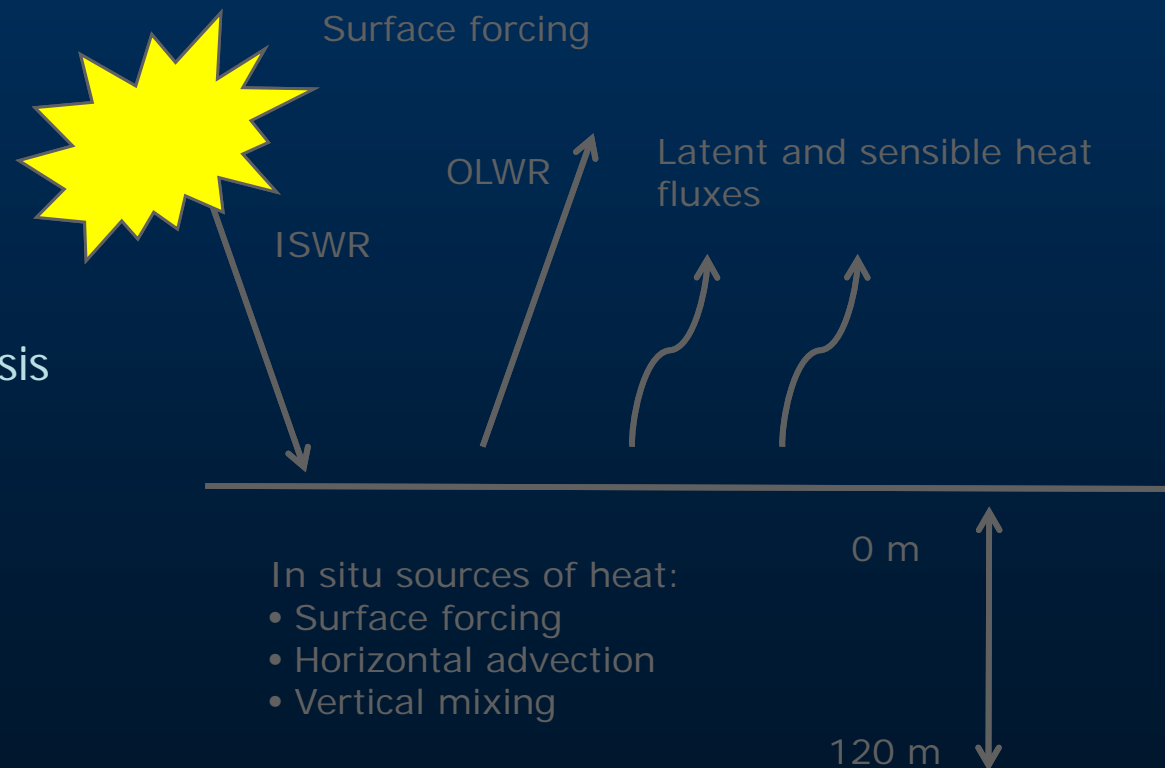
# Method

## Calculation:

- Surface forcing: Calculated from NCEP ( $Q_{TOT} = Q_S + Q_B + Q_H + Q_E$ )
- Heat Content Cycle: calculated from Argo ( $HC = \int C_p(z) A dz$ )

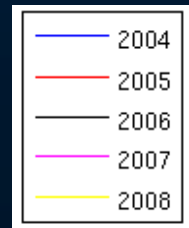
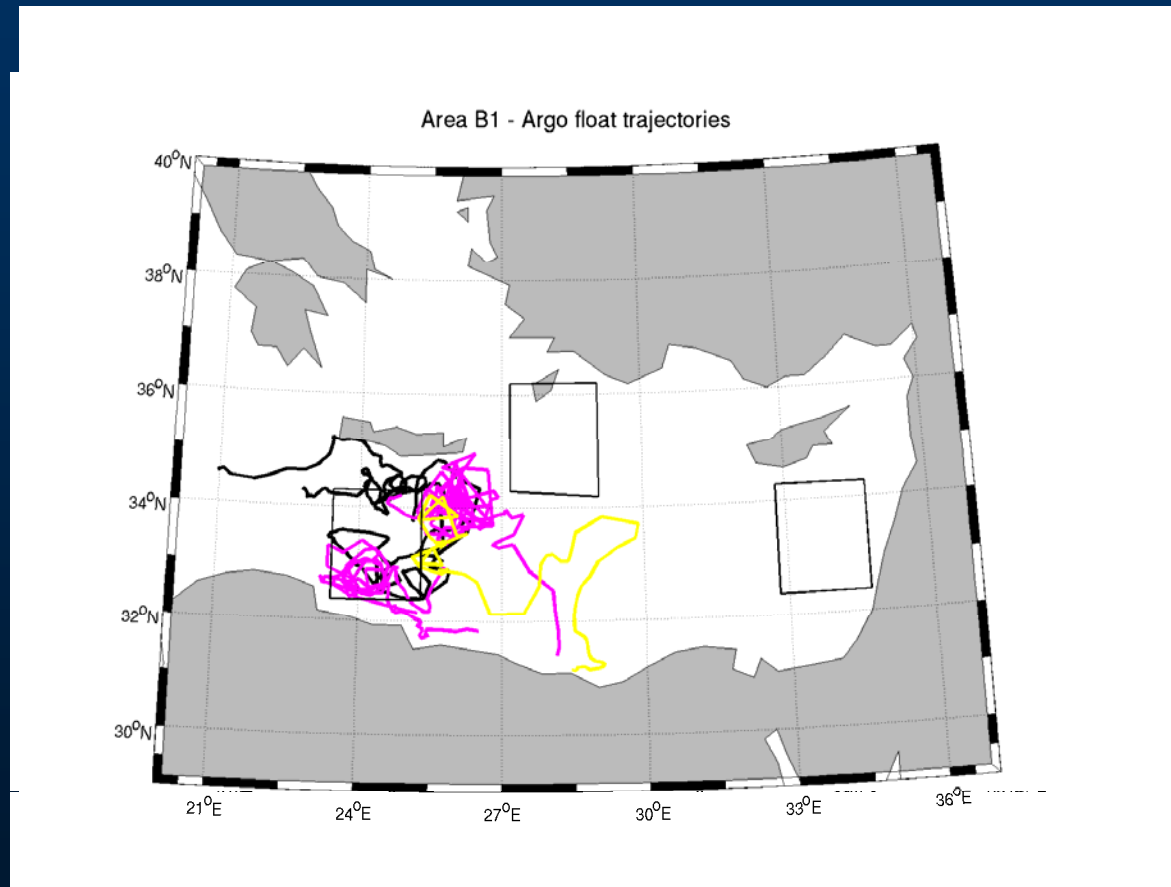
## Comparison:

- NCEP/NCAR grid box areas  $2^\circ \times 2^\circ$
- Multiple floats, multiple years
- 'Along' float trajectories
- Remained within box (approx.)
- 3 Areas in eastern Mediterranean
- 2 Areas in western Mediterranean
- Cumulative heat content annual basis

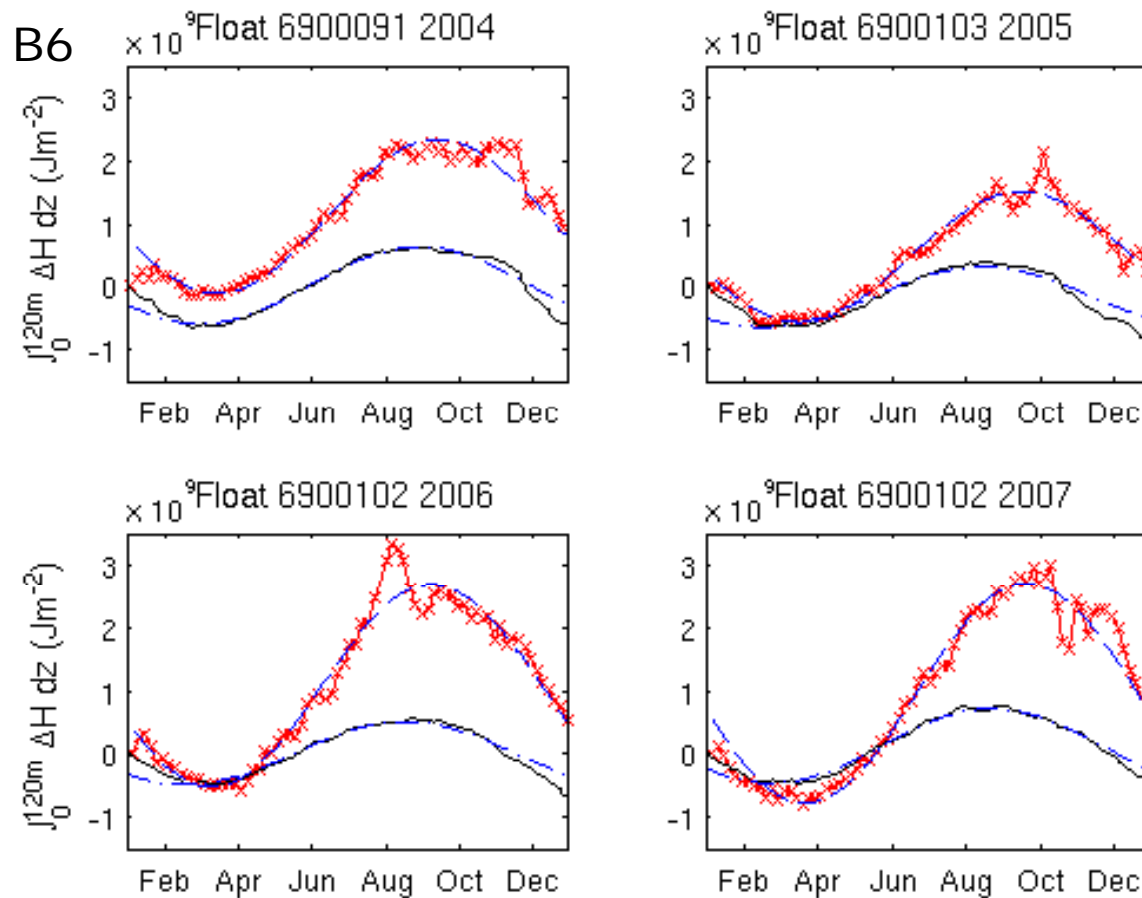




# Sample Results – Eastern Mediterranean



# Sample Results – Area B6



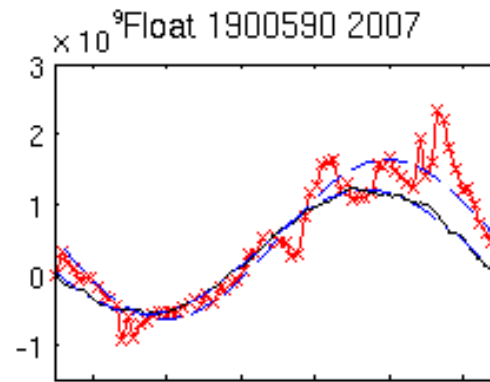
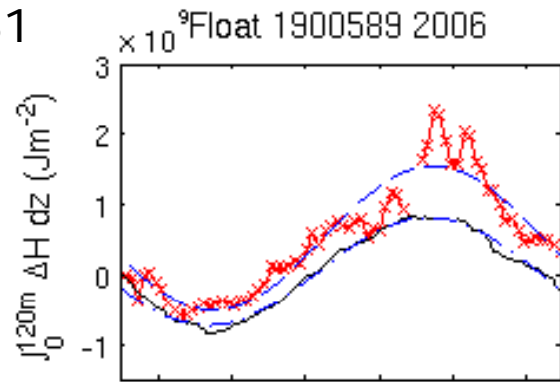
- Argo (red) / NCEP (black)
- Least squares regression (blue dash)
- Key indicators amplitude and date maximum

For Area B6 (SE Levantine)

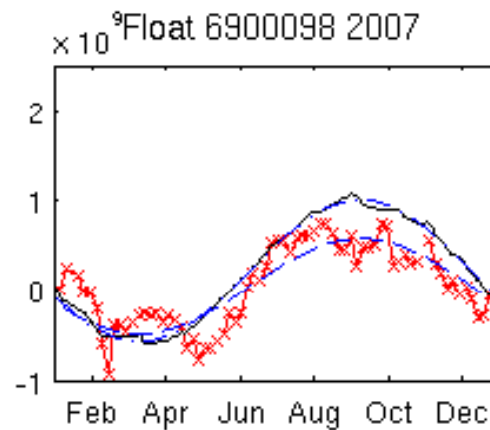
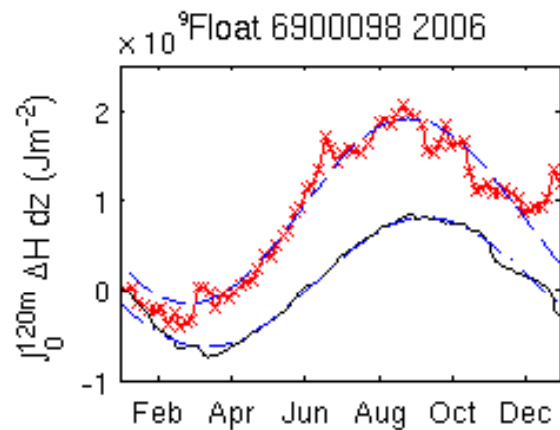
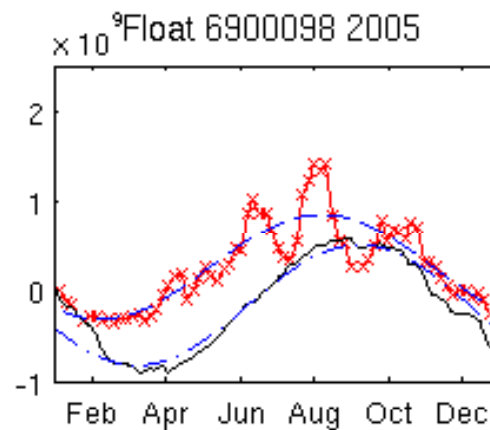
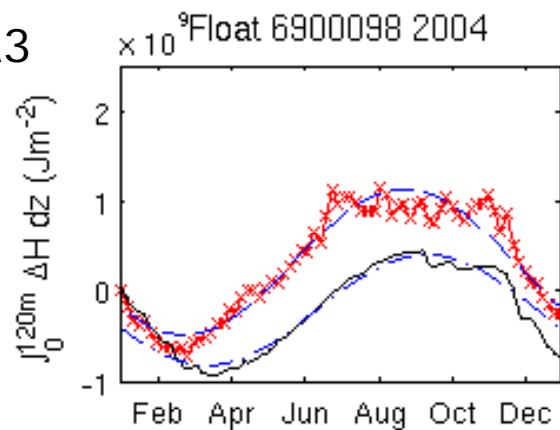
- Consistent summer amplitude Argo cycle > NCEP
- Cumulative  $\pm 15 \text{ Wm}^{-2}$  NCEP margin not explain
- Residual (Argo-NCEP) - has consistent timing and significantly greater amplitude
- Bias, advection, surface forcing?

# Sample Results – Area A3 & B1

B1



A3



For Area B1 (SW Levantine)

- Remarkably similar to NCEP
- Variance and standard deviation confirm

For Area A3 (Mid N Levantine)

- Flatter summer, higher late winter heat content
- Not statistically different to NCEP

# Causes?

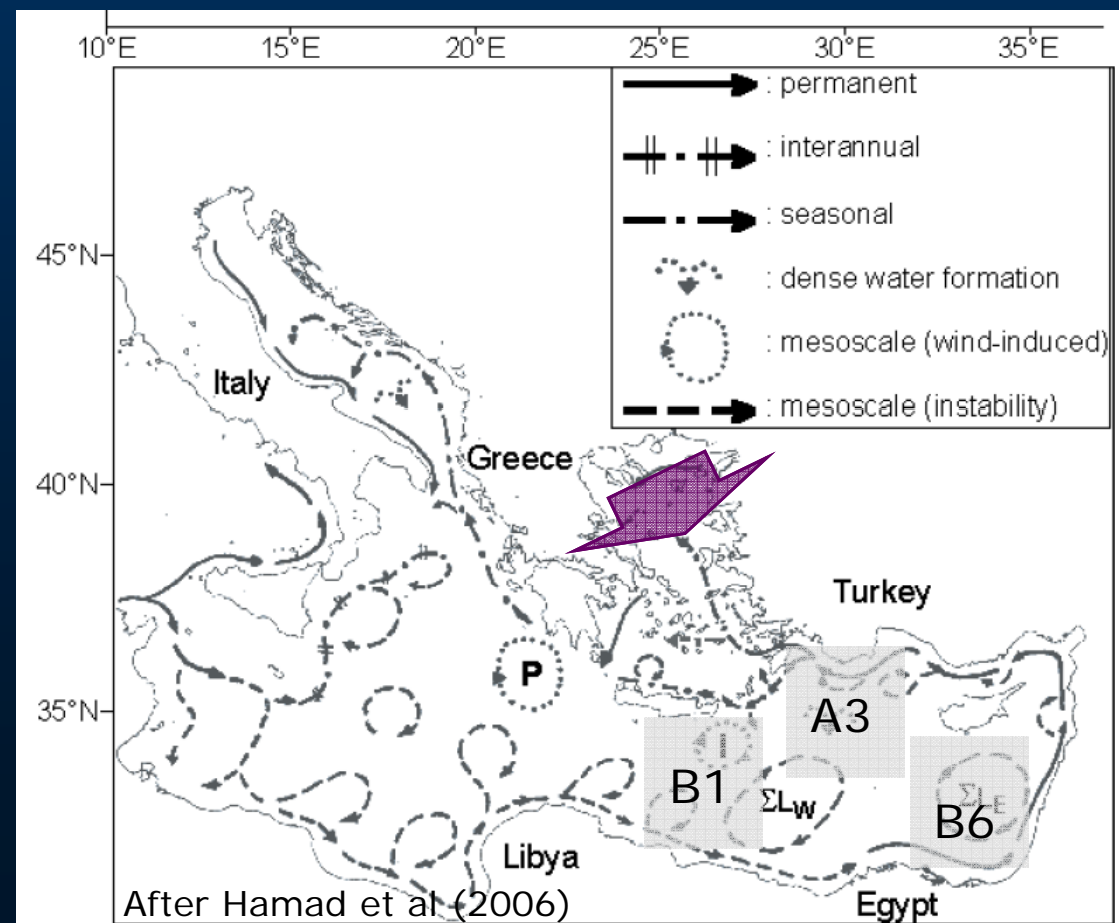
- Eastern Med - 3 areas have different local seasonal patterns of heat content
- No consistent bias with NCEP, B1 good match, B6 significantly different

## Relating to the physical environment

- Surface circulation – AW anti-clockwise basin wide gyre, permanent eddies/meanders
- Meltemi wind – May – Sept

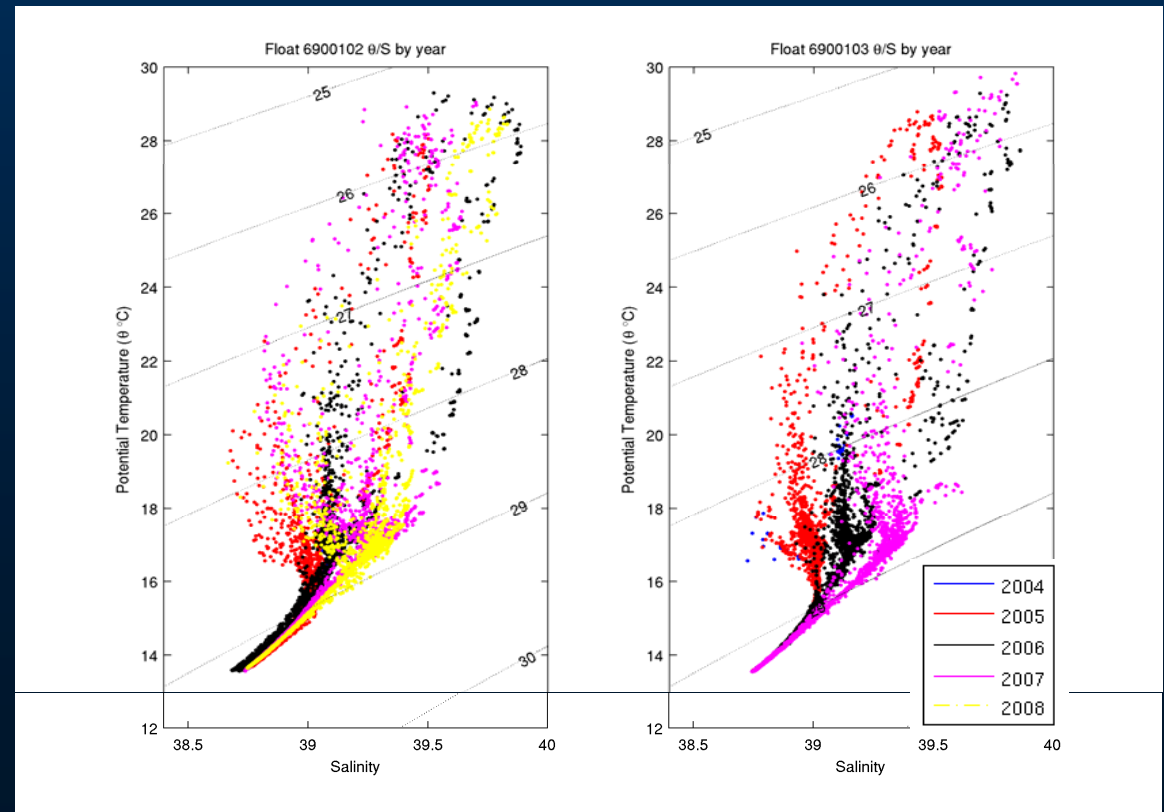
## Insight into causes:

- B6 coincident with Meltemi - advection of warm water south
- A3 cool summer, removal surface waters, stronger AW flow in winter



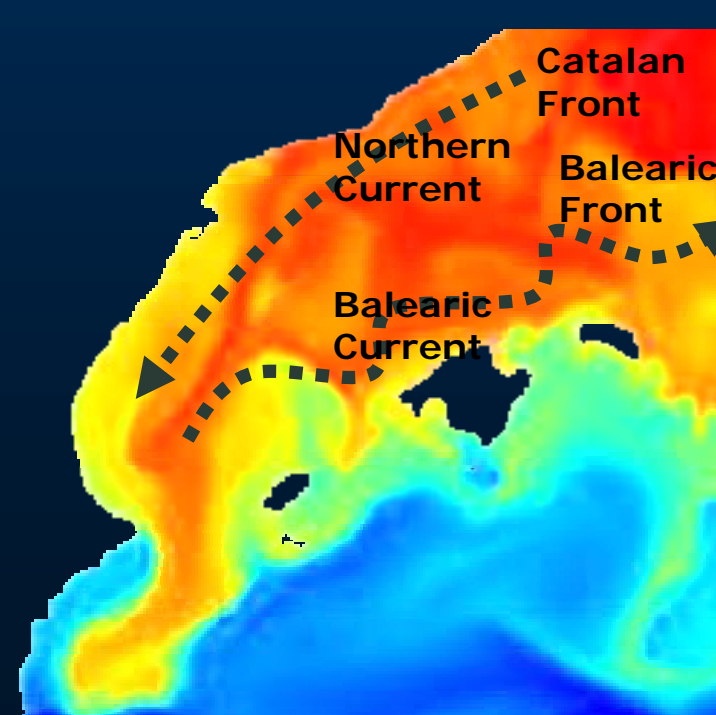
# Insight and Conclusions

- Areas (5) have different local seasonal patterns of heat content captured by Argo
  - No consistent pattern of bias between Argo and NCEP indicated
  - NCEP does a reasonable job in some areas, but complex local winds not well enough represented, finding concurs with other research (Ruiz et al 2008 - downscaled flux data)
  - Likely that significant differences between Argo and NCEP related to advection
  - Further investigation could correlate timing of advection to other local datasets
- 
- Currently float coverage not sufficient for a Mediterranean-wide approach, particularly areas stronger currents

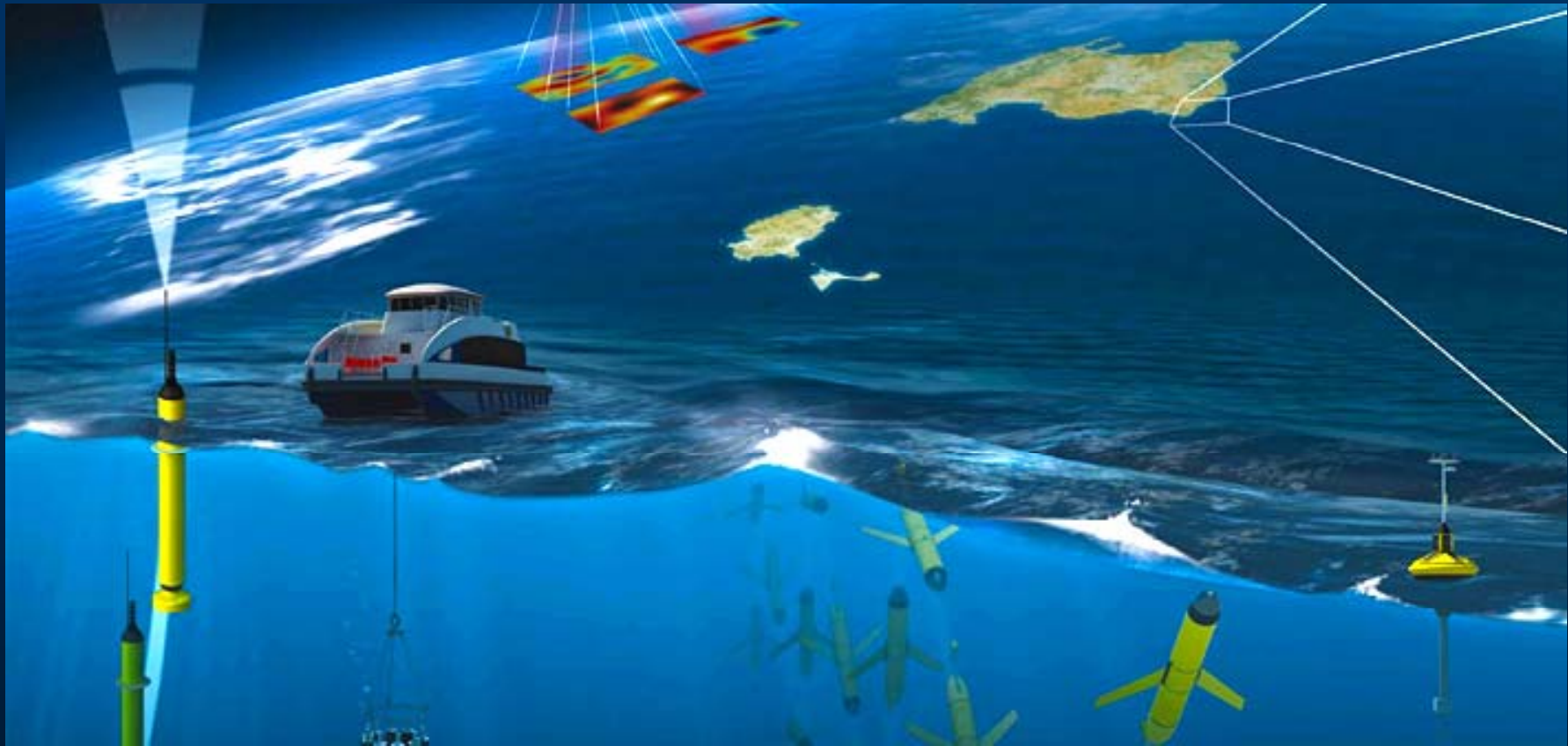


# What next – IMEDEA/NOCS PhD Research Project

- Datasets: Argo, glider, CTD, model
- Rational: The climate of the Mediterranean is influenced by complex interactions across different components of the climate system and studies need to span a range of temporal and spatial scales to validate model representation and to analyse and understand the response of the Mediterranean oceanic processes to climatic variability
- Aim: to try and encompass some of this scale by concentrating on a particular aspect in a particular area and assessing seasonal to decadal changes at a variety of scales
- Focus: variability of physical dynamic elements the Balearics Sea region, specifically the position and strength of the Catalan front and the Balearic front and associated currents
- Including: model outputs ( Med-MFC and ROMS) and a new multi-glider experiment in the south western Mediterranean Sea to investigate submesoscale dynamics
- Just started!



Any questions or comments most welcome.....



# Coastal Ocean Observatories

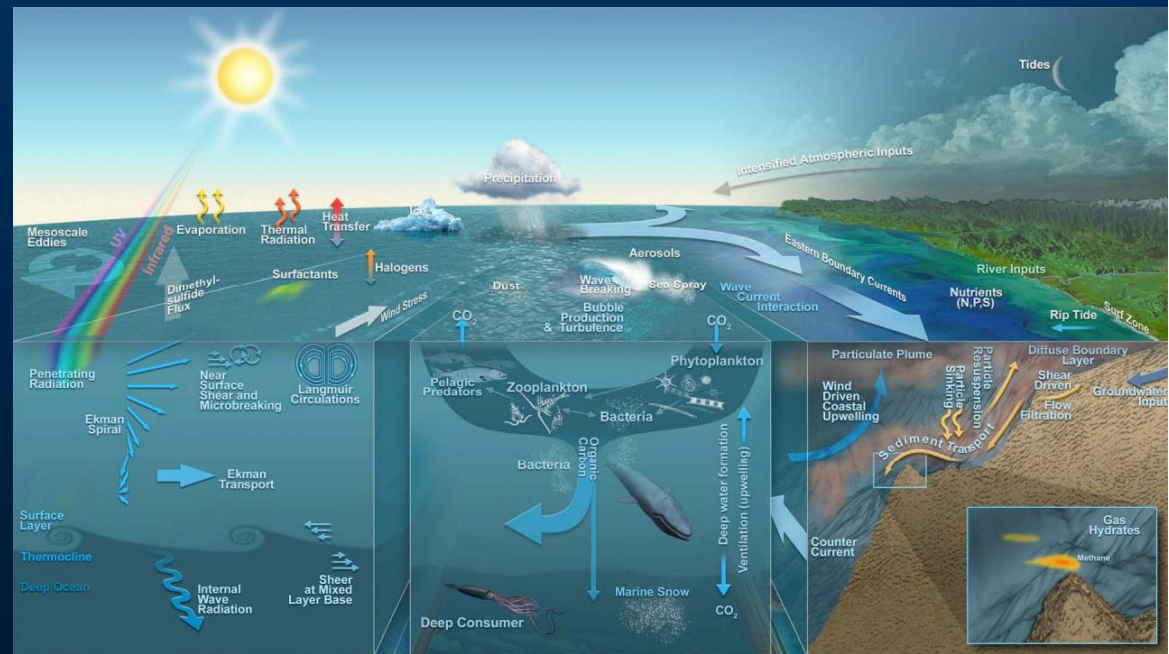
## A New Approach to Marine and Coastal Research

New technologies now allow three-dimensional real time observations, that combined with forecasting numerical models and data assimilation enable

**IMOS, NEPTUNE, VENUS, OOI, IOOS**

A quantitative jump, in scientific knowledge and technology development

And the development of a new form of Integrated Coastal Zone Management, based on recent scientific and technological achievements





# Area of study

Glider

## Missions Background

*The Mediterranean Sea can be considered as a reduced scale ocean laboratory, where processes are characterized with smaller scales than in other oceanic regions.*



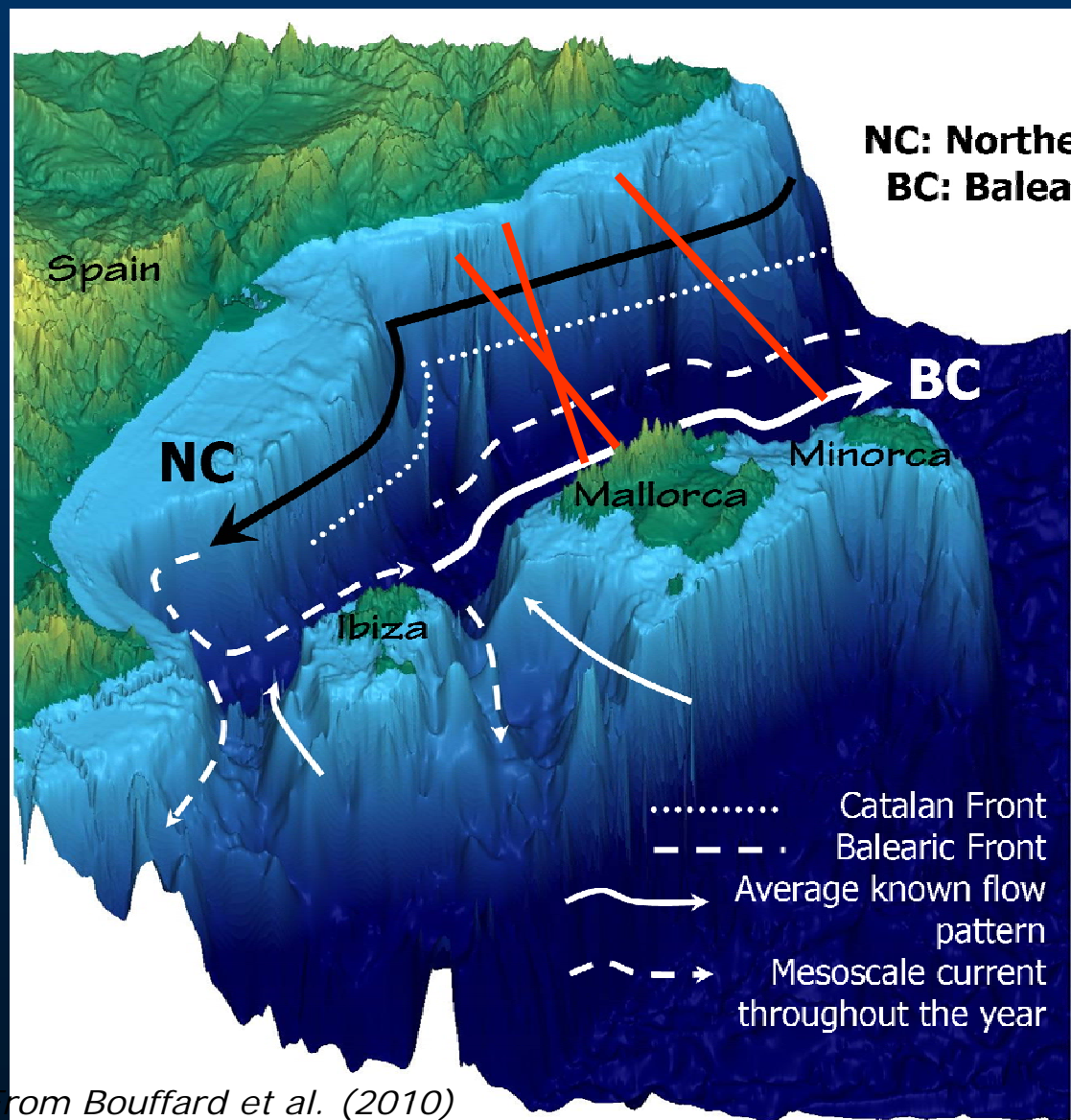
- **ENVISAT:**
  - Balearic Sea: T-773, 6 missions (every 70 days);
- **JASON-1/2:**
  - Alboran Sea: T-172 (July 2008).
  - Balearic Sea: T-70 (August 2008).
- **JASON-1 (new orbit):**
  - Balearic Sea: T-70 (May, Oct & Dec 2009).

**11 glider missions**  
from July 2007 to December  
2009 in the WMed along  
altimeter tracks

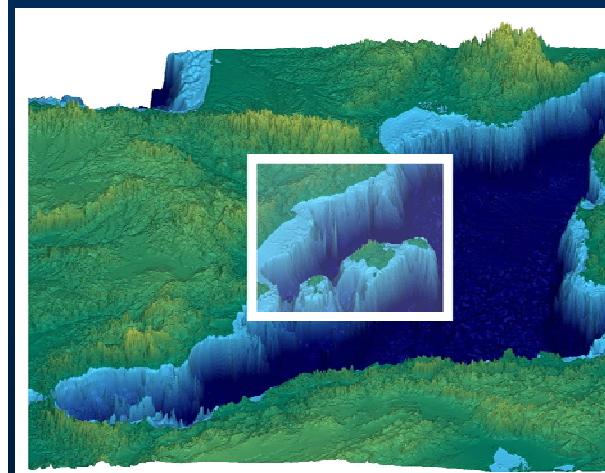
5500 full CTD casts  
+ oxygen, chlorophyll, turbidity

# Area of study

## Circulation



From Bouffard et al. (2010)



***Glider missions  
perpendicular to the  
main features of the  
basin***

# Data Sets



## Envisat /Jason

- Along track SLA (1 Hz / 20 Hz) Horizontal resolution: 7 km / 500 m
- Corrections:
  - o Tides, HR HF barotropic motion (DAC), ...
- Gridded products
- MDT: Mean Dynamic Topography (Rio et al. 2007)
- ADT = SLA + MDT

## Glider

### - Variables:

P, T, S, oxlg., chl., turb.  
Depth averaged GPS currents

### - Vertical extension:

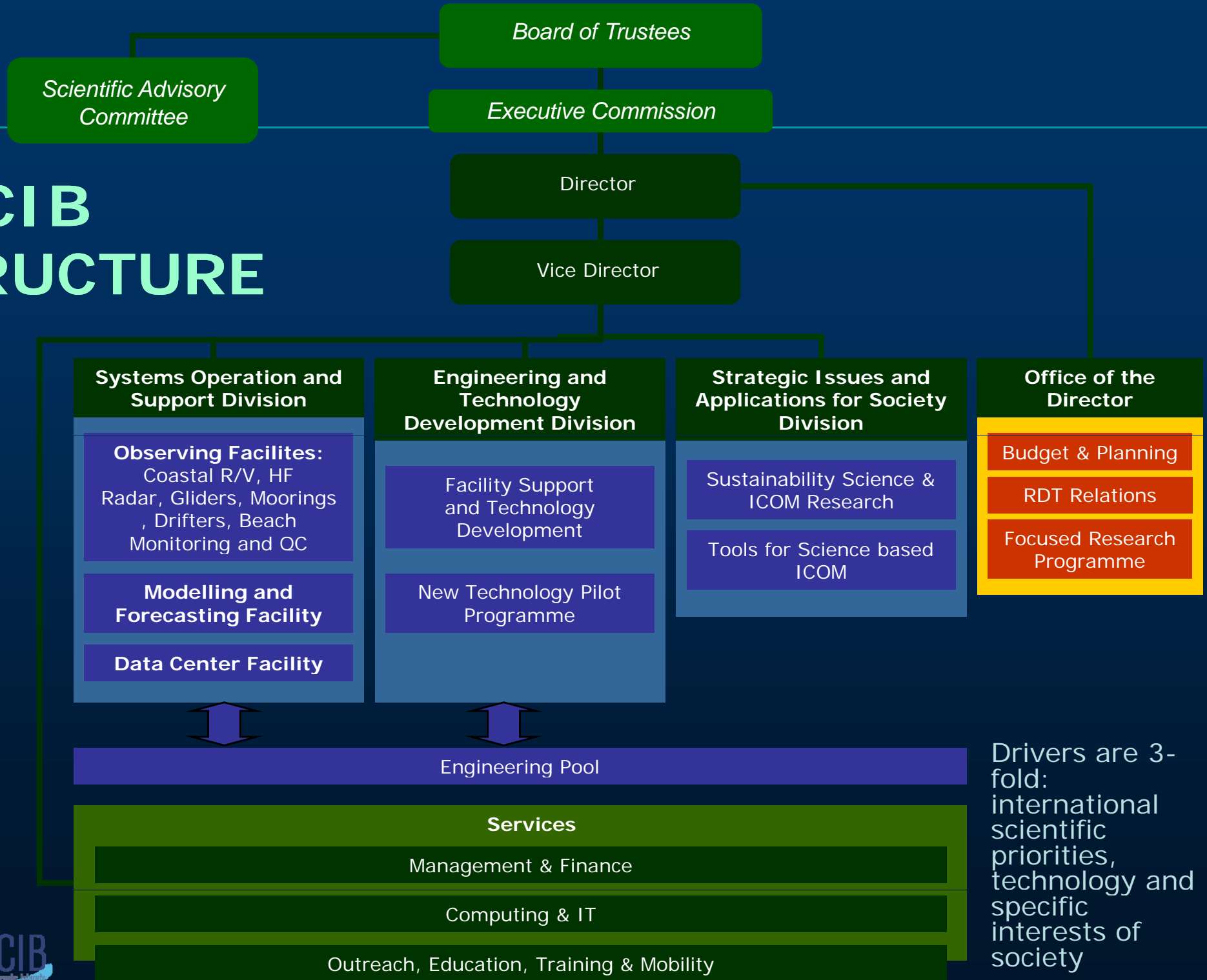
10-180/600 m

### - Horizontal resolution:

300 m/ 1.1 km



# SOCIB STRUCTURE



Drivers are 3-fold:  
international scientific priorities, technology and specific interests of society



# Observations to Deliverables



## Observing Systems

### Fixed

- HF Radar
- Coastal buoys
- Beach Monitoring
- Nearshore Cable Station

### Mobile

- SOCIB R/V Operations
- Gliders
- AUV's and ROV's
- Argo and Surface Drifters
- Fishing Fleet Monitors

## Variables

- U, V (currents, surface and profile)
- T (fixed point, profile, SST)
- Hs, Hm, Tp, Dp (Waves)
- S (fixed point, profile)
- Beach morphology
- Coastal bathymetry
- Sediment samples
- Sediment transport (OBS)
- Fluorescence (profile)
- Oxygen (profile)
- Biogeochemical indicators (N, P, Si, larvae)

## Model Systems

- 3D coastal ocean forecasting system (HOPS)
- Operational currents forecasting system (ROMS)
- Coastal ocean wave propagation model (WAVE)
- Coupled (ROMS - atmospheric) high resolution operational forecasting system
- Coupled (ROMS - NPZD) physical - biological ecosystem model

## E.g. Products, Services & Outcomes

- Data Centre access portal
- Balearic Sea high resolution ocean currents forecast system
- Balearic Sea high resolution wave forecast system
- Early warning system for surge events
- Oil spill / jelly fish invasion trajectory estimations
- Balearic/Mediterranean beach system response to climate change
- Beach erosion and variability monitoring
- Adaptation to EU Framework legislation for the coastal zone
- Beach carrying capacity (physical and social)
- Tools for coastal zone decision makers
- Science based coastal zone policy recommendation
- Forecasting of Blue Fin Tuna spawning location and larval survival rates

# SOCIB: Science, technology and society

- To deliver, through the integration of observational data streams, modeling and cooperation with research institute partners 1) advances in key topics of international interest and 2) through local application and transfer of knowledge to make these advances of relevance to society, particularly in establishing a more science based sustainable management of the ocean and coastal areas.
- Over the longer term, our vision is to advance on the understanding of physical and multidisciplinary processes and their non linear interactions, to detect and quantify changes in coastal systems, to understand the mechanism that regulate them and to forecast their evolution and/or adaptation under, for example, different IPCC scenarios.
- More specifically, SOCIB will address the preservation and restoration of the coastal zone and its biodiversity, through the analysis of its vulnerability under global change and through considering new approaches, such as connectivity studies and Marine Protected Areas optimal design, to advance and progressively establish a more science based sustainable management of the ocean and coastal areas.

# SOCIB Facilities Deployment Schedule

Facilities achieve operational capability over 2011 and 2012  
 Aim to be operational with 8 facilities in 2013  
 With new technology under development

|   | 2009 |     | 2010 |     |     |     | 2011 |     |     |     | 2012  |       | 2013  |       |
|---|------|-----|------|-----|-----|-----|------|-----|-----|-----|-------|-------|-------|-------|
|   | Q3   | Q4  | Q1   | Q2  | Q3  | Q4  | Q1   | Q2  | Q3  | Q4  | Q1/Q2 | Q3/Q4 | Q1/Q2 | Q3/Q4 |
| <b>Systems, Operations and Support Division</b>             |      |     |      |     |     |     |      |     |     |     |       |       |       |       |
| Observing Facilities:                                       |      |     |      |     |     |     |      |     |     |     |       |       |       |       |
| Coastal Research Vessel                                     | CD   | CD  | PDP  | LP  | LP  | C   | C    | C   | C   | C   | IOC   | OM    | FOC   | FOC   |
| Coastal HF Radar  | CD   | CD  | PDP  | LP  | LP  | C   | C    | IOC | FOC | FOC | FOC   | FOC   | FOC   | FOC   |
| Gliders   | CD   | CD  | PDP  | LP  | IOC | IOC | OM   | OM  | OM  | OM  | FOC   | FOC   | FOC   | FOC   |
| Drifters  | CD   | CD  | PDP  | PDP | PDP | PDP | LP   | IOC | IOC | OM  | FOC   | FOC   | FOC   | FOC   |
| Moorings  | CD   | CD  | PDP  | LP  | C   | IOC | OM   | OM  | FOC | FOC | FOC   | FOC   | FOC   | FOC   |
| Marine and Terrestrial Beach Monitoring                     | CD   | CD  | PDP  | LP  | C   | C   | C    | C   | C   | C   | IOC   | FOC   | FOC   | FOC   |
| Data Centre Facility  | CD   | CD  | CD   | PDP | PDP | IOC | IOC  | OM  | FOC | FOC | FOC   | FOC   | FOC   | FOC   |
| Modelling and Forecasting Facility                          | CD   | CD  | PDP  | PDP | LP  | C   | C    | IOC | IOC | OM  | FOC   | FOC   | FOC   | FOC   |
| <b>Engineering and Technology Development Division</b>      |      |     |      |     |     |     |      |     |     |     |       |       |       |       |
| Facility Support and Technology Development                 |      |     |      |     |     |     |      |     |     |     |       |       |       |       |
| Near Shore Station  | CD   | CD  | CD   | CD  | PDP | LP  | PDP  | C   | C   | IOC | OM    | FOC   | FOC   | FOC   |
| Ships of Opportunity/Fishing Fleet Monitoring               | CD   | CD  | LP   | PDP | IOC | IOC | OM   | OM  | FOC | FOC | FOC   | FOC   | FOC   | FOC   |
| <b>Strategic Issues and Application to Society Division</b> |      |     |      |     |     |     |      |     |     |     |       |       |       |       |
| CD PDP IOC IOC OM FOC FOC FOC FOC FOC FOC FOC FOC FOC       |      |     |      |     |     |     |      |     |     |     |       |       |       |       |
| <b>Services</b>   |      |     |      |     |     |     |      |     |     |     |       |       |       |       |
| Management & Finance  | PDP  | IOC | OM   | OM  | FOC | FOC | FOC  | FOC | FOC | FOC | FOC   | FOC   | FOC   | FOC   |
| Computing & IT  | CD   | C   | OM   | PDP | LP  | C   | IOC  | OM  | FOC | FOC | FOC   | FOC   | FOC   | FOC   |
| Outreach, Education, Training & Mobility                    | CD   | CD  | PDP  | PDP | PDP | PDP | IOC  | IOC | OM  | FOC | FOC   | FOC   | FOC   | FOC   |

# Continued...



**Products, Services  
& Outcomes cont.**

- Education, Outreach and Training
- Step improvement in operational oceanography in the Balearic Islands
- 
- Technology development
- Beach safety and RIP currents



# SOCIB Mission and Vision

## MISSION

- The mission of SOCIB is to develop a coastal ocean observing and forecasting system which will provide free, open, quality controlled and timely streams of data to:
  - support research and technology development on key internationally established topics
  - consolidate operational oceanography and associated marine technology development in the Balearic Islands and in Spain
  - support the strategic needs of society in the context of global change

## VISION

- Over the longer term, our vision is to advance on the understanding of physical and multidisciplinary processes and their non linear interactions, to detect and quantify changes in coastal systems, to understand the mechanism that regulate them and to forecast their evolution and/or adaptation under, for example, different IPCC scenarios.
- More specifically, SOCIB will address the preservation and restoration of the coastal zone and its biodiversity, through the analysis of its vulnerability under global change and through considering new approaches, such as connectivity studies and Marine Protected Areas optimal design, to advance and progressively establish a more science based sustainable management of the ocean and coastal areas.