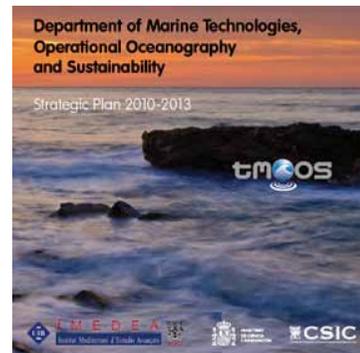


The impact of new information infrastructures in understanding and forecasting the European Seas (from “small” to large scales...): SOCIB, an Ocean Observing and Forecasting System based in the Balearic Islands



Joaquín Tintoré and
the SOCIB/IMEDEA
team



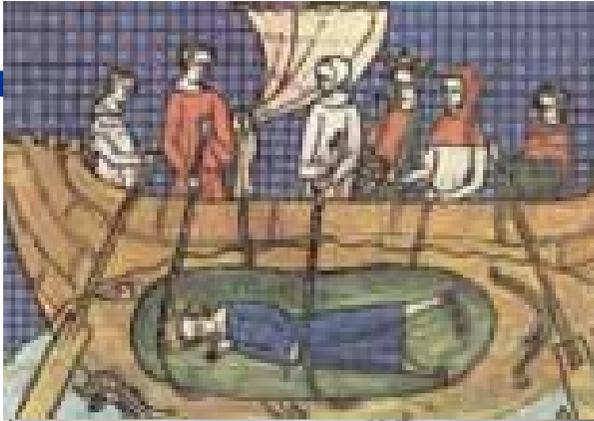
**SOCIB and IMEDEA
(UIB-CSIC)**

<http://www.socib.eu>

OUTLINE

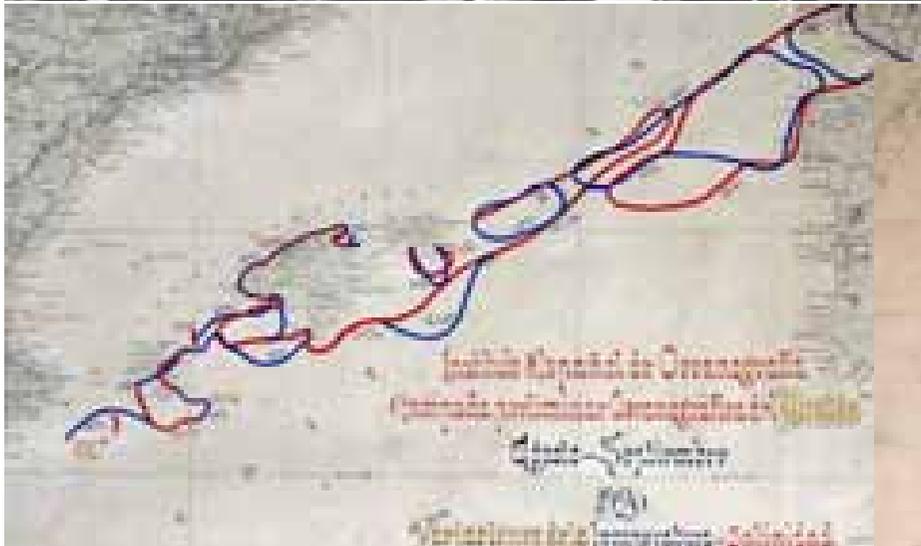
1. The 2012 Oceans' Challenges for Science, Technology and Society
 2. Ocean Information for Society,... what we learned (some examples of global problems addressed)
 3. SOCIB, a new multi-platform approach
-
1. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

The oceans are chronically under-sampled



(Credit, Oscar Schoefield)

The oceans are chronically under-sampled



(Credit, Pere Oliver)

OUTLINE

1. The 2012 Oceans' Challenges for Science, Technology and Society (Barnes, Wunsch, Visbek, Kanzow)
 - Paradigm change in Observing the Oceans
 - Why SOCIB and why now
 - What is SOCIB: a multi-platform OFS
 - SOCIB 3 drivers
2. Ocean Information for Society, what we learned,
 - Meso&submesoscale
 - Aliasing, therefore operational and decadal linked, from A to B....
 - What we are still not understanding, research needs...(esquema procesos...delayney)
3. SOCIB
 - SOCIB focus, scales, platforms and challenges
 - SOCIB view and Implementation timeline
 - Ongoing facilities and initial results
4. SOCIB drivers and the new role of Marine Research Infrastructures to respond to ST&S
 - Innovation in Oceanographic Instrumentation
 - Gliders, an example of rapid innovation
 - Data availability, real time and educational challenges...

Paradigm Shift in Ocean Observation

From: Ship based observation
To: Multi-platform observing systems



**Platform-centric
Sensing Systems**



Coastal Observing
and Forecasting
System



(Adapted from Steve Chien, JPL-NASA)

**Net-centric, Distributed
Sensing Systems**



de les Illes Balears



de les Illes Balears

What is SOCIB?

SOCIB is an Observing and Forecasting System, a **multi-platform distributed and integrated Scientific and Technological** Facility (a facility of facilities...)

- providing streams of oceanographic data and modelling services in support to operational oceanography
- contributing to the needs of marine and coastal research in a global change context.

The concept of Operational Oceanography is here understood as general, including traditional operational services to society but also including the sustained supply of multidisciplinary data and technologies development to cover the needs of a wide range of scientific research priorities and society needs.

In other words, SOCIB will allow a quantitative increase in our understanding of key questions on oceans and climate change, coastal ocean processes and ecosystem variability.

Why SOCIB, why Ocean Observatories, and why now?

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, ...



A quantitative major jump, in scientific knowledge and technology development

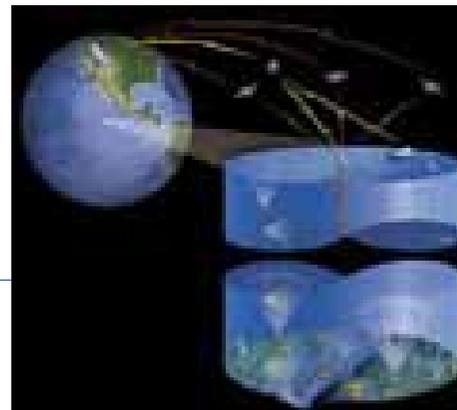


The development of a new form of Integrated Coastal Zone Management, based on recent scientific and technological achievements,

on a global change context (where climate change is one of the most important, but not the only one...), and following sustainability principles



OOI, Regional Scale Nodes (Delaney, 2008)



Ocean Observatories, (Oceanus, 2006)

The SOCIB approach to sustained Marine RI

To assure the real sustainability of the seas and oceans and of the observing systems, in 2007 we designed SOCIB:

→ RESPONDING TO 3 KEY DRIVERS

- Science Priorities
- Strategic Society Needs
- Technology Developments

OUTLINE

1. The 2012 Oceans' Challenges for Science, Technology and Society
 2. Ocean Information for Society,... what we learned in the Mediterranean
 3. SOCIB, a new multi-platform approach
-
1. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

Regional Issues (of global interest)

- Strait's outflow (Alborán Sea) and water masses interactions, fronts (AO front).
- Mesoscale and sub-mesoscale variability / characteristics, eddies and filaments (Balearic & Alborán sub-basins).
- 3d dynamics of mesoscale structures, w estimations using QG Omega and SQG, assimilation PE models, models experiments, induced vertical biogeochemical exchanges. Ecosystem response.
- Mesoscale effects on sub-basin scale circulation (Balearic Sea/Algerian sub-basin) and on local circulation (canyons).
- Mesoscale/sub-basin interactions with basin scale circulation: blocking effects, recirculation and with shelf / slope exchanges...
- Transient forcing episodes and its effects on sub-basin and basin scale circulation (Water Masses and also MLD) and beaches (!)
- New Technologies, for addressing the “scales and scales interaction problem” as well as the “synopticity problem”...: gliders

Motivation: the background... IMEDEA work since 1990 's... - Strategic Plan 2010-2013

20 years of **peer reviewed 'basic' Research Activity**: fronts, mesoscale eddies, shelf/slope exchanges, shelf dynamics, satellite altimetry, waves, sediments, beach variability, etc...

that evolved incorporating ...

Technology Development (both transfer of technological products – spin off AMT- and transfer of management technologies –beach management, recreational boating carrying capacity, tools for decision support; ESI/NOAA, sustainability indicators-)

that evolved as requested by society...

Applications to respond to society needs (beach erosion, beach response extreme events, sand re-nourishment, socio-economic valuation, ICZM, ICOM, MSP).

(Available pdf file at:

<http://imedea.uib-csic.es/tmoos>)



Eastern Alborán Sea dynamics and basin scale interactions

OCTOBER 1988 J. TINTORE, P. E. LA VIOLETTE, I. BLADE AND A. CRUZAT

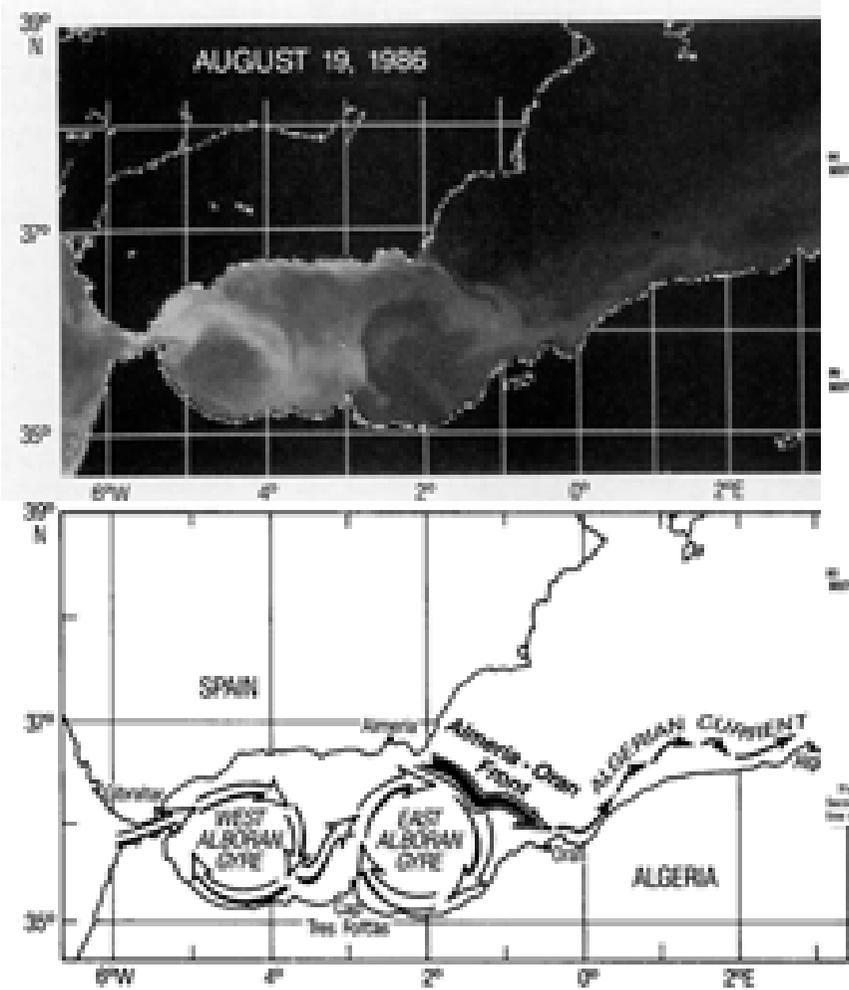


FIG. 1. (Top) A satellite thermal image of the Alborán Sea, showing the continuity of the regional circulation. As with the other satellite imagery in this paper, this NOAA AVHRR-IR image was registered to a Mercator projection and enhanced to show the ocean features. (Bottom) A schematic drawing of the circulation identifying the features displayed in the satellite thermal image (after Arnone et al. 1988).

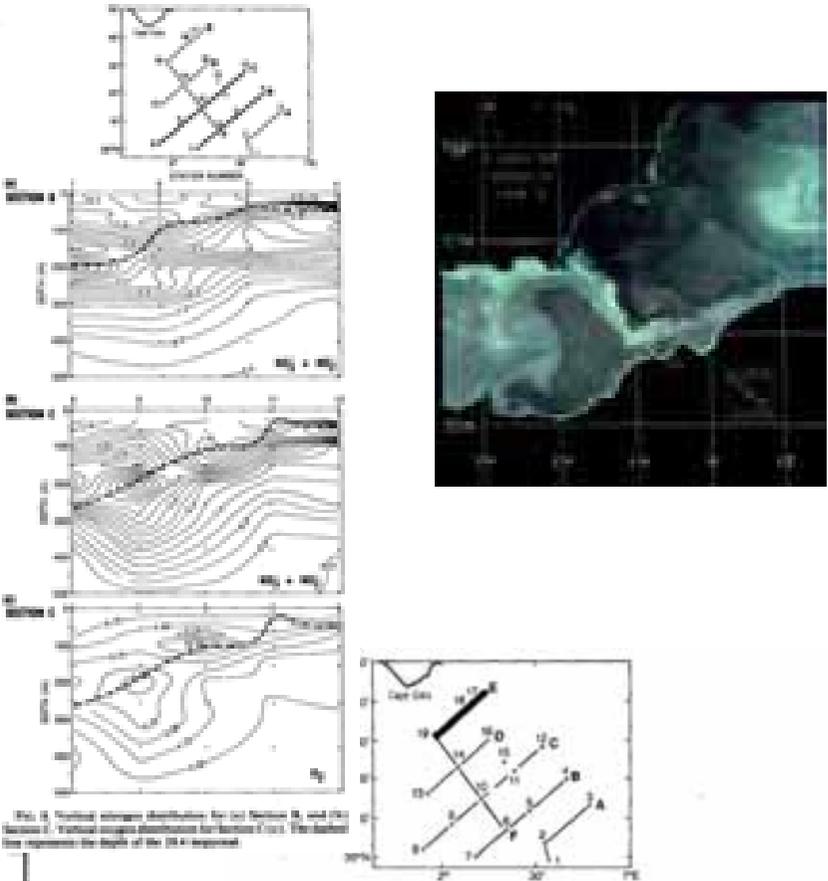


FIG. 9. Vertical images of temperature and salinity profiles for Section B and Section C. The schematic diagram at the bottom of the figure represents the location of the sections.

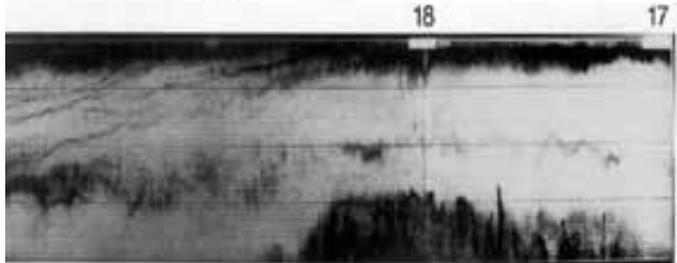
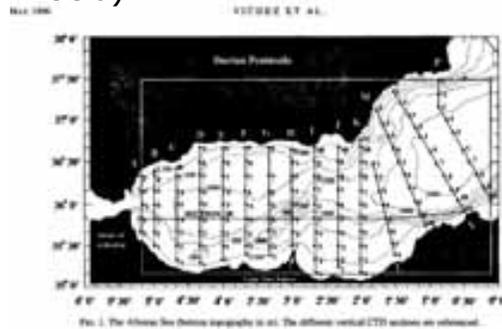


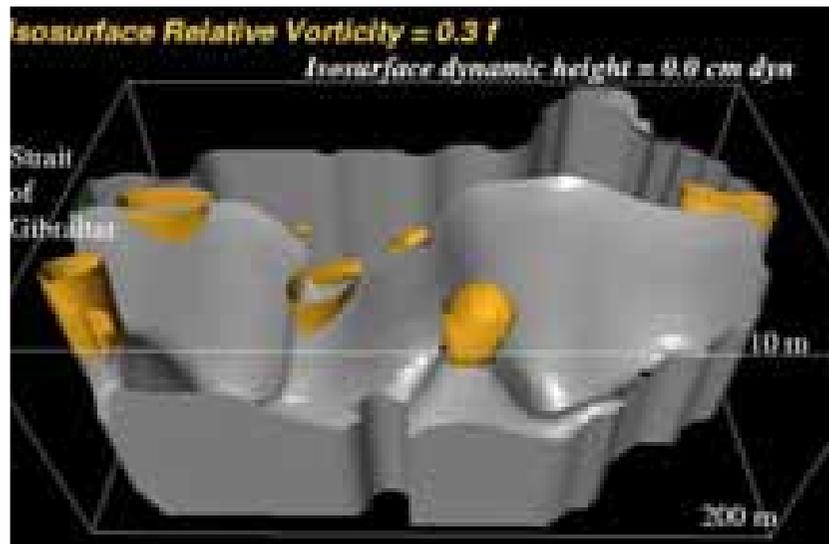
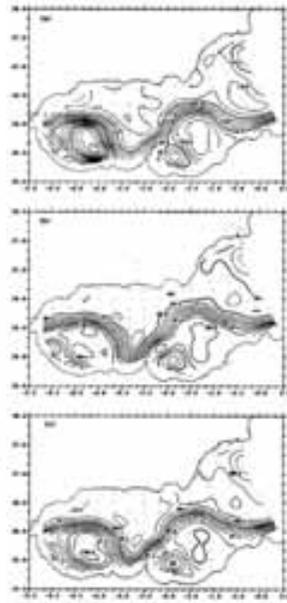
FIG. 10. Echo-sounder chart for Section B.

Mesoscale dynamics, vertical motions, size structure of phytoplankton, biogeochemical fluxes

(Viúdez, Tintoré, Haney, 1996)



17 Sept to 7 Oct. 1992, R/V García del Cid



letters to nature

floras, angiosperms typically constitute only a very small percentage of the total diversity^{23,24}—perhaps reflecting low pollen production and poor dispersal abilities associated with insect pollination. Similarly, with one strongly disputed exception angiosperm wood has not been recorded from Aptian or older rocks, and angiosperm leaves in Aptian or earlier floras are also extremely rare. However, exceptionally preserved whole plants reported from the Lower Cretaceous Crato Formation, Brazil, document that diverse herbaceous water plants were present by the Aptian–Albian and were a prominent part of the angiosperm assemblage of this flora²⁵. These observations suggest that the apparent discrepancy between the diversity of angiosperm reproductive structures and the diversity of leaves and wood during the earliest phases of angiosperm diversification may in part be explained by the low potential of leaves and stems of herbaceous plants, including water lilies and monocots, to be preserved.

Received 20 October; accepted 23 December 2005

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Acknowledgements

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Mesoscale vertical motion and the size structure of phytoplankton in the ocean

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Phytoplankton size structure is acknowledged as a fundamental property determining energy flow through 'microbial' or 'herbivore' pathways'. The balance between these two pathways determines the ability of the ecosystem to recycle carbon within the upper layer or to export it to the ocean interior'. Small cells are usually characteristic of oligotrophic, stratified ocean waters, in which regenerated ammonium is the only available form of inorganic nitrogen and recycling dominates. Large cells seem to characterize phytoplankton in which inputs of nitrate enter the euphotic layer and exported production is higher^{2–4}. But the size structure of phytoplankton may depend more directly on hydrodynamical forces than on the source of available nitrogen^{5–7}. Here we present an empirical model that relates the magnitude of mesoscale vertical motion to the slope of the size–abundance spectrum^{8–10} of phytoplankton in a frontal ecosystem. Our model indicates that the relative proportion of large cells increases with the magnitude of the upward velocity. This suggests that mesoscale vertical motion—a ubiquitous feature of eddies and unstable fronts—controls directly the size structure of phytoplankton in the ocean.

Mesoscale, seasonal and interannual variability in the Mediterranean Sea using a numerical ocean model

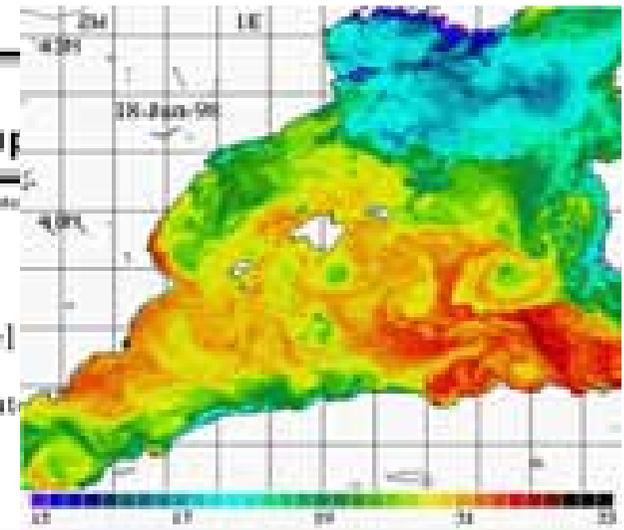
Vicente Fernández ^{a,*}, David E. Dietrich ^a, Robert L. Haney ^b, Joaquín Tintoré ^a

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Received 4 November 2002; received in revised form 17 February 2003; accepted 2 July 2004

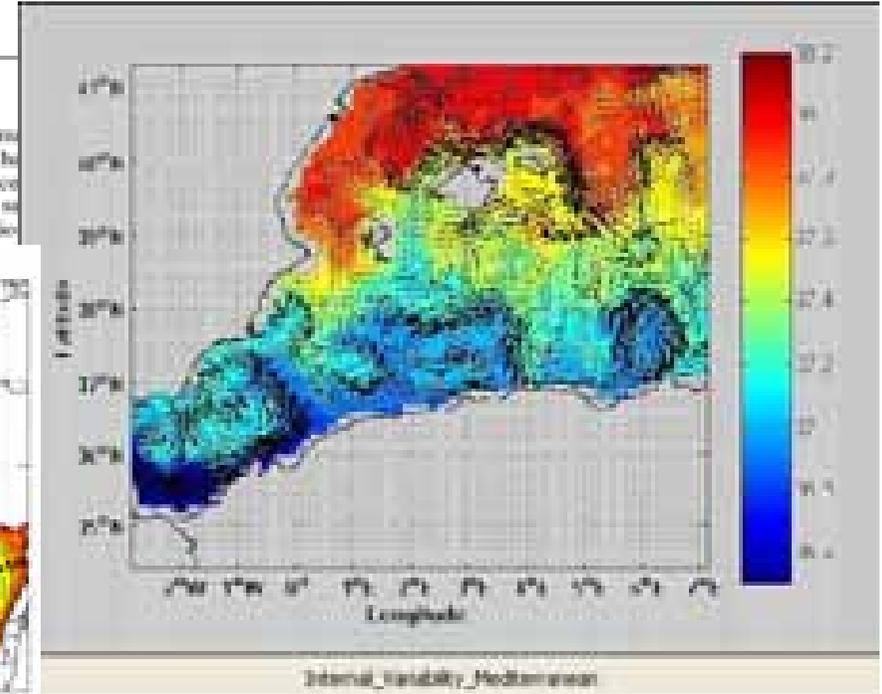
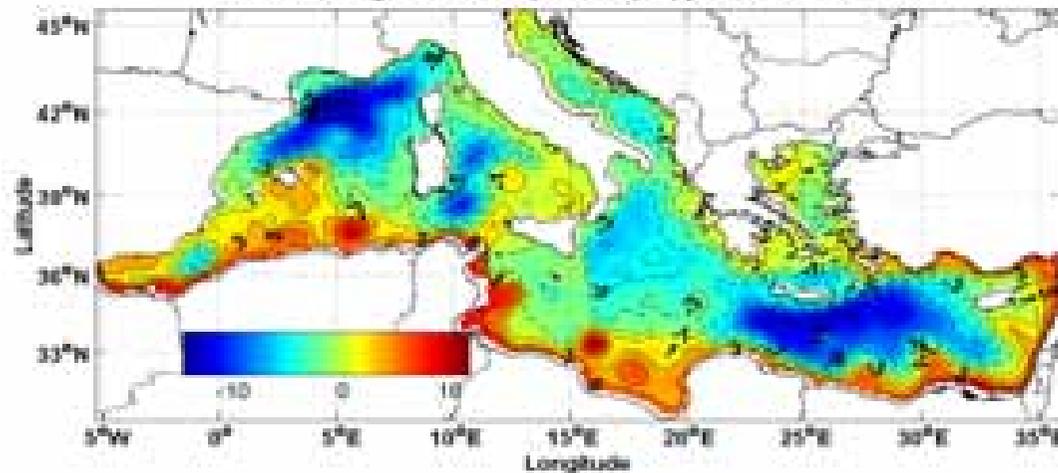
Available online 10 May 2005



Abstract

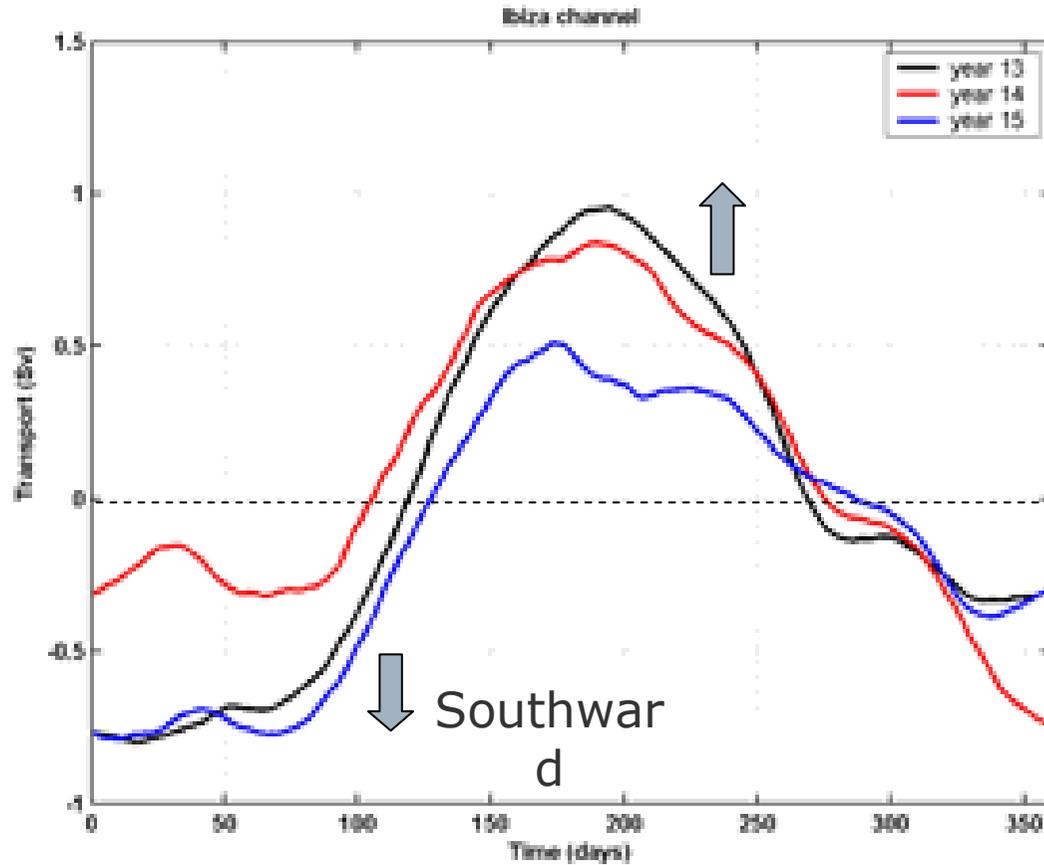
In this paper, we present the results from a 18° horizontal resolution numerical simulation using an ocean model (DoeCAST) that is stable with low general dissipation and the fourth-order numerics with reduced numerical dispersion. The ocean model is forced with mean winds and relaxation towards monthly climatological surface temperature and salinity. The model results are validated against observations and the volume transport obtained is assessed by computing the volume transport through certain sections.

Annual average sea surface pressure (cm) year 15th of simulation



Interannual variability in the Mediterranean

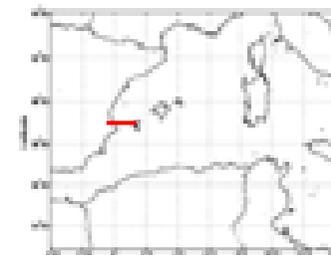
Volume transports



Observations: Northward intrusion of 0.2 to 0.7 Sv in the summer

Southward transport of 1 to 1.5 in winter

(Pinot et al., 2002)



Fernandez, Dietrich, Haney, Tintoré, Prog. Oceanogr., 2003

Coastal ocean forecasting, pre-operational Systems: Oil spill, Search and Rescue, etc...



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Journal of Marine Systems 71 (2008) 79–98

JOURNAL OF
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A forecast experiment in the Balearic Sea

Reiner Onken ^{a,*}, Alberto Álvarez ^b, Vicente Fernández ^b, Guillermo Vizoso ^b,
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Available online 3 June 2007

Abstract

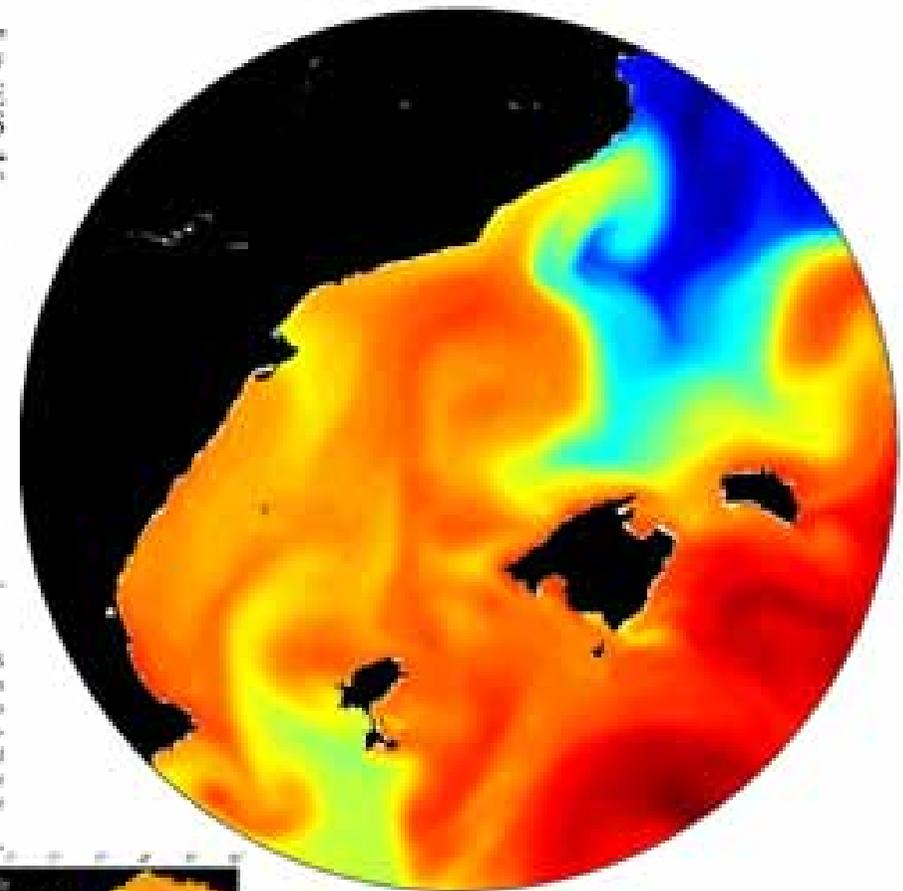
A forecast experiment in the Balearic Sea is presented which is based on the Harvard Ocean Prediction System (HOPS). HOPS is modular, containing a high-resolution primitive equations model, packages for objective analysis and data assimilation (Optimum Interpolation), an interface to implement atmospheric forcing and another interface for one-way nesting of HOPS into any other larger-scale circulation model. Here, to prevent false advection from open boundaries, HOPS is nested into the basin-scale DircAST model (Dietrich, D.E., Haley, R.L., Fernández, V., Josey, S.A., Tintoré, J., 2004. Air–sea fluxes based on observed annual cycle surface climatology and ocean model internal dynamics: a non-damping zero-phase-lag approach applied to the Mediterranean Sea. *J. Mar. Syst.*, 52, 143–165) and atmospheric forcing fields were provided in terms of HIRLAM fields by the Spanish National Institute of Meteorology.

The forecast capability of HOPS is demonstrated in terms of a hindered subregion of the Balearic Sea which were acquired in mid September and used for model initialization, that of the second survey serves for validation is evaluated quantitatively by three different objective methods, comparison fields, and pattern correlations, both for temperature and salinity. In five validation data set than the fields used for initialization, i.e. the forecast!

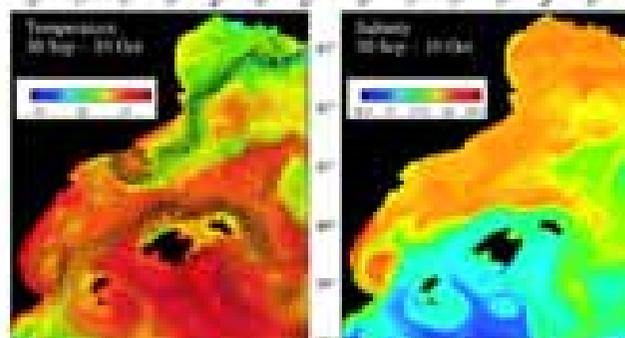
Taking into account further available options of HOPS (implementing biological modules, two-way nesting), the system is operational for a wide range of applications, with high-resolution operational data sets of a coastal ocean forecasting system.

Keywords: Mediterranean Sea; Balearic Sea; Operational model; Forecast model;

DAY = 1



SST from 11/2008



System



Illes Balears



Shelf/slope exchanges – canyons interactions – mean flow/frontal instabilities



Available online at www.sciencedirect.com



Progress in Oceanography 46 (2002) 129–148

Progress in
Oceanography

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Shelf-slope exchanges by frontal variability in a steep submarine canyon

A. Jordi ^{*}, A. Orfila, G. Basterretxea, J. Tintoré

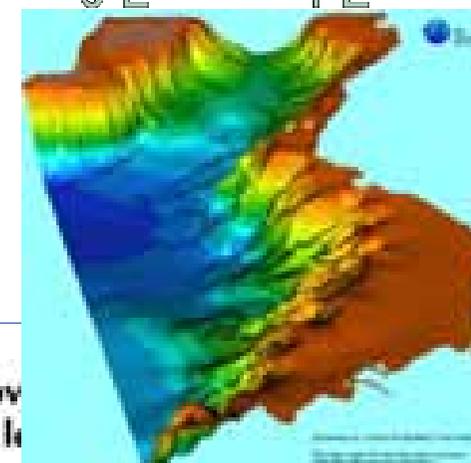
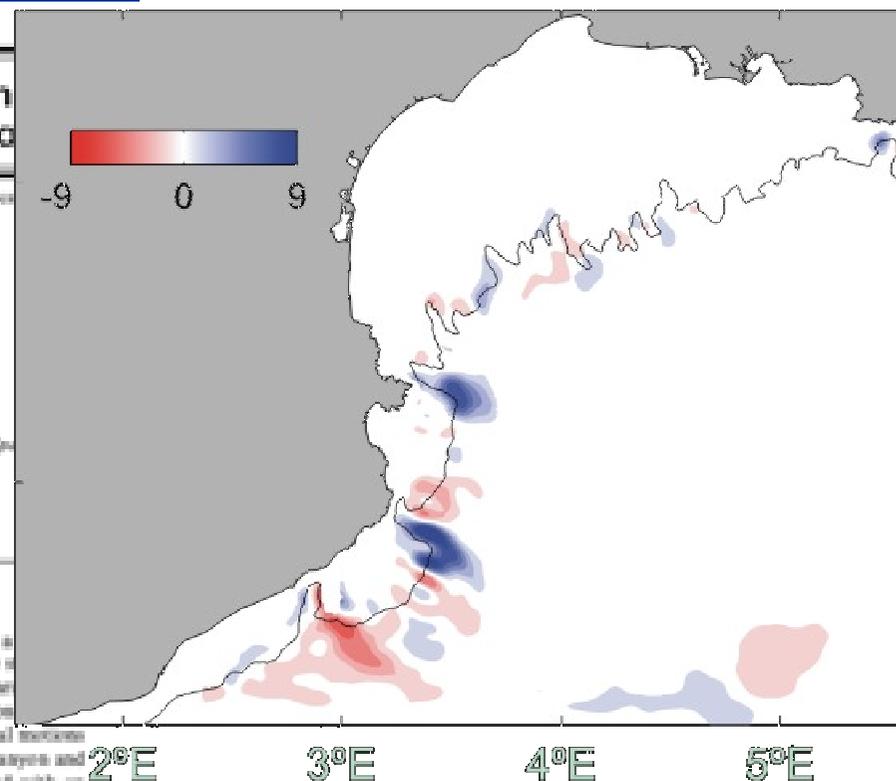
IMEDEA, Institut Mediterrani d'Estudis Avançats (CSIC-UIB), C/ Miquel Marqués, 21, 07190 Esporles, Sp.

Received 9 October 2002; received in revised form 21 March 2003; accepted 29 July 2003
Available online 13 May 2004

Abstract

We study the dynamics of a frontal jet and its short-timescale variability generated by the interaction with a steep submarine canyon using a limited-area fine-resolution three-dimensional coastal ocean model. The focus is on the narrow Palamós Canyon located off the northeast Catalan coast (northwestern Mediterranean) that is characterized by the presence of a permanent along-slope density-driven current. First, we analyze the stationary circulation with different jet locations and show a deflection of the flow in the vicinity of the canyon. Significant vertical motions develop as a result of these current adjustments; the general pattern such as downwelling upstream of the canyon and upwelling downstream are always observed. Second, we analyze the circulation and exchange associated with an offshore displacement of the jet; this produces a meander propagating with the flow that interacts with the canyon. We find that the resulting three-dimensional patterns present an oscillation characterized by an intense downwelling followed by upwelling. As a result of this interaction, shelf-slope exchanges and vertical motions are enhanced in the area compared with the passing of a meander above a shelf that is not indented by a submarine canyon. The resulting horizontal transports through the Palamós canyon represent up to 10% of the along-shore fluxes on the shelf and appear to be sufficient to exchange the shelf water of the Gulf of Lions and Catalan sea in 2.5 years. Considering the number of canyons existing in the area, we can estimate an exchange of all the shelf waters in less than 3 months. © 2005 Elsevier Ltd. All rights reserved.

Keywords: Submarine canyon; Shelf-slope exchange; Numerical coastal ocean model; Frontal variability; Northwestern Mediterranean



Residence time, coastal–open ocean exchanges, eutrofication



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CONTINENTAL SHELF
RESEARCH

Continental Shelf Research 33 (2013) 139–152

www.elsevier.com/locate/CSR

Residence time and *Posidonia oceanica* in Cabrera Archipelago National Park, Spain

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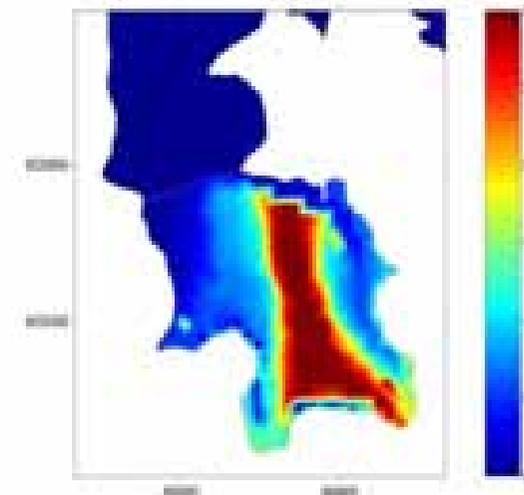
Received 16 April 2012; accepted in revised form 12 January 2013; available online 12 January 2013
 Available online 12 March 2013

Abstract

Flowing through and within the bay are studied in a small inlet in Cabrera National Park, Western Balearic Islands. Flowing time is studied using ADCIRC to simulate flow. Observed flowing time data are compared with the results of three-dimensional coastal ocean circulation models. Residence time is assessed using virtual Lagrangian particles tracking the trajectory originating within the analyzed domain. Results show a good agreement between observed flowing timescales of the flowing time (i.e. 4 days from the ADCIRC data and 16 days from the current residence time simulations) yield a broad range of values, from 1 h to the bay to over 30 days depending horizontal and vertical position where particles were released. A continuous lateral east–west flow (LTF) is found within a zone of 0.7 days. Results obtained for the flowing time appear to have a distribution that members of the important *Posidonia oceanica* present inside the Park. Bio-irrigation patterns and other coastal environments create a non-uniform distribution of the area of accumulation of non-suspension that indicate that residence time concept is the correct approach when studying the impact of ocean on biological communities.

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Keywords: Balearic Islands; Flowing time; Residence time



Pre-operational systems being implemented; coastal ocean and beaches

Journal of Coastal Research	30	3	553-566	Third Floor Beach, Florida
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A Nearshore Wave and Current Operational Forecasting System

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ABSTRACT

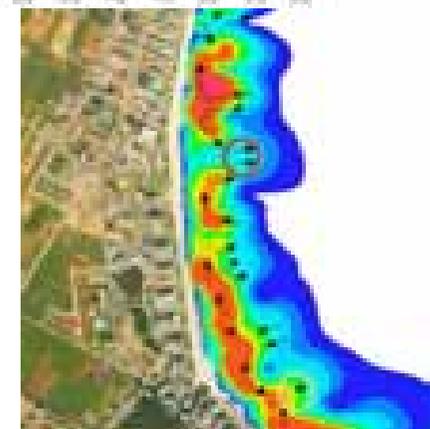
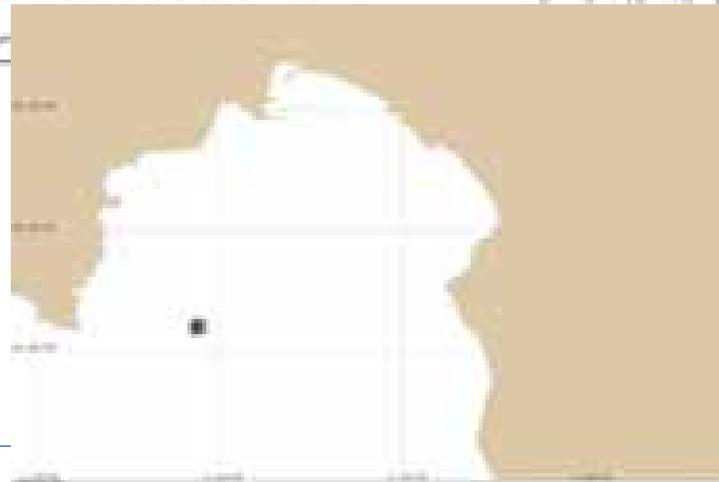
ALVARO ALVAREZ-ESTRELLA, A., ORFILA, A., OÑATIVOLA, M., MEDINA, R., VIVES, G., and TINTORÉ, J. A nearshore wave and current operational forecasting system. *Journal of Coastal Research*, 30(3), 553-566. Florida, 2013. 14 pp.

An operational forecasting system for nearshore waves and wave-induced currents is presented. The new (FV) has been built to provide real time information about nearshore conditions for beach safety system has been built in a modular way with four different autonomous submodels providing, twice a wave and current forecast, with a temporal resolution of 1 hour. Making use of a sixth degree panel system propagation locally long wave were applied to the shore. The resulting solution allowed are depth integrated 'barotropic' model to derive the resulting current fields. The system has been in beach located in the northeastern part of Mallorca Island (northern Mediterranean), characterized by a process during summer season. The FV has been running for 3 years and is a complete tool for beach safety management.

KEYWORDS: Rip currents, wave propagation, forecasting, nearshore, coastal ocean



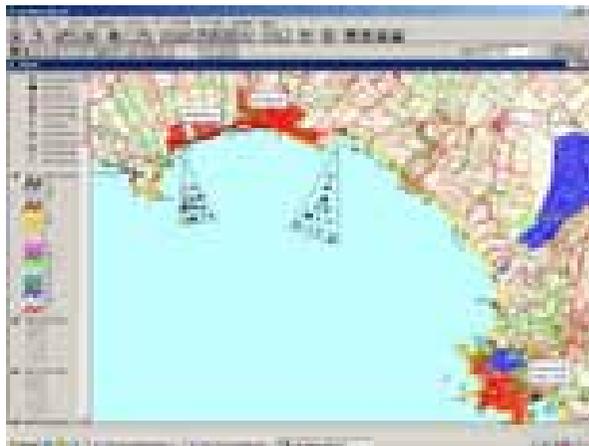
- Oil-spill mapping
- Land vulnerability
- Security in beaches – rip currents
- Prediction of trajectories from Tsunamis.



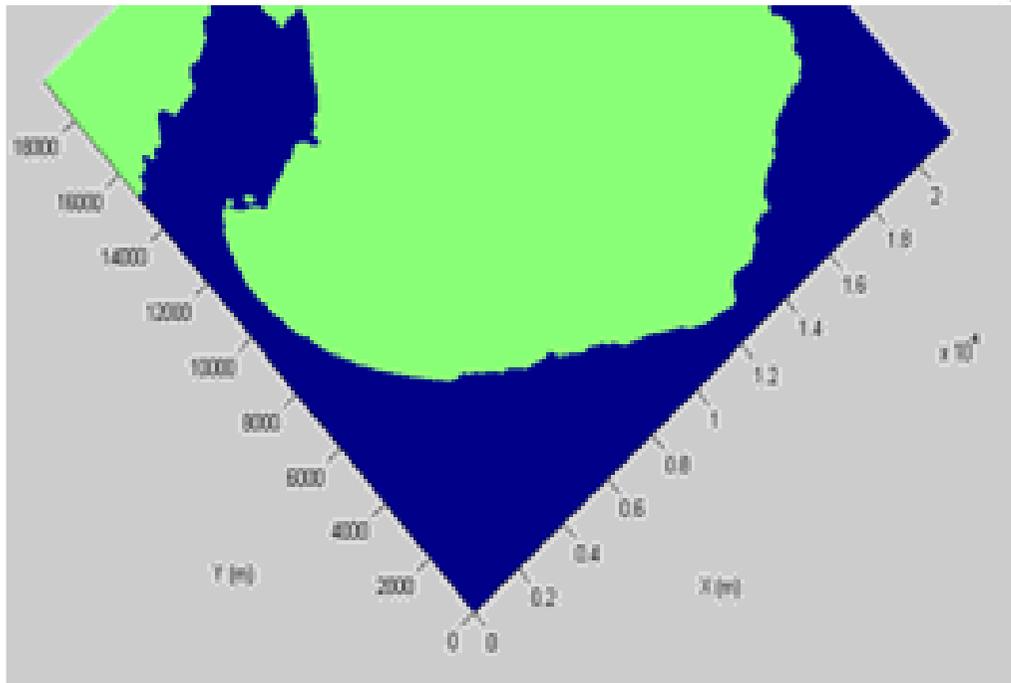
Tools for decision support under oil spill: ESI for all Balearic coast (1.200 km coastline)

This system incorporates all the available information and identifies resources at risk, establishing protection priorities and identifying appropriate response.

ESI (Environmental Sensitivity Index)



Results at local scale, beach and coastal infrastructures, harbours...

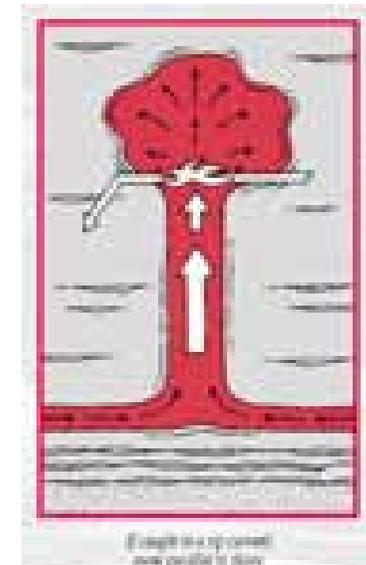


We know that with today's knowledge, actions undertaken in the past would be done differently

(extreme storms Nov. 2001)



Technology development



Beach monitoring using cameras, breakers, rips, bathymetry changes, etc.

Technology Development, IMEDEA transfer to new spin off company AMT, UIB-CSIC / 2005)



AUV's

GSM and
**New
Iridium
drifters**

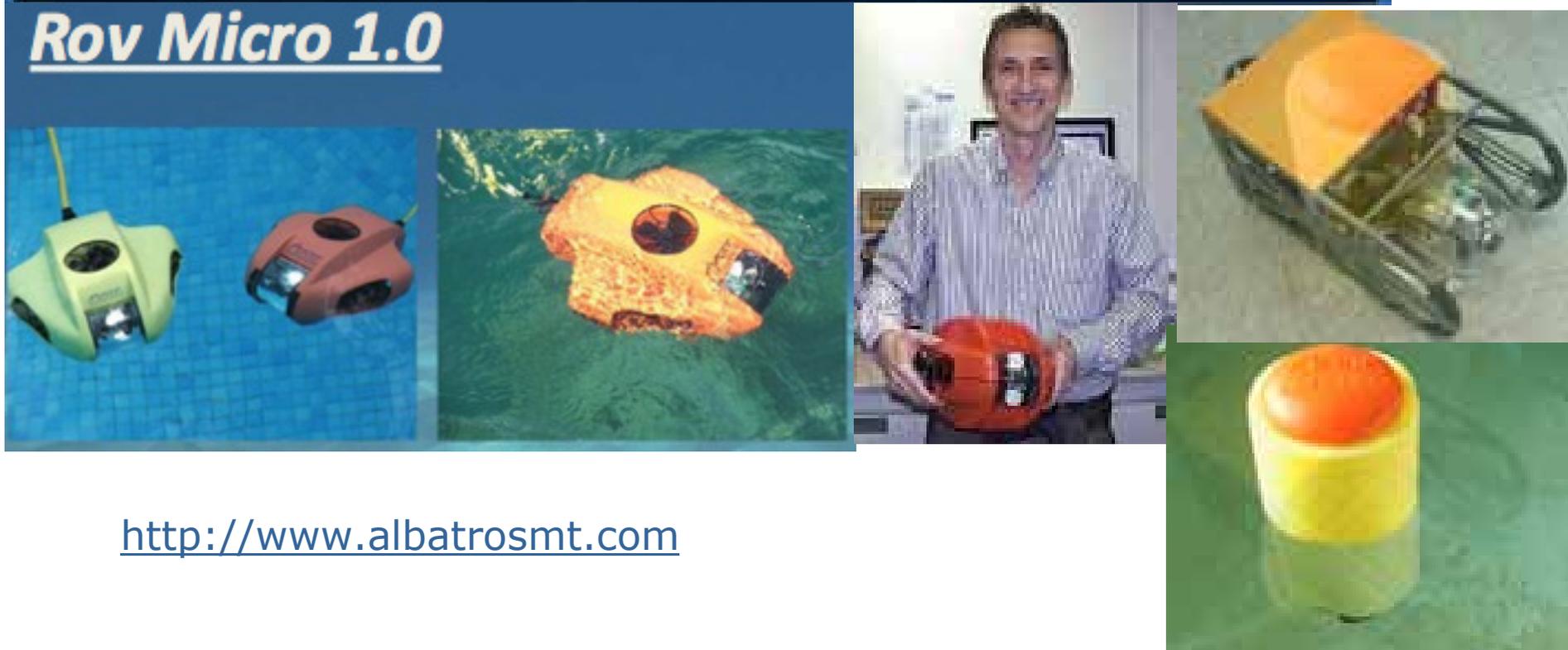
**Albatros
Marine
Technologies**
- Spin off -



ROV's

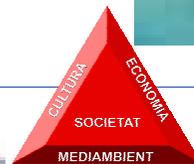
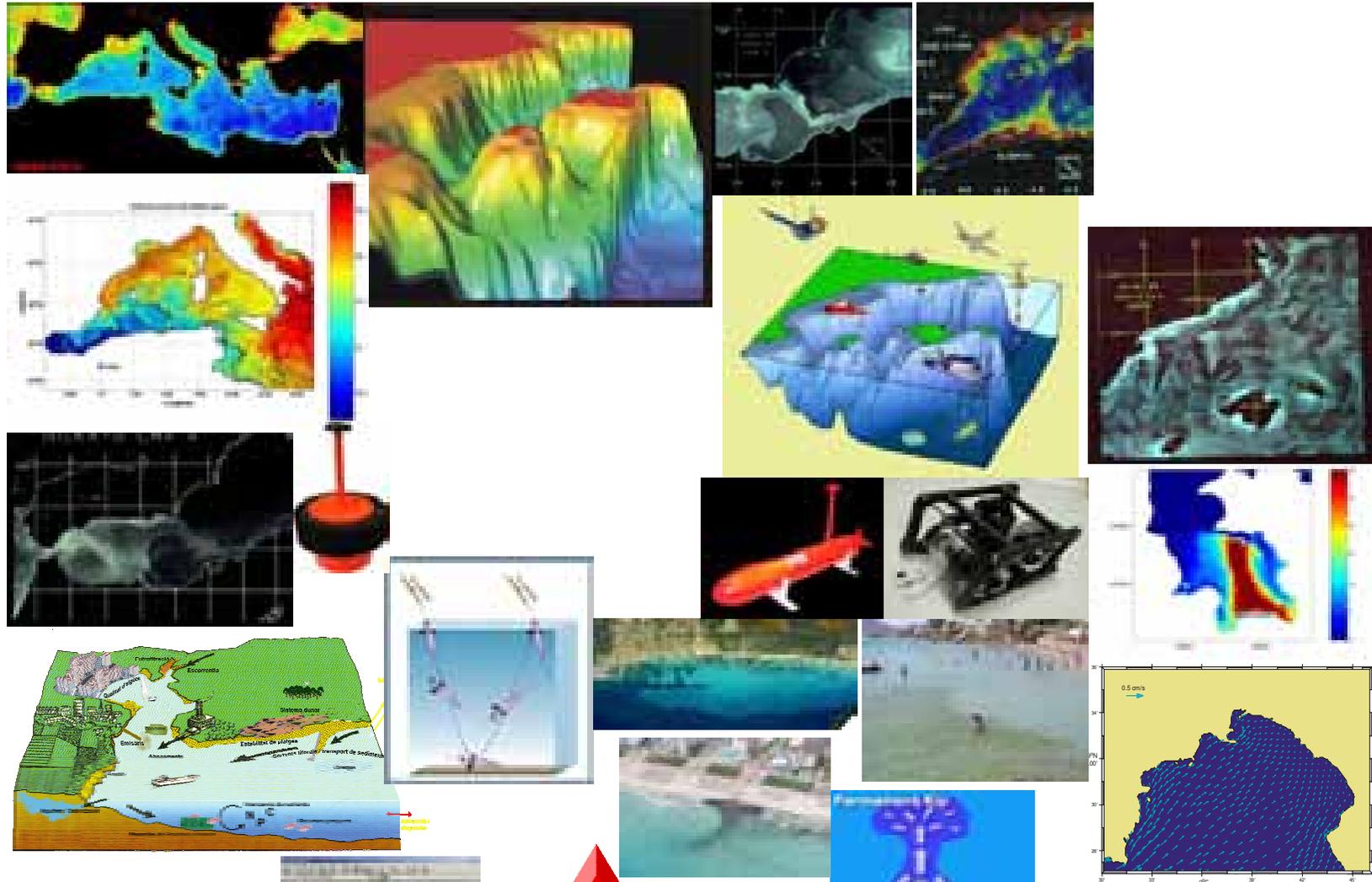


Technology Development, IMEDEA transfer to new spin off company AMT, UIB-CSIC / today 2011)



<http://www.albatrosmt.com>

In summary, background...



In summary... addressed **regional issues of global interest**

Examples from **SCIENCE, TECHNOLOGY DEVELOPMENT AND APPLICATIONS FOR SOCIETY:**

Example... SCIENCE:

Strait's outflow (Alborán Sea), MAW-MW convergences, interactions, fronts (AO front).

Mesoscale and sub-mesoscale variability / characteristics, eddies and filaments (Balearic & Alborán sub-basins).

3d dynamics of mesoscale structures, w estimations using QG Omega and SQG, assimilation PE models, models experiments, induced vertical biogeochemical exchanges. Ecosystem response.

Mesoscale effects on sub-basin scale circulation (Balearic Sea/Algerian sub-basin) and on local circulation (canyons).

Mesoscale/sub-basin interactions with basin scale circulation: blocking effects, recirculation and with shelf / slope exchanges...

Transient forcing episodes and its effects on sub-basin and basin scale circulation (Water Masses and also MLD) and beaches (!)

New Technologies, for addressing the “scales and scales interaction problem” as well as the “synopticity problem”...: gliders

Patching together a world view

Data sets encapsulating the behaviour of the Earth system are one of the greatest technological achievements of our age — and one of the most deserving of future investment.

Now or never

Monitoring the Earth system requires great expertise, not just to build the instruments but to use them properly and interpret their output. Many scientists are, however, far from enthused by projects that do not involve the forming and testing of hypotheses. At worst, monitoring is traduced as stamp collecting and looked down on as drudgery.

Such attitudes must not be allowed to prevail. Testing hypotheses about how the world works requires not just information on the current state of the three-dimensional globe, but on its progress through the fourth dimension of time. Data on the colour of the sea that are not gathered today can never be gathered in the future — gaps left in the record cannot be filled (see page 782). And continuous data sets are going to be vital to the validation of the ever more informative models of the Earth system that we need.

This is why operational systems for data collection in which scientists play key roles are so important. Only they can give us multiscale and multifactor ways of seeing the world that are up to the challenges of the twenty-first century. When the expenditure needed to maintain these data flows conflicts with the funds needed to support fresh scientific research, researchers must acknowledge that there is a strong case for preferring continuous, operational monitoring. An accurate and reliable record of what is going on can trump any particular strategy for trying to understand it.

There is only one Earth, with only one history, and we get only one chance to record it. Ideas not followed through can be taken up again later. A record not made is gone for good. Long zooms in and out of our ever more detailed images of Earth will delight and inform us for years to come. But no digital trickery can replace the steady, fateful path from past to future.

Responding Science... and Society issues

Project based
- 3 years -
Can be done!!

But is inefficient

Next Step



SOCIB

NEWS

Determining Critical Infrastructure for Ocean Research and Societal Needs in 2030

PAGES 204-211

The United States has jurisdiction over 11 million square miles of ocean — an expanse greater than the land area of all 50 states combined. This vast marine area offers researchers opportunities to benefit from research not in an integrated Earth system but also presents challenges to society, including emerging resources and fisheries, industrial accidents, and outbreaks of waterborne diseases. The 2004 Gulf of Mexico Deepwater Horizon oil spill and 2010 Japanese earthquake and tsunami are vivid reminders that a broad range of infrastructure is needed to advance scientific and societal understanding of the ocean.

The National Research Council's (NRC) Ocean Studies Board was asked by the National Science and Technology Council's Subcommittee on Ocean Science and Technology, comprising 20 U.S. government agencies, to examine infrastructure needs for ocean research in the year 2030. This report reflects concerns, among a myriad of marine issues, over the present state of aging and obsolete infrastructure, limited fiscal capacity, growing technology of gaps, and declining national leadership in marine technological development. These issues were brought to the nation's attention in 2004 by the U.S. Commission on Ocean Policy.

The committee also provided a framework for prioritizing future investments in ocean infrastructure. **It recommends that development, maintenance, or replacement of ocean research infrastructure assets be prioritized in terms of societal benefit, with particular consideration given to addressing important science questions, sustainability, efficiency, and integrity, and the ability to contribute to other missions or applications.** These criteria are the foundation for prioritizing ocean research infrastructure investments by estimating the economic costs and benefits of each potential infrastructure investment and finding those investments that collectively produce the largest expected net benefit over time. While this

increasing technological scientific understanding (20 questions). Many of the questions in the report (e.g., sea level rise, sustainable fisheries, the global water cycle) reflect challenging, multidisciplinary science issues that are already relevant today and are likely to take decades of effort to solve. As such, U.S. ocean research will require a growing suite of ocean infrastructure for a range of activities, such as high-quality sustained time series observations of water masses consisting of a broad range of spatial and temporal scales. Consequently, a coordinated national plan for making future strategic investments becomes an imperative for addressing societal needs. Such a plan should be based on broad priorities and be reviewed every 5–10 years to update the federal investment, the report states.

The committee envisioned the past 20 years of technological advances and ocean infrastructure investments (such as the rise in the use of self-propelled, networked, underwater autonomous vehicles, powered infrastructure that would be required to address future ocean research questions, and characterized ocean infrastructure needs for 2030. This infrastructure was that ships will continue to be essential, especially because they provide a platform for enabling other infrastructures, such as autonomous and remotely operated vehicles complex and

enabling technology systems under development (20 questions). Many of the questions in the report (e.g., sea level rise, sustainable fisheries, the global water cycle) reflect challenging, multidisciplinary science issues that are already relevant today and are likely to take decades of effort to solve. As such, U.S. ocean research will require a growing suite of ocean infrastructure for a range of activities, such as high-quality sustained time series observations of water masses consisting of a broad range of spatial and temporal scales. Consequently, a coordinated national plan for making future strategic investments becomes an imperative.

—DUSTYAN GAZDAR, Ocean Studies Board, National Research Council, Washington, D.C.; Email: dgazdar@nrc.edu; ERIK BORTON, Florida State University, Tallahassee; and ROBERT FINE, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL



OUTLINE

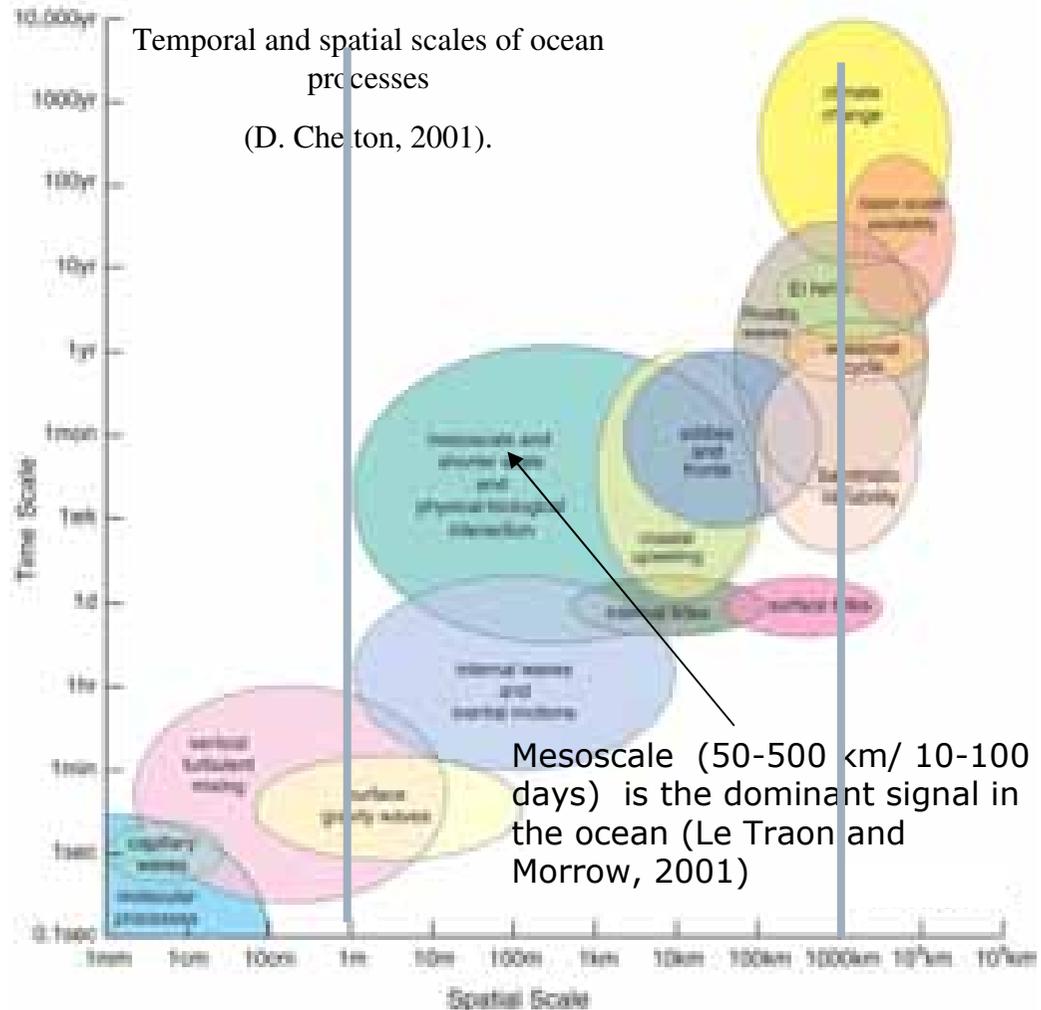
1. The 2012 Oceans' Challenges for Science, Technology and Society
2. Ocean Information for Society,... what we learned in the Mediterranean
3. **SOCIB, a new multi-platform approach**
 1. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

SOCIB Scales Focus: ocean variability at mesoscale/sub-mesoscale, interactions and ecosystem response

Theory and observations have shown that there is a maximum energy at the mesoscale (include fronts and eddies ~10-100km),

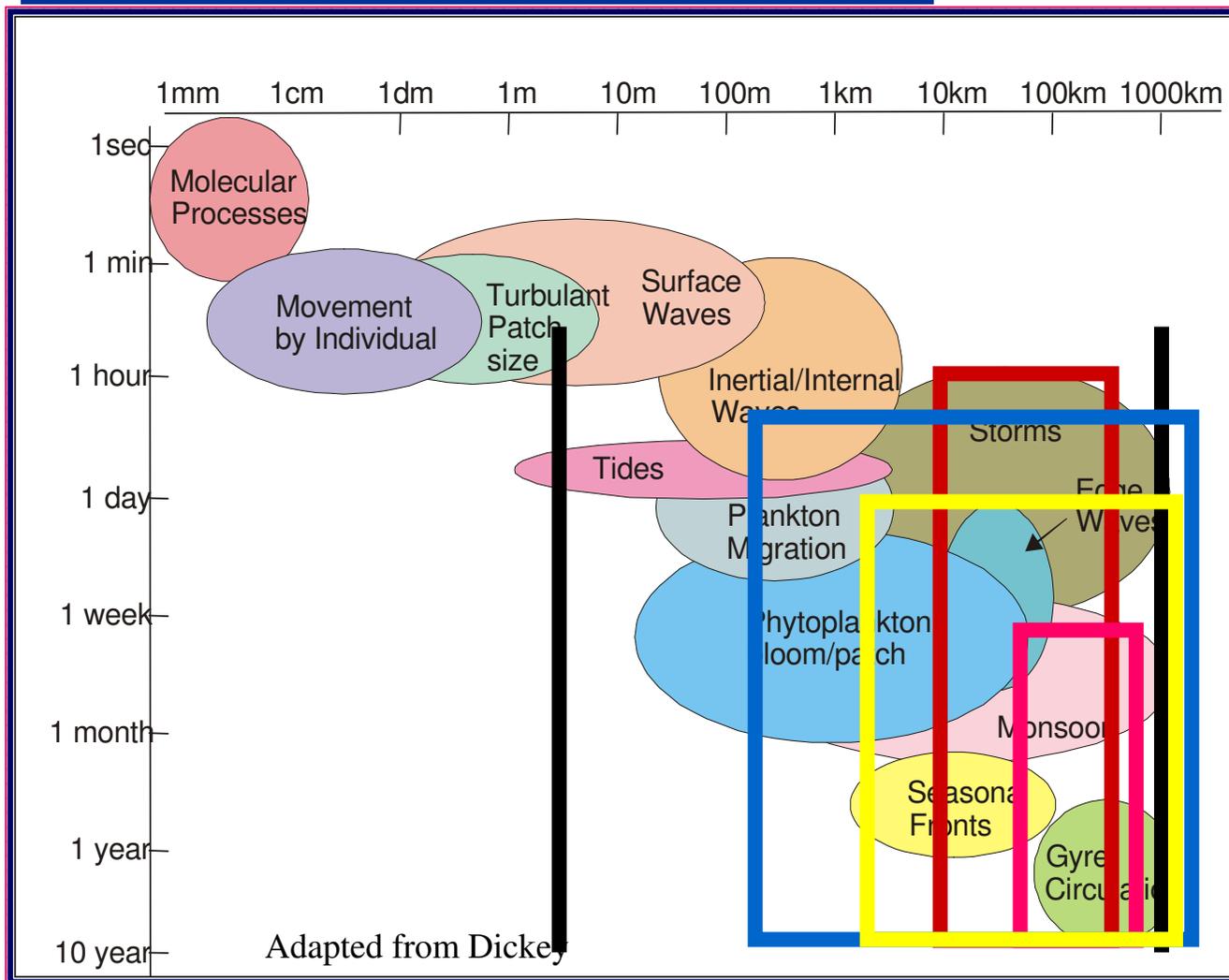
SOCIB focus: mesoscale & submesoscale and their interactions with general circulation and their effects on vertical motions, impact on ecosystem variability.

With inputs from 'both sides'.... (nearshore and coastal ocean and also seasonal/inter-annual and decadal variability)



SOCIB scales

SOCIB scales and monitoring tools



- Gliders**
- Fixed Platforms**
- HF radar**
- 24 m R/V**
- Catamaran**
- Satellite**

The real challenge at SOCIB for the next decade...:

To use and integrate these new technologies to carefully and systematically

- Monitor the variability at small scales, e.g. mesoscale/weeks, to
- Resolve the sub-basin/seasonal and inter-annual variability and by this
- Establish the decadal variability, understand the associated biases and correct them ...

Implementation

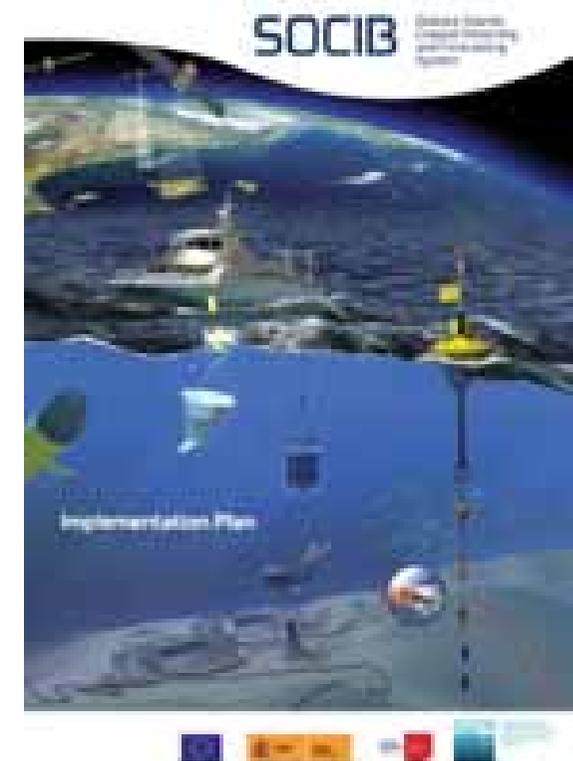
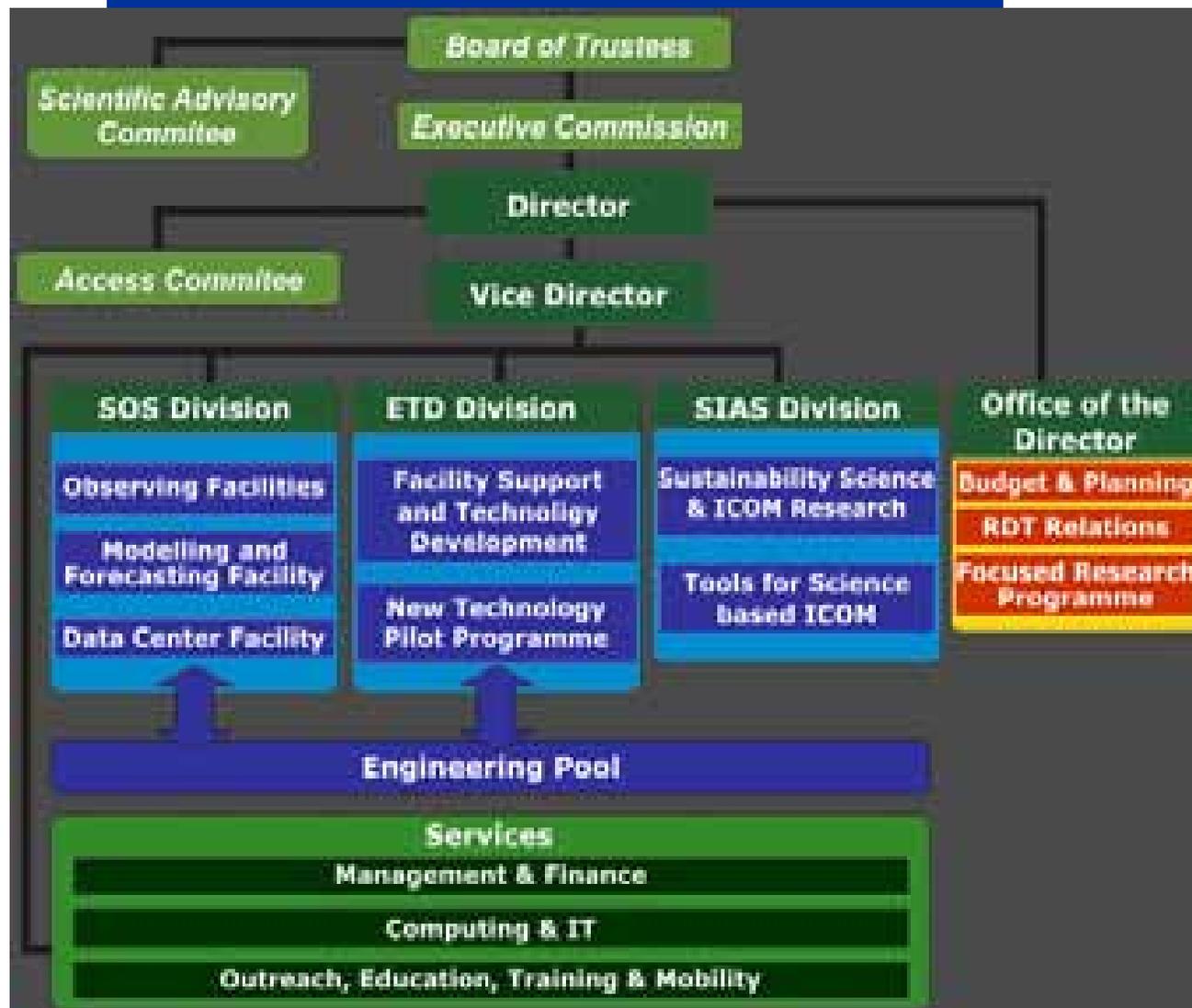
	2009		2010				2011				2012		2013	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1/Q2	Q3/Q4	Q1/Q2	Q3/Q4
Systems, Operations and Support Division														
Observing Facilities:														
Coastal Research Vessel	CD	CD	PDP	LP	LP	C	C	C	C	C	IOC	OM	FOC	FOC
Coastal HF Radar	CD	CD	PDP	LP	LP	C	C	IOC	FOC	FOC	FOC	FOC	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
Engineering and Technology Development Division														
Facility Support and Technology Development	CD	CD	PDP	LP	IOC	IOC	OM	OM	FOC	FOC	FOC	FOC	FOC	FOC
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
Strategic Issues and Application to Society Division	CD	PDP	IOC	IOC	OM	FOC	FOC	FOC	FOC	FOC	FOC	FOC	FOC	FOC
Services														
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

Project Stages:

CD	Concept Development
PDP	Planning, Design and Pilots
LP	Legal Procedure/Purchase
C	Construction
IOC	Achieve Initial Operational Capability
OM	Operation and Maintenance
FOC	Final Operational Capability

Table 2: Implementation Schedule Summary for the major SOCIB elements, detailed schedules are available in Annex 3. All available at www.socib.es

SOCIB Structure and Implementation Plan



Systems Operations and Support Division

1. Observational Facilities (major elements)

- New Coastal Research Vessel (24 m LOA – 1.200 km coastline in the Islands)
- HR Radar
- Gliders
- Fixed Platforms and Satellite products
- ARGO and surface drifters
- Nearshore beach monitoring



2. Forecasting sub-system

- Ocean currents (ROMS) and waves (SWAN) at different spatial scales, forced by Atmospheric model (WRF) and ecosystem coupling (NPZ)

3. Data Centre

- Quality control and Web access in open source
- Effective data archiving, internationally accepted protocols, delivery and communication

SOCIB Facilities and Services – 2012 www.socib.es

Already from SOCIB and/or in kind from CSIC, IEO and UIB and agreement with PE:

SYSTEMS OPERATIONS AND SUPPORT DIVISION

OBSERVING:

- Glider Facility (7 Slocum + 2 iRobot gliders)
- Satellite remote sensing products
- ARGO profiles and Surface drifters Facility (pilot)
- Coastal Buoys real time Facility (pilot)
- Nearshore beach monitoring Facility (pilot)

MODELLING

- Numerical Forecasting Facility

DATA CENTER

- Data Center



- Proven capability
- Pilot projects
- Non sustained

APPLICATIONS AND STRATEGIC ISSUES SOCIETY DIVISION

- ICZM and Science based sustainable coastal and ocean management

Bluefin Tuna target project

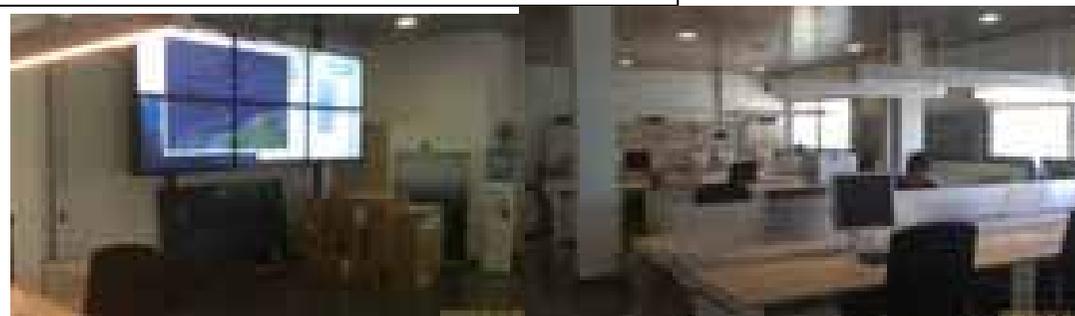
ENGINEERING AND TECHNOLOGY DEVELOPMENT DIVISION

- New technologies

Parc Bit – office –
Since August 2009

SERVICES

- Management and Finances
- Computing and IT's
- Outreach and Education



IMPLEMENTATION PLAN; approved July 2010

SOCIB Glider Facility

We have established new facilities for glider operations at IMEDEA

Electronics & Gliders
Laboratory →



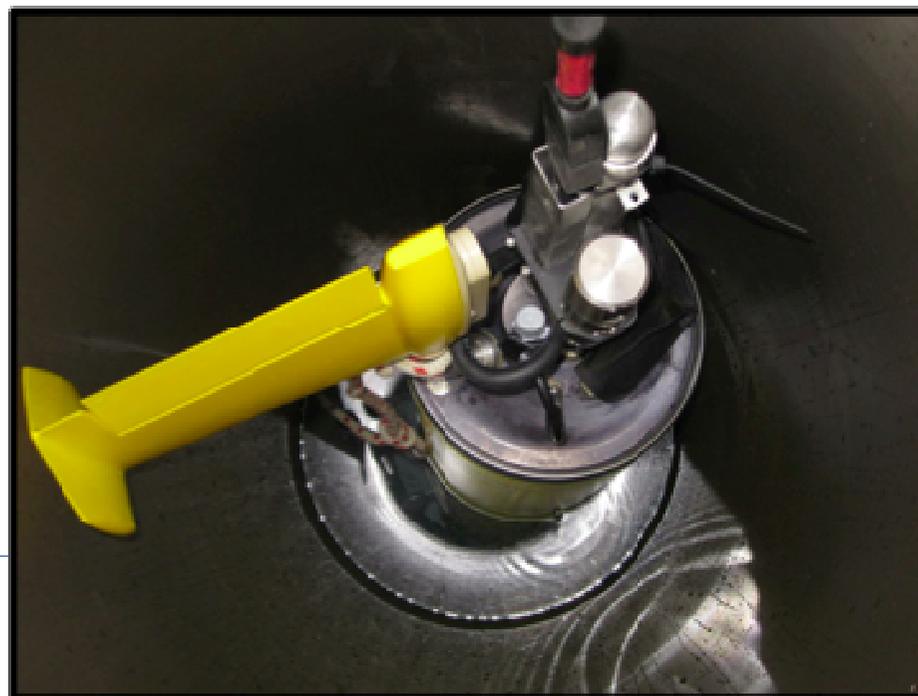
Ballasting Lab &
Pressure Chamber →



Collaboration:
Search and Rescue
801 Squadron
and local authorities →



ty



SO

Gliders Facility: Science



**Mesoscale – Submesoscale /
Vertical motions - biogeo effects**

**Eddy/mean flow interactions –
Blocking effects General Circulation**

GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L14607, doi:10.1029/2009GL040001, 2009

JGR, 2010

Vertical motion in the upper ocean from glider and altimetry data
Simón Ruiz,¹ Ananda Pascual,¹ Bartolomé Garza,¹ Isabelle Pujol,² and Joaquin Tintore¹

Coastal and mesoscale dynamics characterization using altimetry and gliders: A case study in the Balearic Sea
Jérôme Bouffard,¹ Ananda Pascual,¹ Simón Ruiz,¹ Yannice Faugère,² and Joaquin Tintore^{1,2}

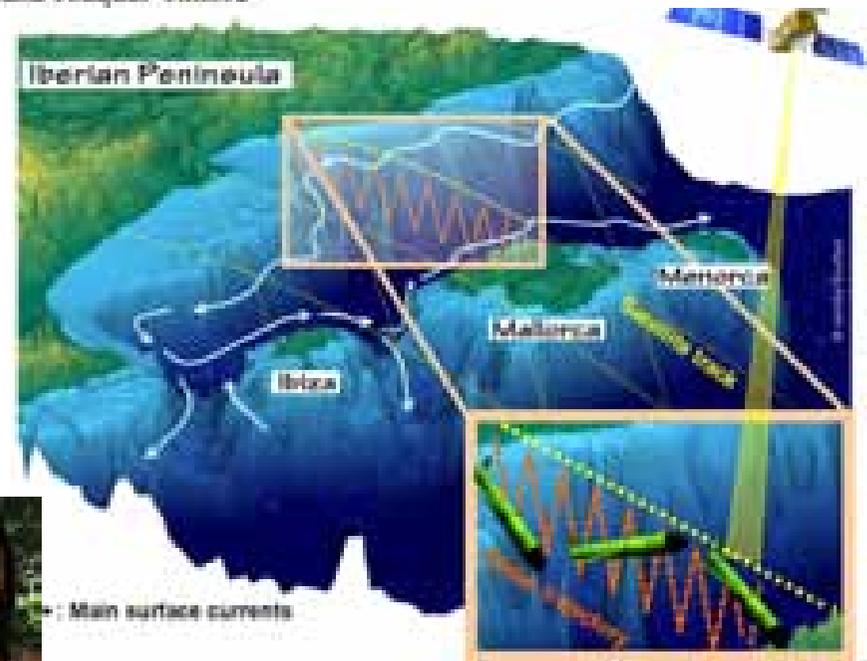
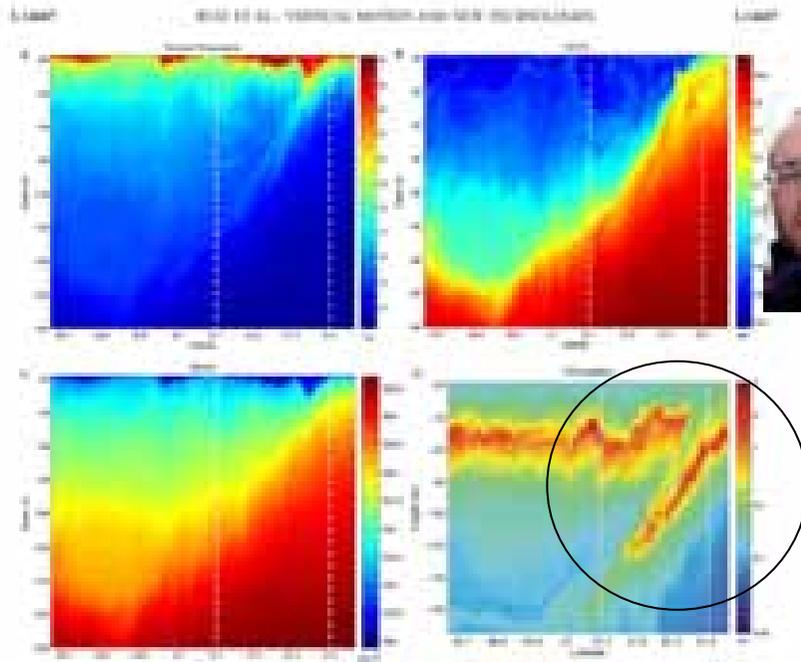


Figure 2. Vertical motion characteristics (1) color map of vertical motion (m/s) from glider altimetry data (2) color map of vertical motion (m/s) from altimetry data (3) color map of vertical motion (m/s) from glider altimetry data (4) color map of vertical motion (m/s) from altimetry data. White dashed lines indicate the location of the glider tracks.

Gliders Facility: Science



Heat content and MLD

GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L01603, doi:10.1029/2011GL050078, 2012

Underwater glider observations and modeling of an abrupt mixing event in the upper ocean

Simón Ruiz,¹ Lionel Renault,² Bartolomé Garau,² and Joaquín Tintoré^{1,2}

Received 20 October 2011; revised 1 December 2011; accepted 2 December 2011; published 13 January 2012.

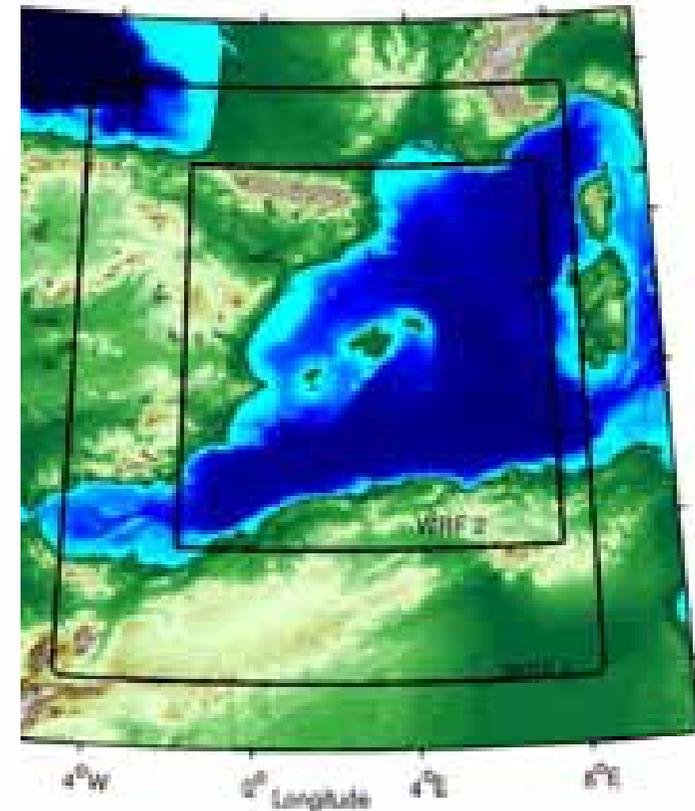
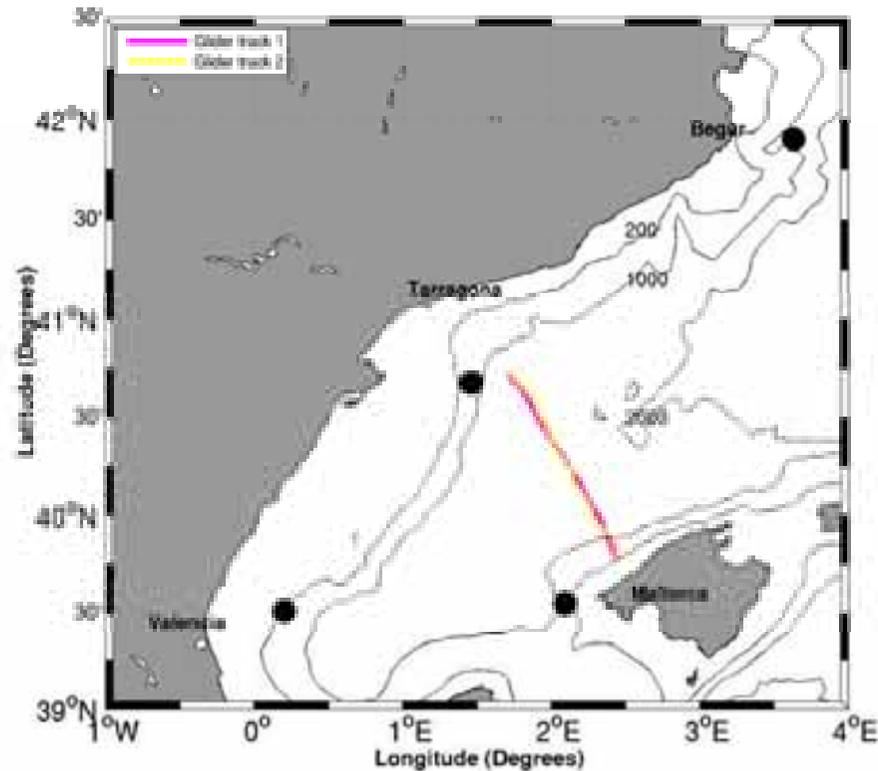
Main results:

- Intense winds (up to 20 ms⁻¹) and buoyancy forcing during December 2009 induced strong vertical mixing of the upper ocean layer in the Balearic Sea.
- High resolution glider data from a coastal glider reveal a surface cooling of near 2°C and the deepening of the Mixed Layer Depth by more than 40 meters in the center of the basin.
- The heat content released to the atmosphere by the upper ocean during this mixing event exceeds 1000Wm⁻². Consistent WRF estimates.

Gliders Facility: Science, MLD



Study area and sampling

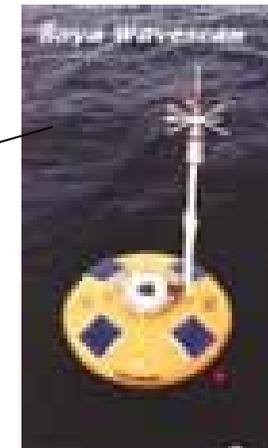
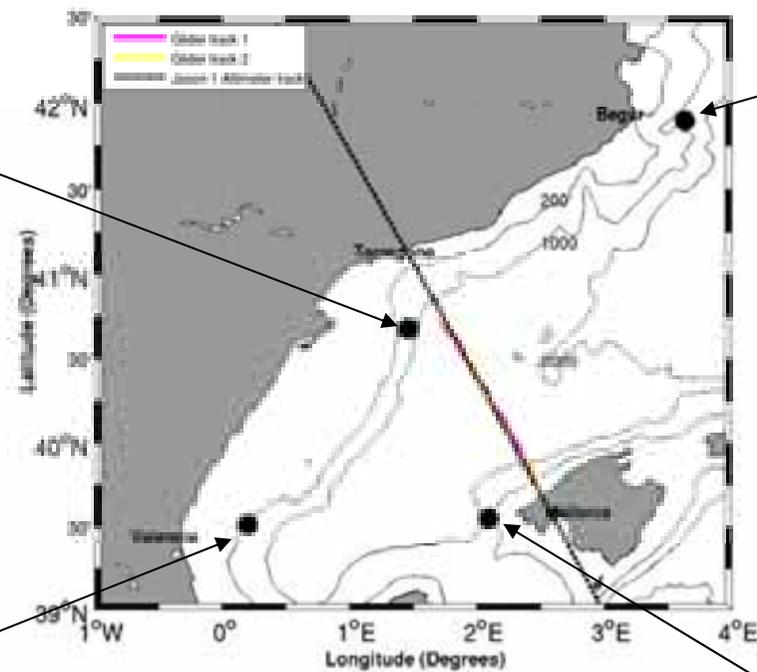


(left) Map of the study area in the Northwestern Mediterranean Sea. Glider tracks (magenta and yellow lines) are indicated. Black dots correspond to locations of the 4 oceanographic/meteorological deep-buoys. (right) Model domains for the WRF model implementation.

Gliders Facility: Science, MLD



Data set: Puertos del Estado Deep buoys network in the WMED



- Meteorologic, oceanographic and waves
- Hourly data



Consell de les Illes Balears



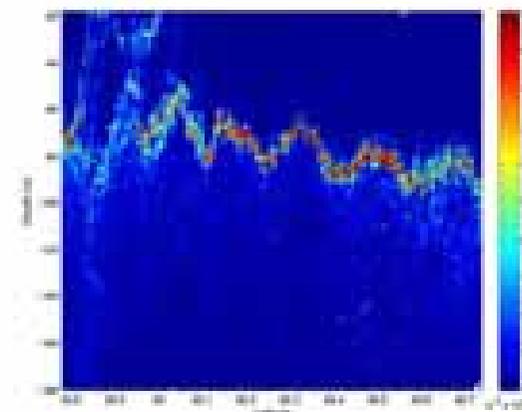
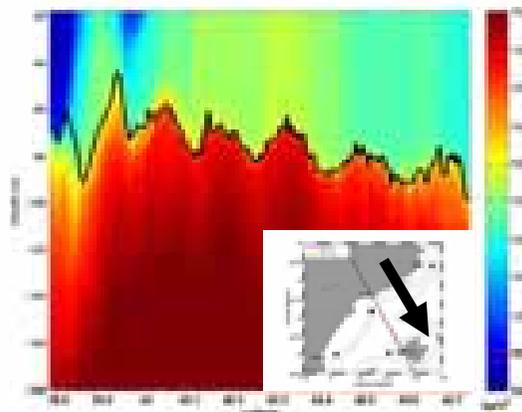
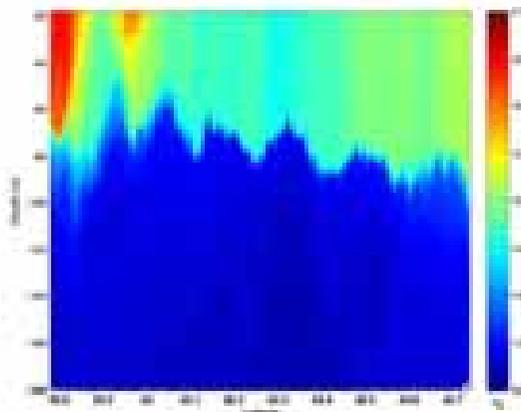
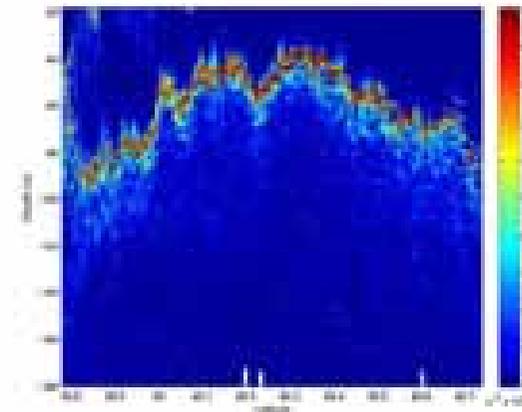
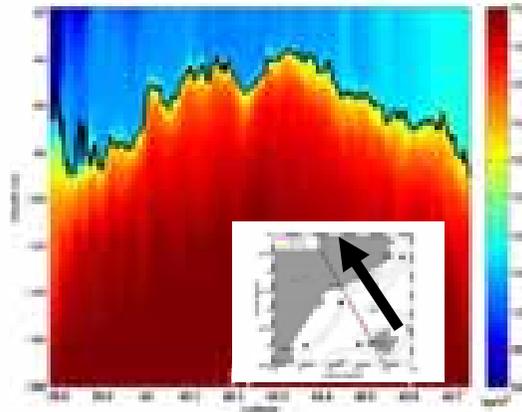
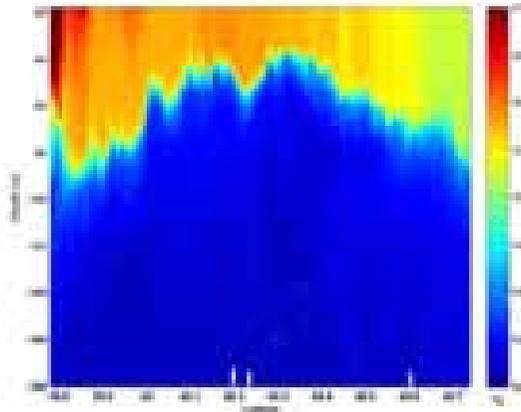
Gliders Facility: Science, MLD



Temperature

Density

N



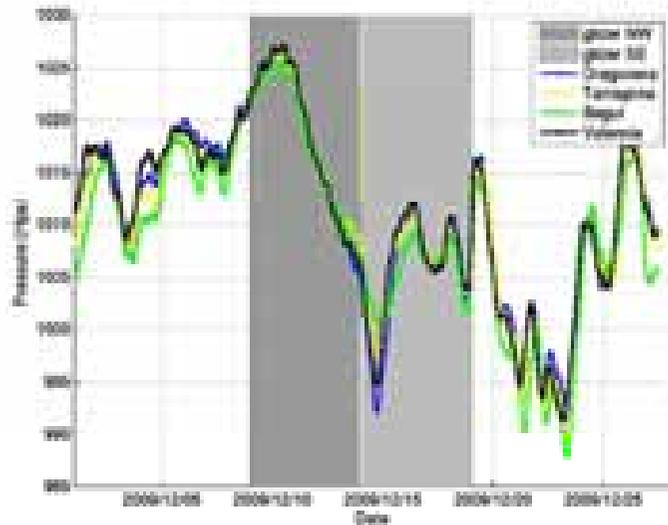
Vertical sections of high-resolution temperature , density and Brunt-Väisälä frequency obtained from glider (top) 'go' and (bottom) 'return.' The black line on the density field corresponds to the Mixed Layer Depth (MLD).

Gliders Facility: Science, MLD

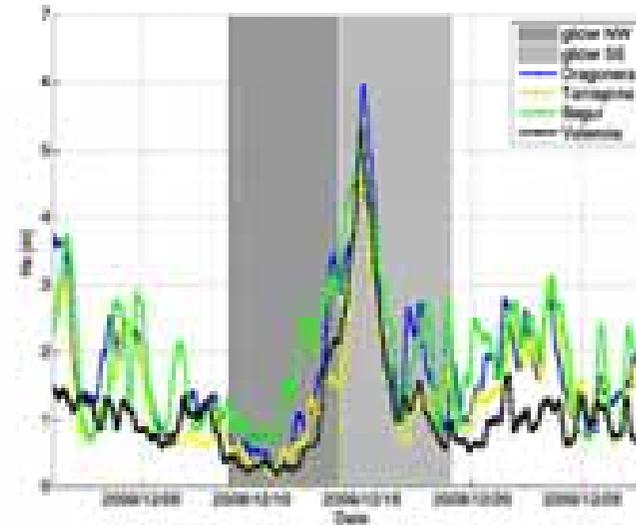


Results: Buoys PdE network

Atmospheric pressure



Significant wave height

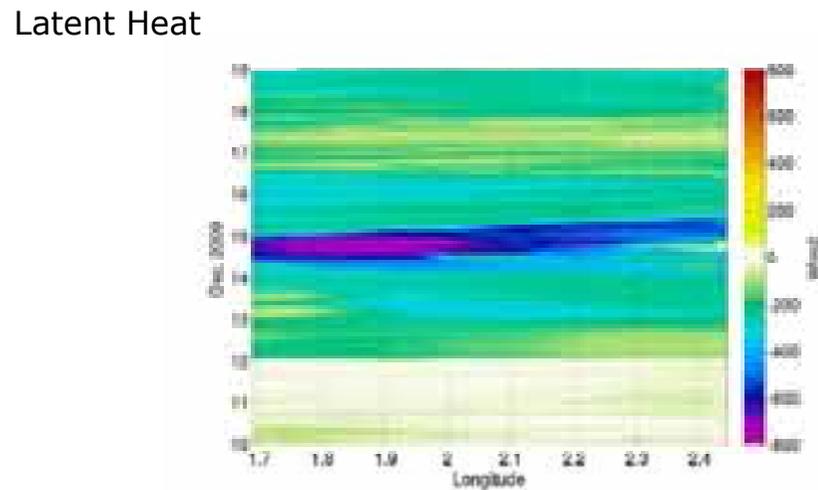
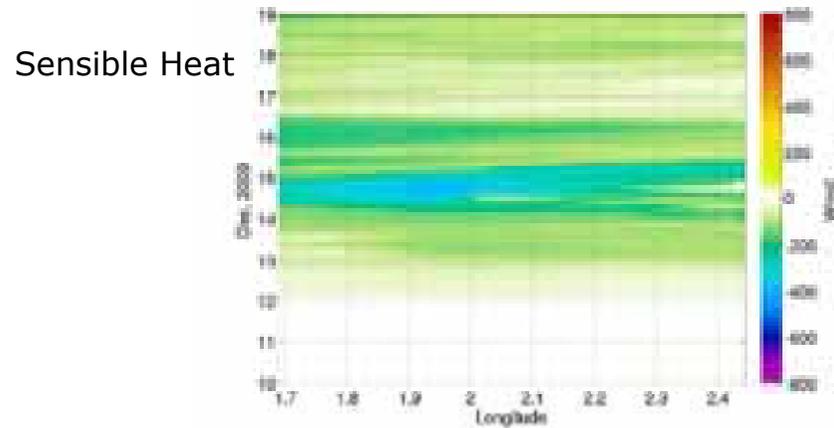


Atmospheric pressure and significant sea surface height measured during glider mission. Gray shadow colour indicates coincident period between glider and buoy measurements.

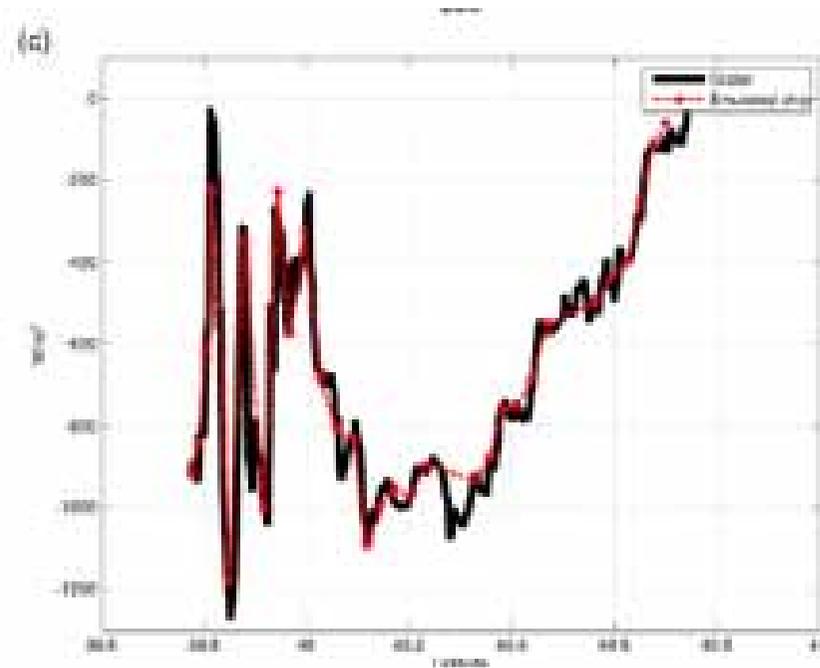
Gliders Facility: Science, MLD



Results; Heat content, modelling and glider data



From the WRF model



Heat content from glider data

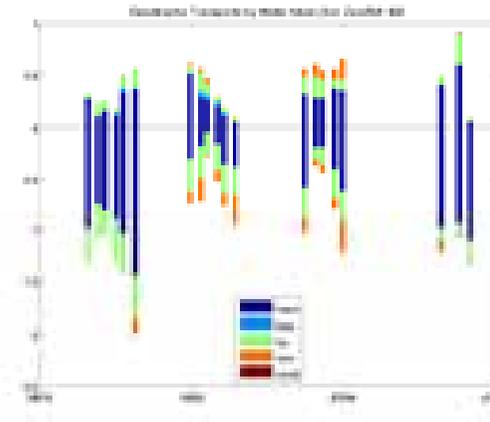
Gliders Facility: Operational



- After 28 glider missions (started in 2006), + 10.000 profiles
- Since January 2011; routine operations in Ibiza and Mallorca Channels (150 miles section)

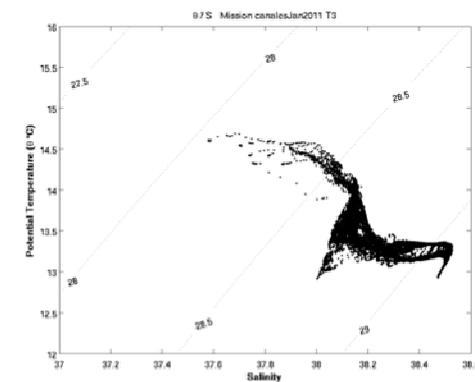
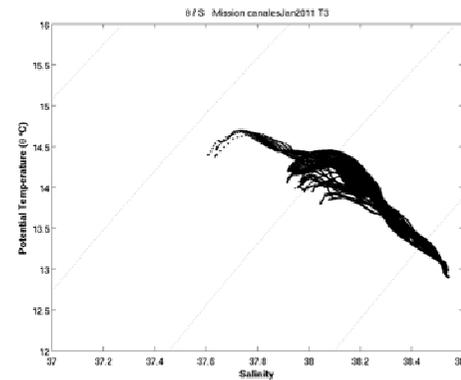
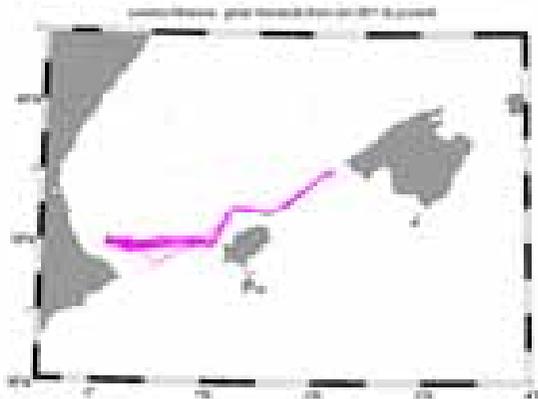


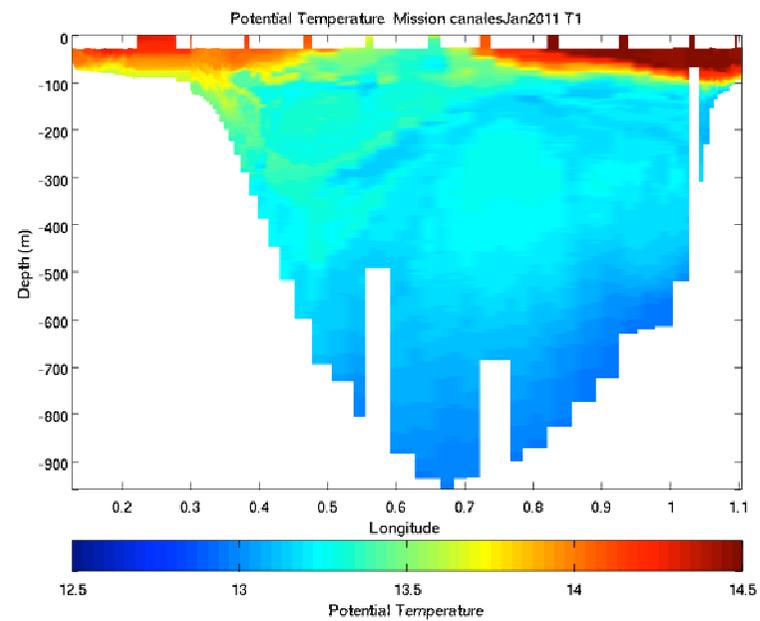
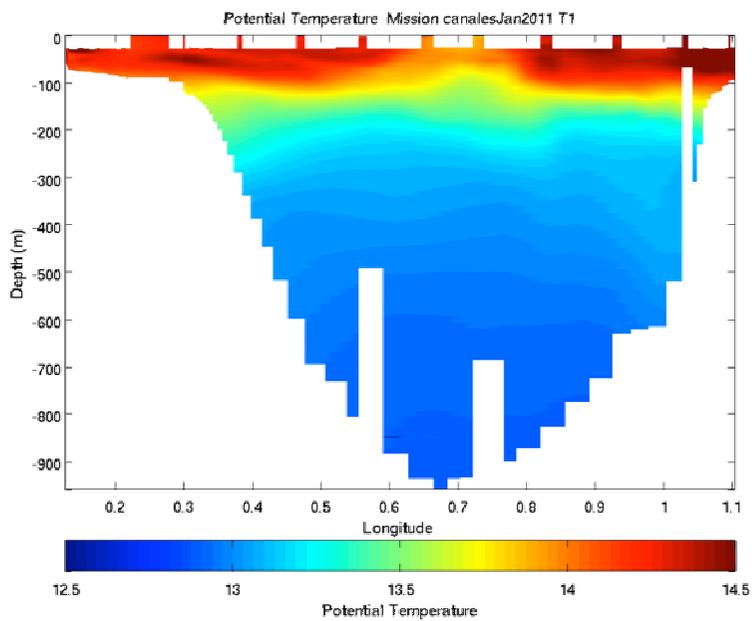
Major transport changes

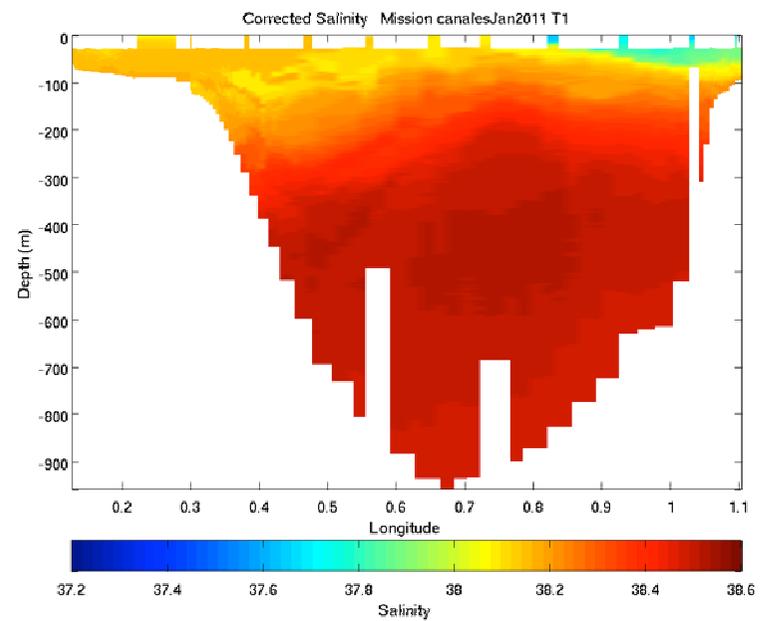
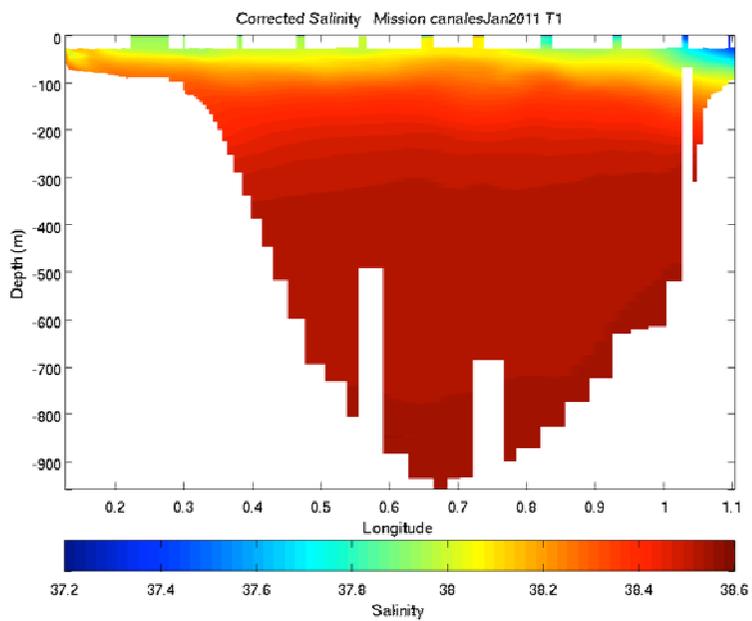


NEED DEFINE KEY CONTROL SECTIONS EU

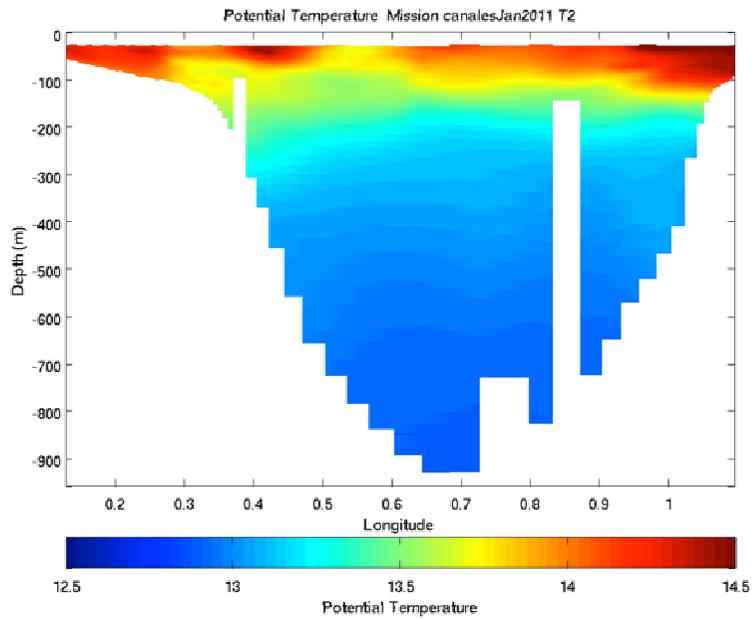
TS diagrams ROMS / Glider



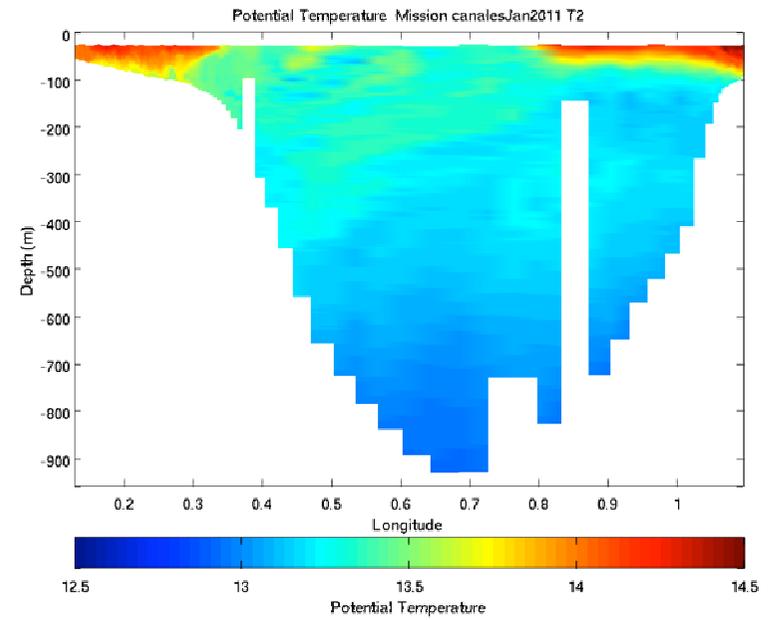


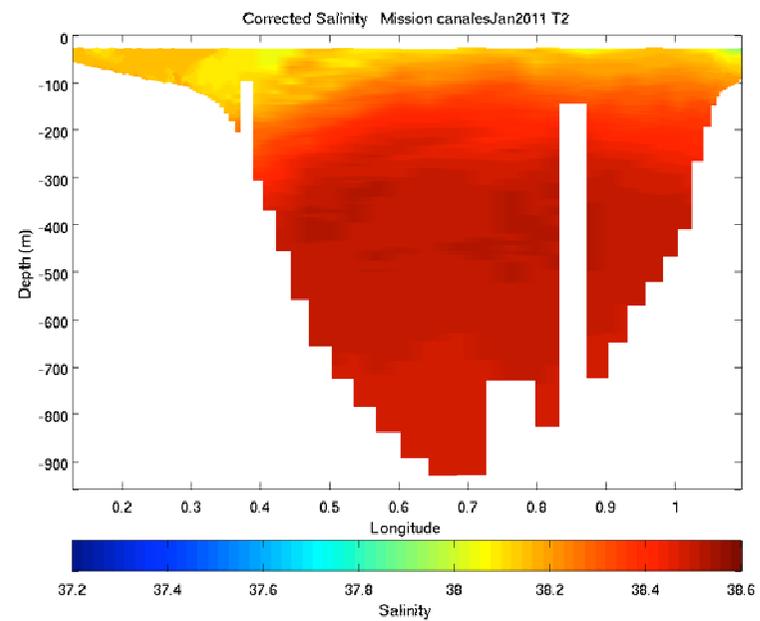
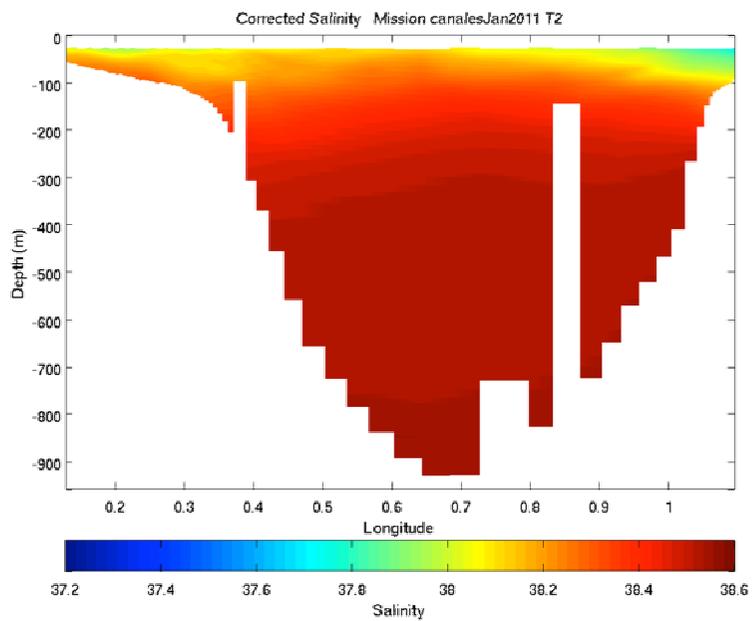


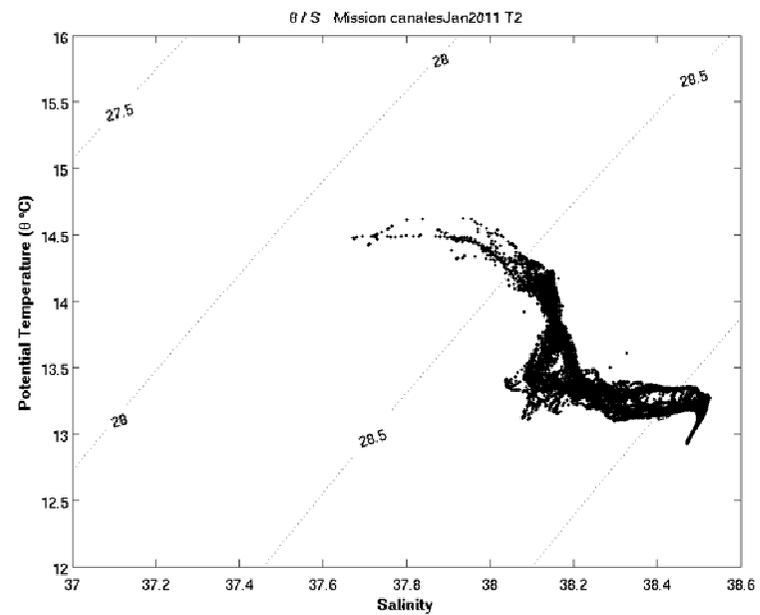
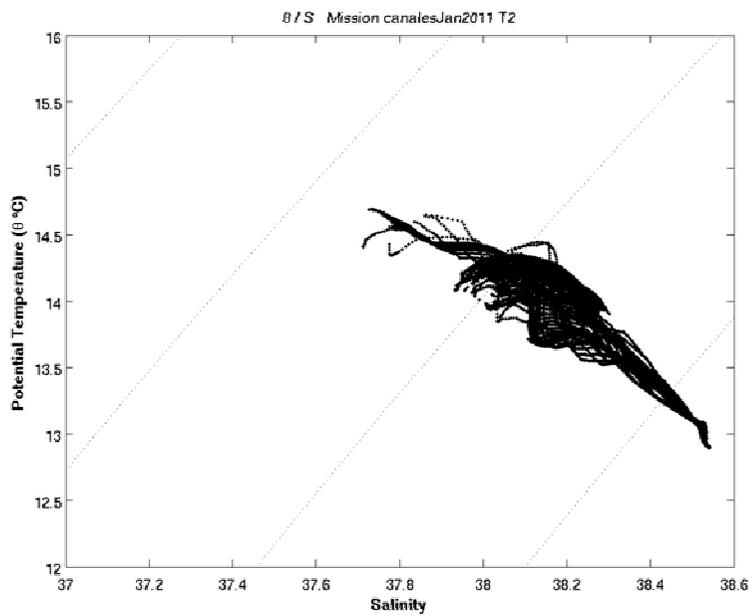
MODEL

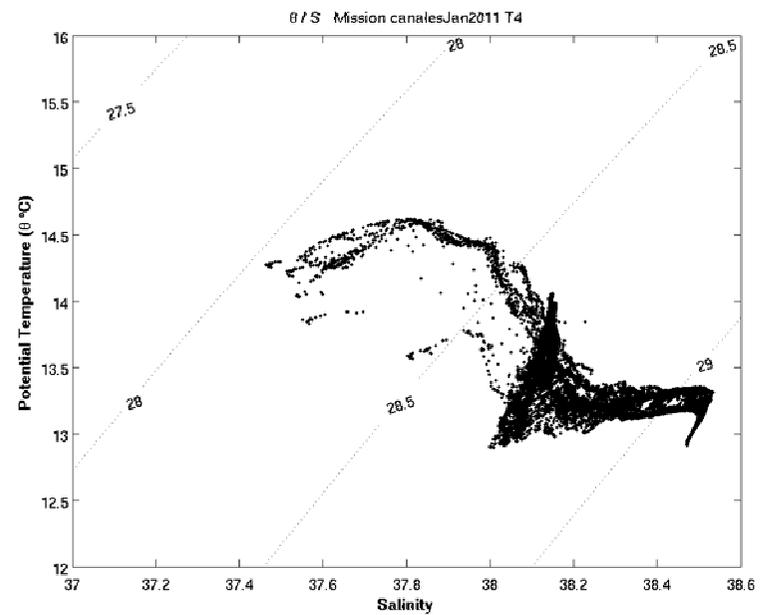
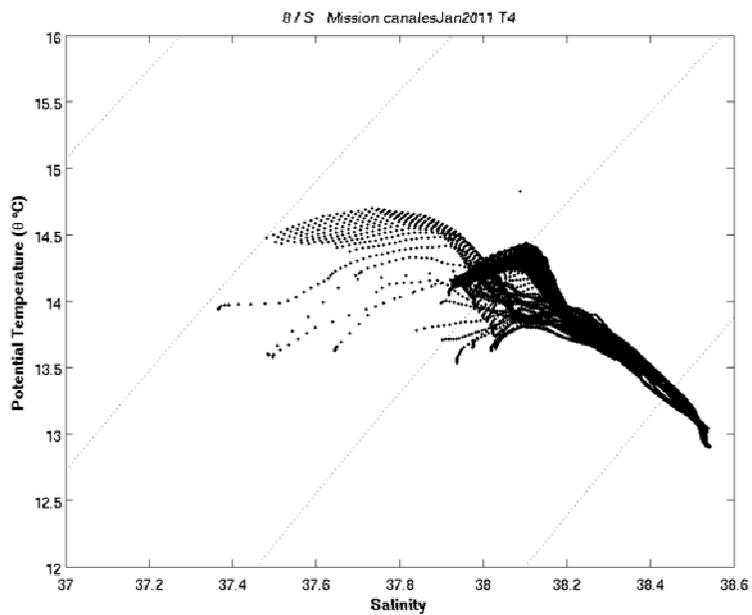


GLIDER





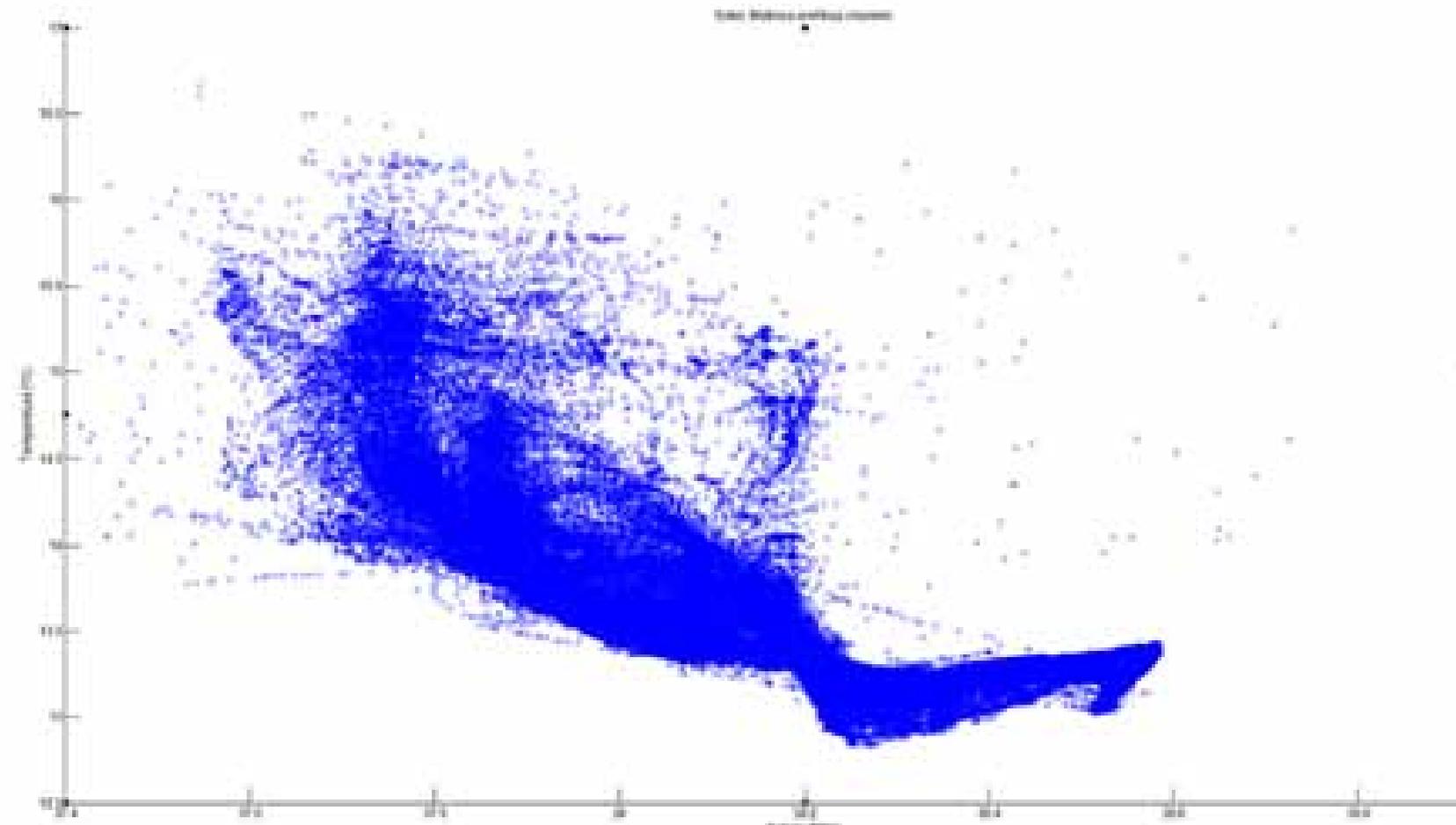




1st SOCIB Seaglider mission (ongoing, April 19 reaching Ibiza): – April 2012 –

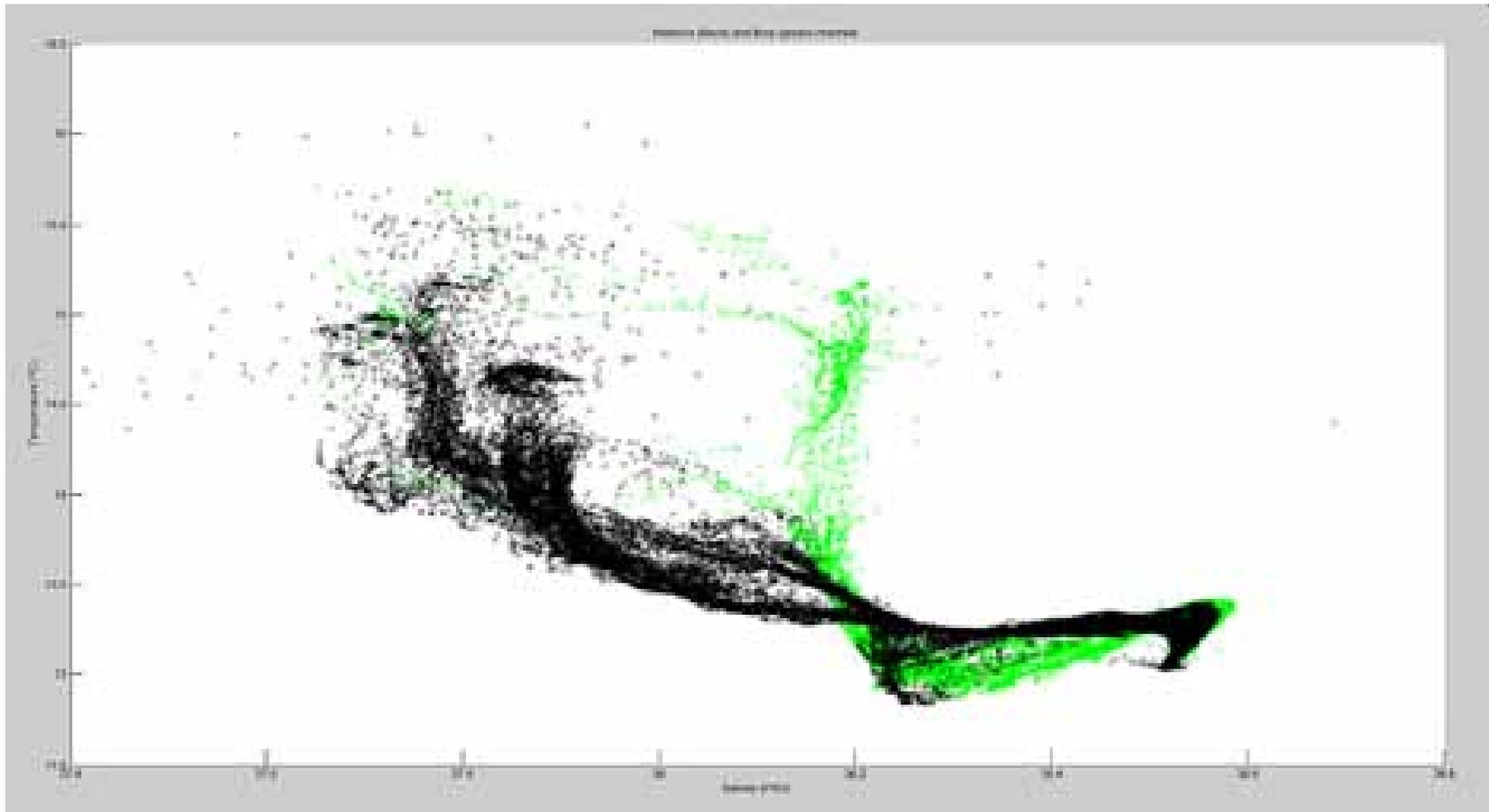


1st SOCIB Seaglider mission (ongoing, April 19 reaching Ibiza): – April 2012 –



All dives, since deployment

1st SOCIB Seaglider mission (ongoing, April 19 reaching Ibiza): – April 2012 –



Mallorca channel (black), Ibiza channel (green)

SOCIB Glider Facility (Summary)

Glidors (a fleet of ...) ?:

- They allow long term, sustained, multidisciplinary monitoring of the coastal ocean for example at key control sections.

- They are providing new evidences of the complexity of the coastal ocean, by resolving tridimensional mesoscale and submesoscale instabilities **never fully observed before**, showing the intrinsic dynamical relevance of theses instabilities, their interactions and effects on the mean circulation, and their role on the response of the ecosystem.
 - **A major observational breakthrough is appearing upfront.** It will trigger theoretical and numerical developments...
 - Examples from Balearic and Alborán Seas have been shown, suggesting the capabilities that will soon arise from monitoring with fleets of gliders, physical variability and ecosystem response at meso and submesoscale...

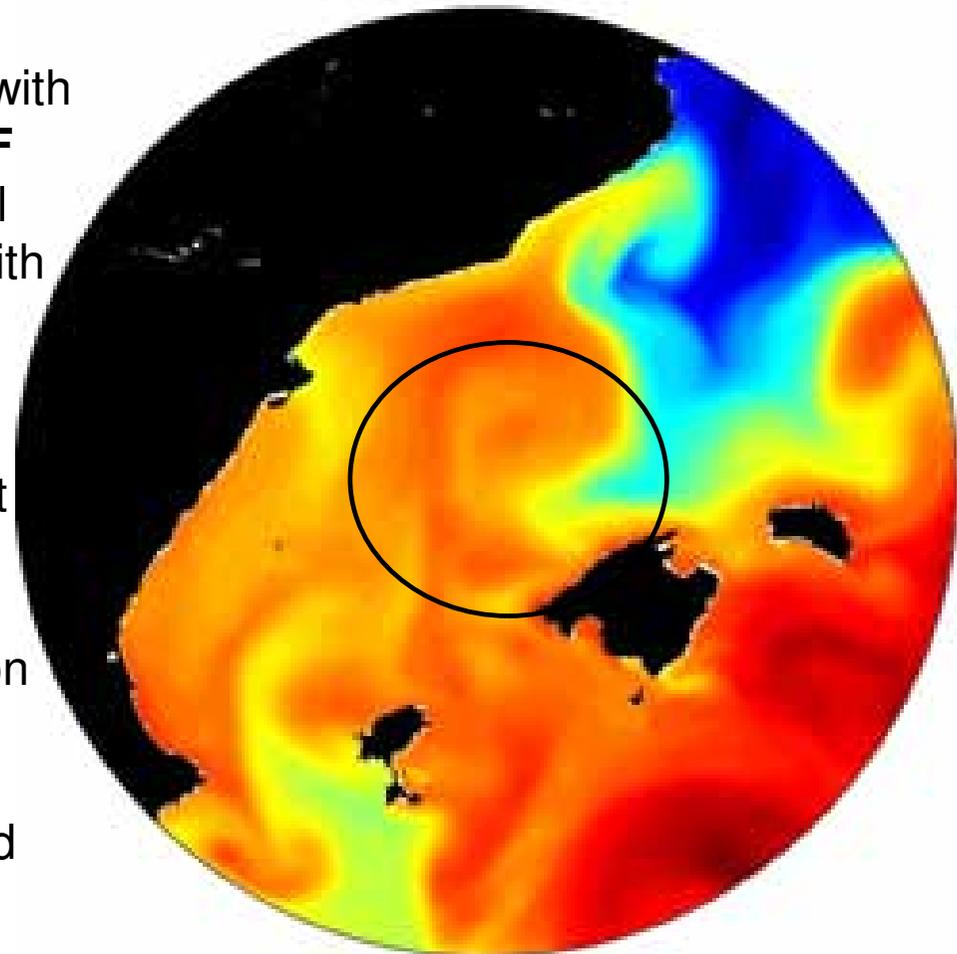
Modelling Facility

Operational Modeling: **ROMS**, 2km, to reproduce and maintain mesoscale features, interactions. In collaboration with PE and in the frame MFS/MOON. **WRF** Atmospheric Model. **SWAN** for coastal ocean wave Dynamics and Habor (with PE)

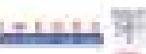
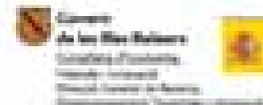
Aim :

- Validate the model with measurement (gliders, ...)
- From available data and model simulation (5 years), study the formation of mesoscale structures.
- Understand impact of meso/submesoscale on circulation and on the ecosystem

DAY = 1



SST from 11/2008



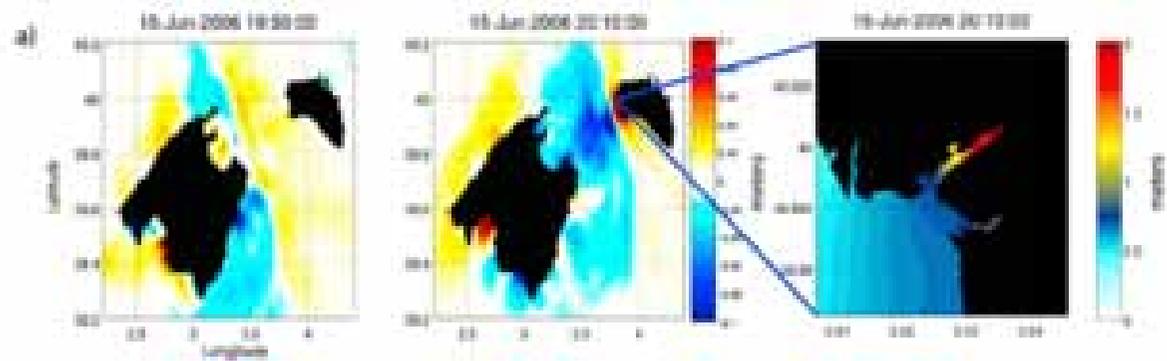
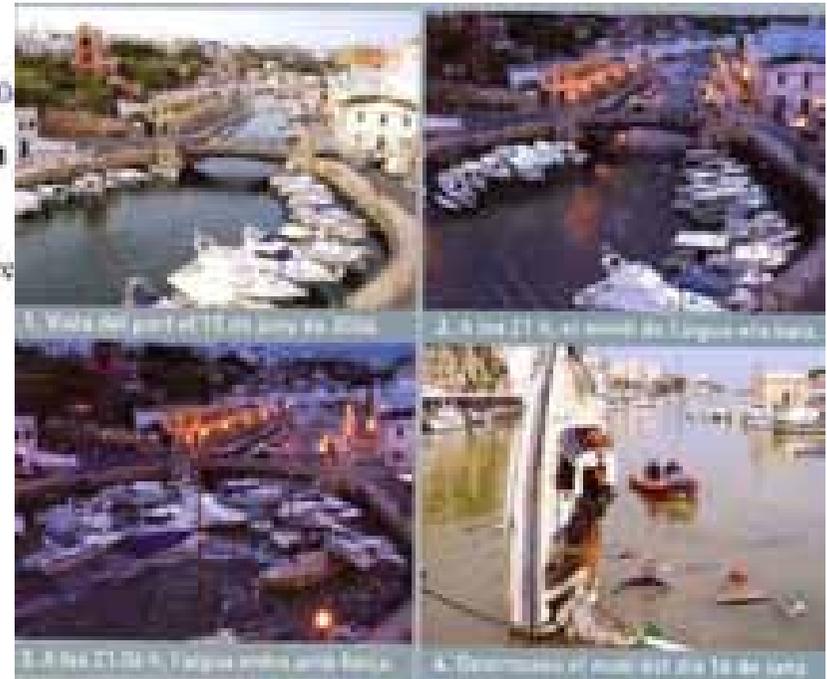
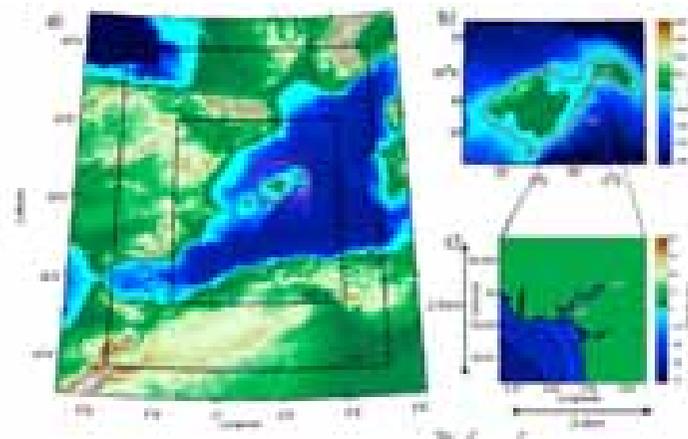
Modelling Facility; Meteotsunamis forecasting

GEOPHYSICAL RESEARCH LETTERS, VOL. 38, LXXCCXX, doi:10.1029/2011GL015400

1 Toward the predictability of meteotsunamis in the Balearic Sea
 2 using regional nested atmosphere and ocean models

3 Lionel Renault,¹ Guillermo Vazco,² Agustin Jansá,³ John Wilkin,⁴ and Joaquin Tintore

4 (Received 4 March 2011; revised 29 March 2011; accepted 30 March 2011; published XX Month 2011)



Centre for Earth System Science
 Institute of Oceanography
 Spanish Research Council
 Spanish Government
 Spanish Ministry of Science and Innovation

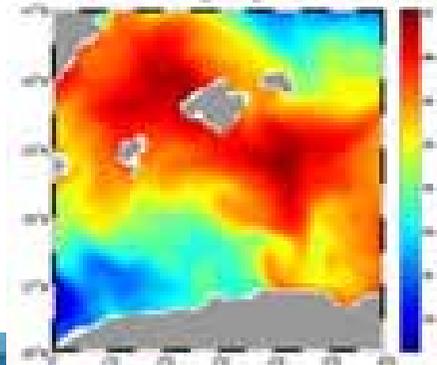


Bluefin Tuna Target Project: scientific problem solving for sustainable fisheries: at SOCIB since 2011

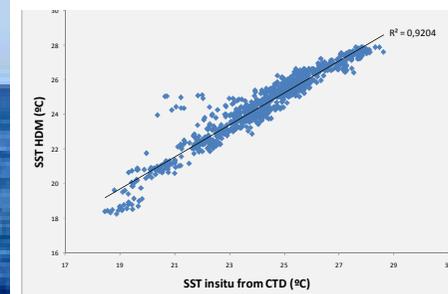


Initial Activities and First Results:

- Compilation of historical larvae data from various projects at IEO
- Link fishing data with ROMS, remote sensing and in situ hydrography
- Validate ROMS historical hydrographic data (SST and SSS) in the study area
- Development of an analysis framework and tools for modelling habitat-species relations.
- Development of field campaigns for studding specific key ecological questions
- Organize a inter-institutional working framework for data management and project flow control



ROMS derived SST vs CTD

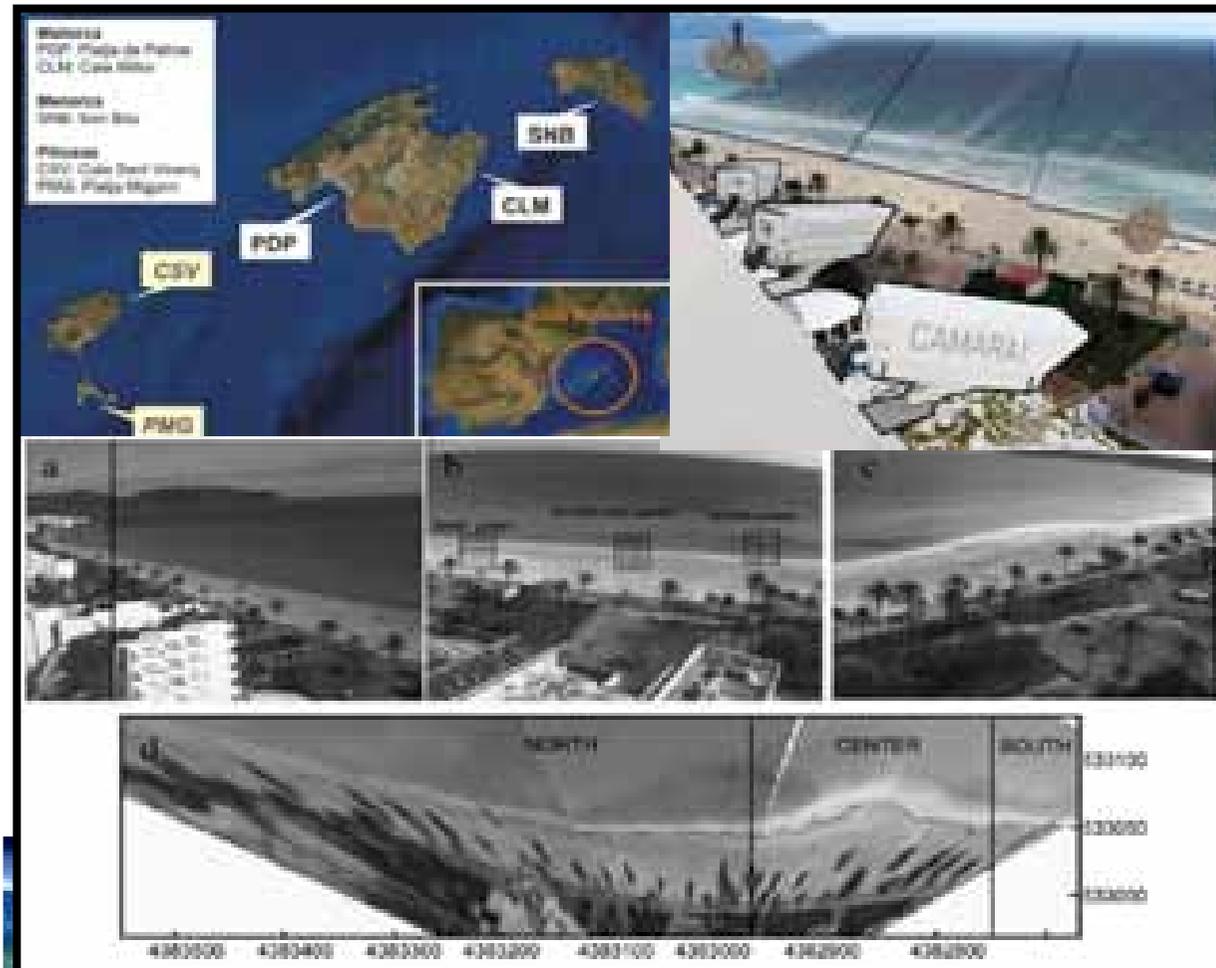


University of the Balearic Islands
Instituto de Oceanografía
Departament d'Enginyeria i Ciències
Ambientals i Tecnològiques



Marine and Terrestrial Beach Monitoring Facility

TMTBMF is a MODULAR SYSTEM designed to monitor continuously and in an autonomous way short and long term physical beach hydrological and morphological parameters.



MOBIMS

Beach videomonitoring
(SIRENA)

Waves and currents
(ADCPs)

Bathymetry and beach
profiles surveys

Sediment parameters

**PRODUCTS & SERVICES FOR
BEACH MORPHODYNAMICS
RESEARCH, BEACH SAFETY
& COASTAL MANAGEMENT**

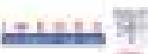
Data Centre Facility

A crucial element for real multi-platform integration, a pilot element for a Spanish Data Management strategy.

Goal: to provide researchers and users with a **system** that allow to **locate and download the data** of interest (near real time and delayed mode) to **visualize, analyze** and manage the information.

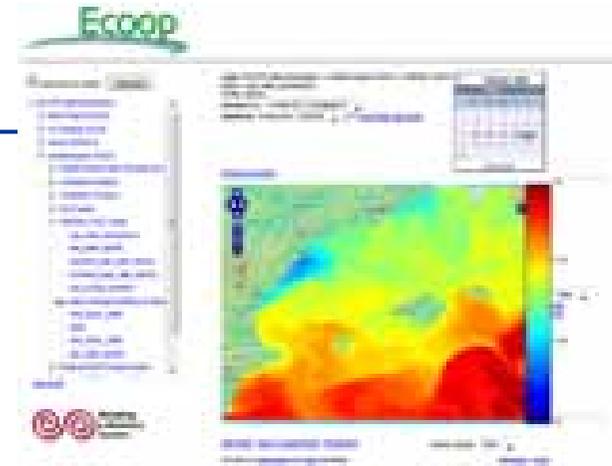
Principles of SOCIB Data Center: the data are,

- Discoverable, accessible, 'collect once, use many' (data and metadada)
- Freely available
- Interoperability, standardization and sharing guarantee

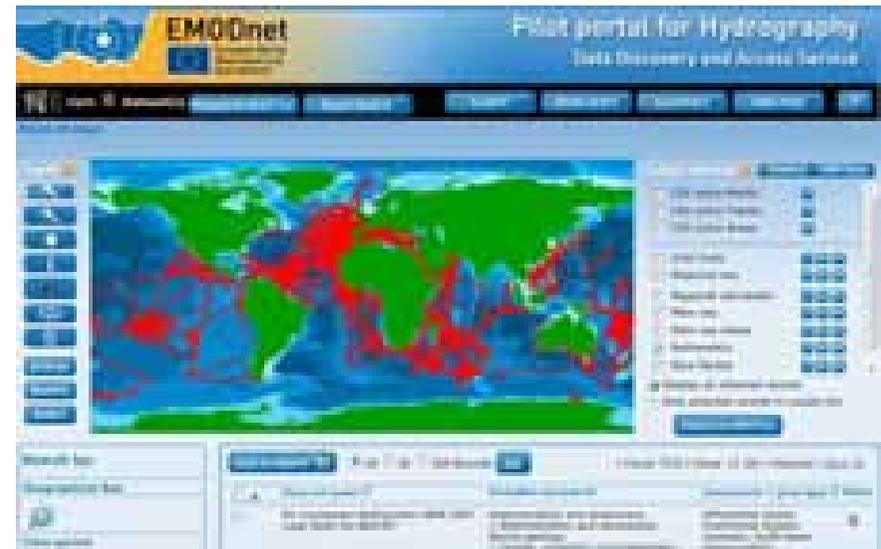


Data Centre Facility

The European framework



The international framework



Data Center: Science and Technology

To accomplish the full lifecycle data (from the modeling and observing systems ingestion up to the user), the data center has defined seven steps for the Data Management Process:

1. Platform management and communication
2. Quality Control assurance
3. Metadata Aggregation and Standardization
4. Data Archive
5. Data Search and Discovery
6. Data Policy and distribution
7. Data Viewing



Data Centre: Technologies

The main technologies used are: OPeNDAP/THREDDS server hosting CF-compliant NetCDF; the open-source RAMADDA as a content management system and collaboration services for Earth Science data. Those technologies permit the distribution, cataloging and discovery over the oceanographic data.

1. Multi Platform Management



Already available: gliders, drifters, moorings, ad-
up, beach monitoring cameras, ... Real-time
monitoring and wide descriptions of data sets
(standard-compliant)

2. Data Archive



Informatic infrastructure: to securely archive data
and metadata and retrieve them on demand

3. Distribution



OPeNDAP, WCS, WMS, HTTP, FTP, ... to
access the data in an interoperable manner
from client applications.

4. Catalog



THREDDS to organize data and Metadata in
automatic searching

5. Discovery

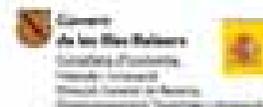


RAMADDA to search for and find data sets of
interest for human interaction

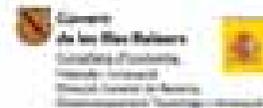
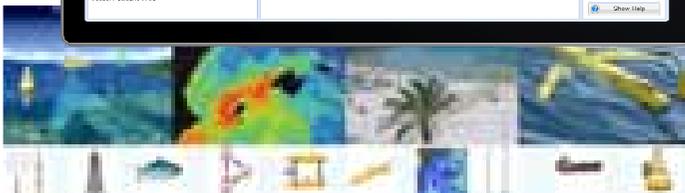
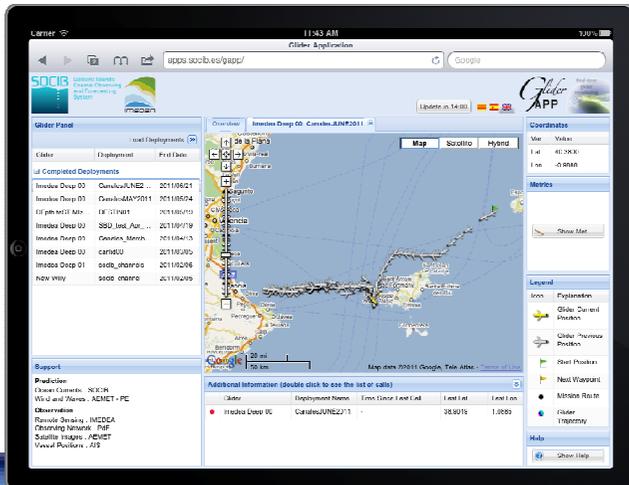
6. Analysis and Visualization



IDV, own Web Applications, GODIVA, LAS...
capability to provide an integrated viewing
service



Data Centre (Technologies; example of Apps)



OUTLINE

1. The 2012 Oceans' Challenges for Science, Technology and Society
 2. Ocean Information for Society,... what we learned in the Mediterranean
 3. SOCIB, a new multi-platform approach
-
1. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

Innovation in oceanographic instrumentation

3 elements:

- Oceans complexity imply and drive a need for improvement of instrumental capacities
- The innovation process, complexity and incubation time
- The key to success

(Curtin and Belcher, TOS, 2008)

Innovation in Oceanographic Instrumentation

BY THOMAS S. CURTIN AND EDWARD G. BELCHER

INTRODUCTION

The tools of oceanography include instruments that measure properties of the ocean and models that provide continuous estimates of its state. Major improvements in tool capabilities lead to leaps in understanding, and this increased knowledge has many practical benefits. Advances in tool capabilities are sometimes viewed as an objective of basic research, a viewpoint reflected in the basic research funding category of "science and technology" (S&T).

The complexities of and incubation times for advancing instrumentation are often not fully appreciated, resulting in unrealistic expectations and decreasing support. Greater understanding of the process of innovative instrument development can contribute to increasing its effectiveness (as measured in technical, depending on performance goals) (Blackburn, 1991), stimulated or suppressed depending on institutional factors (Van de Ven, 1999; Office of

Technology Assessment, 1991), and assessing or disrupting depending on value propositions (Chambers, 1997). For example, going from a float to a float-bottle was an incremental innovation, whereas going from bottle casts to CTD profiles was a radical innovation. Mixed current meters incrementally advanced from the recording of gauges, to mechanically digitized signals on reel-to-reel tape, to solid state reading, to digital conversion and memory. Radical innovations of current field measurement came with the acoustic Doppler current profiler.

In large organizations, established innovation often occurs in research departments, particularly when the projects have champions. "The new idea either finds a champion or dies" (Stokes, 1995). In other parts of the same organization, innovation may be suppressed by the costs associated with re-engineering a system and meeting personnel competition. The incubation times of the

company cannot flow together or with one line 30 years. Its oceanographic observation, when complete coverage is an objective, a continuing innovation would be a sampling platform with improved propulsion that doubles its speed. A disruptive innovation would be a new platform with much slower speed, but with much longer duration and a low enough cost to be deployed in great numbers. Here, we will focus on radical, stimulated, disruptive innovation that involves both science and engineering.

To increase continued innovation in basic research, the histories of many radical innovations, ranging from the transistor to solar to the Internet, have been documented (Bachler, 1999; Harrell, 1976; Nelson, 1983; Stone and Gwynn, 1976; Wilson, 1981; Wilson, 1984). The National Acquisition History Team at the US Army Center of Military History is also preparing a document on this subject. These case study documents that "rapid" innovation in

Oceans complexity, needs for improvement of instrumental capacities

Rationale:

The Oceans; a complex system, changing, under-sampled: tools to study them include

- Instruments to measure properties
- Models for continuous estimates of states and evolution

Improvements in tools capabilities



Increase understanding



Major practical benefits

The innovation process (for advancing oceanographic instrumentation)

Complexity of innovation process: needs to be known, to avoid unrealistic expectations and/or discontinuous support.

Incubation time: 15-30 years (computer mouse, 30 years). Gliders 10 years. ¿?

Innovation can be incremental or radical, stimulated or suppressed.

The innovation process (for advancing instrumentation)

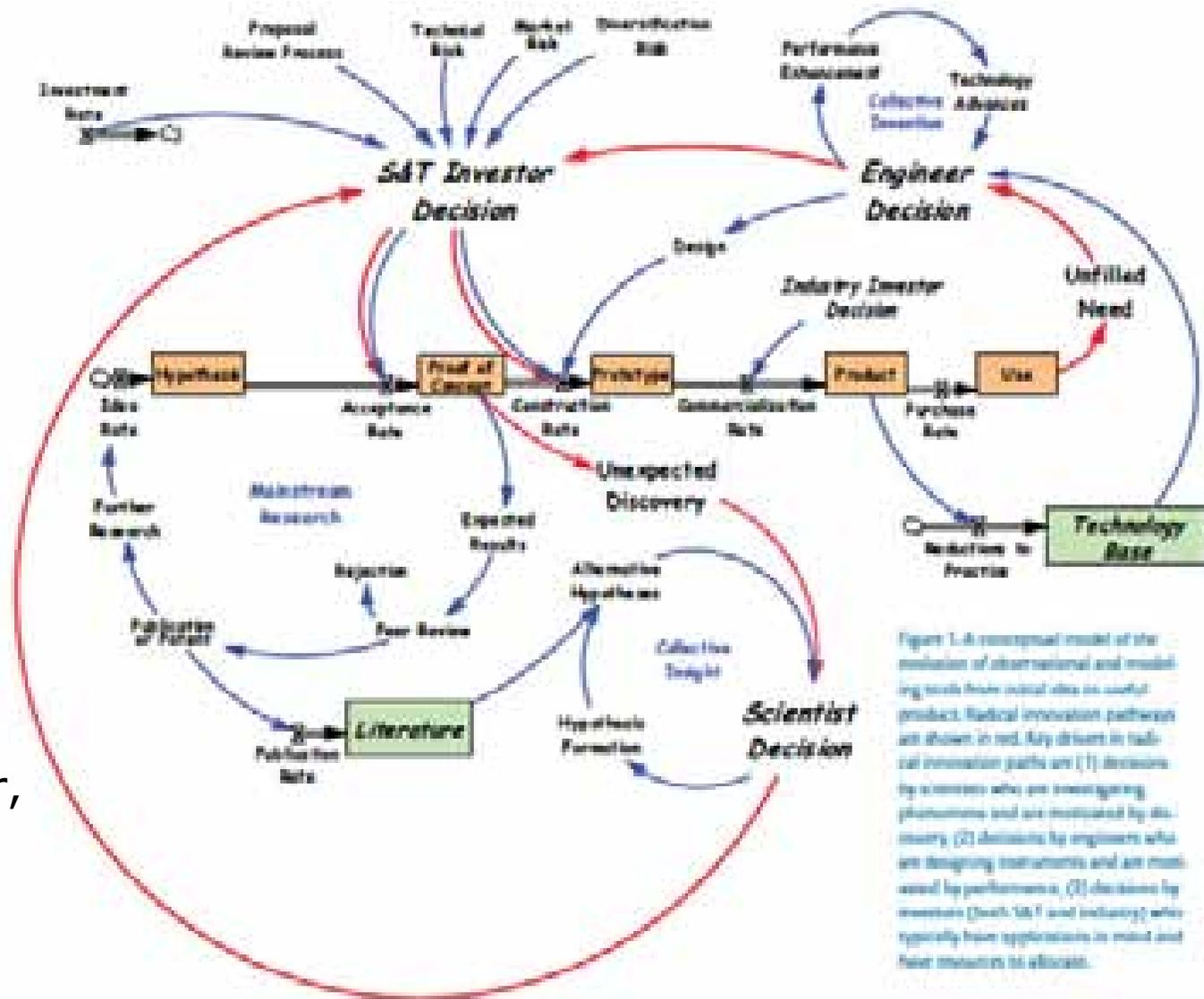


Figure 1. A conceptual model of the evolution of observational and modeling tools from novel ideas to useful product. Radical innovation pathways are shown in red. Key drivers in radical innovation paths are (1) decisions by scientists who are investigating phenomena and are motivated by discovery, (2) decisions by engineers who are designing instruments and are motivated by performance, (3) decisions by investors (both S&T and industry) who typically have opportunities to invest and have resources to allocate.

(Curtin and Belcher, TOS, 2008)



The innovation process (for advancing instrumentation)

Why is it important? : we need synoptic coverage

And... “Every time a new instrument has arrived, new key findings”...

Examples of innovations:

- Ships → Public – Private transfer
- Satellites → Ocean Weather...
- CTD → Micro-structure,
- Buoys- ARGO profilers →
- Currentmeters (rotor to ADCP) → Spectrum...
- Gliders → Submesoscale - ...



The real challenge for the next decade...:

To use and integrate these new technologies to carefully and systematically

- **Monitor the variability at small scales, e.g. mesoscale/weeks, to**
- **Resolve the sub-basin/seasonal and inter-annual variability and by this**
- **Establish the decadal variability, understand the associated biases and correct them ...**

The innovation process (disruptive, gliders)

Incubation time for gliders; 1/2

Why?:

... “A coherent set of scientists, engineers, and investors that envisioned the scientific goal, understood the technology potential and sustained the funding” (Curtin and Belcher, TOS; 2008).

The key to success for radical innovation in oceanographic instrumentation

1. Visionary leadership
2. Close coupling between science and engineering
3. A coherent investment strategy based on distributed, coordinated resources
4. Effective processes for communication, feedback, and contingency planning.
5. Incentive to assume responsibility for risky instrumentation development projects without undue career jeopardy.

In summary: work in collaborative, multidisciplinary teams, be tenacious and focused on long term objectives while producing short-term success, and find creative champions among funding agencies and investor organizations.

The role of new marine research infrastructures (MRI/ICTS/Ocean Observatories....)

→ Need to...: **RESPOND TO THE 3 KEY DRIVERS**

- Science Priorities – (ok!)
- Strategic Society Needs (more listening!, policy makers&managers endorsement), MSFD (GES); Energy, Tourism, etc.
- New Technology Developments (companies, social society endorsement)

Coastal Observing and Forecasting Systems are particularly well placed

AND → Need to define a **JOINT STRATEGY** (European level in the international framework, more than coordination, Partnership...between Observing and Forecasting Systems !!!)

Thank you!!!