Project	AtlantOS – 633211
Deliverable number	10.3
Deliverable title	An overview of main issues facing ocean observatories and the evaluation of their value-added to society
Description	Economic Benefits Main Issues Paper and Foresight Workshop
Work Package number	10
Work Package title	Engagement, Dissemination and Communication
Lead beneficiary	KDM
Lead Author	Jan-Stefan Fritz (KDM)
Contributors	Annotated Bibliography: Sandra Kettelhake (KDM) Presentations: See Annex 2
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Last updated: 10 October 2016

Contents

An overview of main issues justifying an evaluation of the economic potential and societal-benefits of data from ocean observatories

I. Background and Aim

The following is a summary of the arguments and views presented and expressed by a variety of individuals in a series of meetings over the course of a twelve-month period during which the merits and challenges to an AtlantOS-OECD initiative on ocean data were discussed. The contents for these meetings were defined by individuals representing a variety of institutions including a number of AtlantOS partners, the OECD, NOAA, the Institute for Ocean Resources Exploitation Ltd. (Canada) and the London School of Economics. In addition to numerous tele- and bilateral meetings, two more formal meetings took place:

- A meeting of 6 people on the occasion of the Oceanology International Trade Fair (15 – 17 March 2016) held in London on 16 March 2016.
- A joint AtlantOS-OECD scoping workshop to discuss and assess the economic potential of enhanced ocean observation. Approximately 25 experts attended the meeting, which was held from 27-28 June 2016 in Kiel. In preparation for the Kiel workshop, background information was collected to provide an overview of the main issues facing ocean observatories and their value-added to society. Specifically, speakers were invited to prepare detailed presentations and an annotated bibliography was prepared (see Annexes 2 and 3).

One of the key preparations for these workshops was an annotated bibliography (Annex 1) which serves to review the existing literature on the economic benefit of ocean observatories.

The aim of the discussions referred to above was to assess whether a situation was given, that could justify a more detailed assessment of the economic potential of data from ocean observatories. Overall, participants in the meetings agreed there was a need for such an initiative. They also agreed that its broader aim should be to develop a better understanding of the role of ocean data from in situ and space-based observatories in the ocean economy and its long-term outlook, including the creation of new jobs. It was argued that specific emphasis should be placed on analyzing the 'big data' economic value chains and locating the large public sector investments in ocean observation therein. The study would thus contribute to decision-making on the future of ocean observations, by better understanding their potential societal benefit and the financial sustainability needed to this end?

This report summarizes the views arguing for launching a joint AtlantOS-OECD initiative. This is important, as there existed a wide range of views on what such an assessment should focus on and upon what data and information it could be based. In fact, at the above mentioned meetings there was not a single individual that argued against assessing in more detail the economic potential of data from ocean observatories. This report serves to summarize the variety of views expressed during these initial discussions. As such, it draws specifically on the meetings and discussions held up to and including the Kiel workshop, including the attached bibliography and presentations. The current report was written, the bibliography prepared and the above workshops were organized in fulfilment of AtlantOS Deliverable 10.3.

Please note: A workshop report detailing the discussions of the Kiel meeting, including the priorities for next steps will be delivered as D10.4.

II. The main issues justifying a detailed study of the economic potential of data from ocean observatories

Societal Benefits of ocean observatories

Over the past two decades an increasing number and variety of ocean observatories has been and is still being launched. Improvements in technologies, including sensor developments and technological efficiency gains, have helped this spread. However, observers have noted that the demand for data from the oceans is also growing. A number of specific reasons for this increasing demand have been cited, including that data are valuable:

- For an increasing number of economic interests;
- For technology testing and development (e.g. calibration);
- For an improved scientific understanding of the oceans;
- For a better understanding of the natural capital and ecosystem benefits of the oceans;
- For a better understanding of the role of the oceans in the overall earth system and especially their role in weather and climate;
- To the formulation of policies, monitoring of policy compliance and effectiveness associated with measures to protect the environment or regulate ocean uses, for safety and emergency response, as well as the protection of coastal communities;
- To support operational needs, e.g. for metocean information needs of commercial maritime activities and operations.

Historically, sustained ocean observations have developed as a patchwork of research initiatives as well as policy/regulation-driven monitoring and observations for specific operational/commercial needs. Since 1990 and the establishment of the Global Ocean Observing System, states have begun to agree that sustained and integrated operational capacity supporting research and multiple socio-economic were needed. Only more recently have national components of GOOS reached significant levels of maturity as integrated systems delivering sustained data and information services e.g. IOOS (USA), IMOS (Australia), Copernicus (EU), Ocean Networks (Canada). One of the biggest characteristics of the recent developments is that so far most functioning ocean observatories have been funded by individual states, though sometimes in small international consortia. ARGO is one of very few global exceptions, though contributions to this effort are nationally funded and operated, except in the case of the EU. One of the few areas of more systematic international cooperation is on the conceptual front, including the development of the Essential Ocean Variables in 2009.

Challenges in quantifying the societal benefits

According to some observers, one of the key challenges holding-back the development of more systematic observing systems has been the issue of defining and quantifying the societal benefits. To date, most political and scientific decisions regarding ocean observatories at the European and international levels have been based on the assumption that the socio-economic benefit justifies the expenditure on marine scientific research and operational oceanography. It was specifically noted by some observers that the ocean observatories community has been lucky to have many observation systems approved because even though the assumptions about societal benefit are probably broadly correct, but are hard to prove. Indeed, some observers are convinced that it is possible that the real benefits of an ocean observing system are much higher than is expected, but again this is difficult to prove without the data or even a recognized method for such a calculation.

The lack of empirical evidence to assess the value-added of ocean observatories was deemed by some observers to be the result of operational oceanography probably being in an immature pioneer state during the 1990s and early 2000s. In that stage, simple and approximate means were applied to measure probable benefit. One observer described what was termed a “Zero Order Calculation” as being particularly popular in some countries. According to this method you sum the turnover, revenue or value added by all marine industries and related activities to arrive at a percentage of GNP, and then assume that operational oceanography could add approx. 1% to this figure through improved efficiency as well as loss and accident avoidance. A number of studies start by alluding to the complexity of cost-benefit analysis and then resort to the 1% rule as a pragmatic expedient. As a result of such uncertainty, most benefit analyses have been confined to case studies of specific benefits for direct applications (e.g. harmful algae blooms and beach closures as well as port observations and port operations). These are derived with widely differing methodologies and sometimes inconsistent results. They are also often locally specific and thus difficult to aggregate and/or compare. These observations are widely reflected in the existing literature (see Annex 1).

Ultimately, observers agreed that if further investment is to be considered on a large and/or global operational scale, the socio-economic justification for ocean observation must become much more robust. During the discussions, participants identified a variety of specific challenges facing attempts at articulating more sophisticated cost-benefit analyses regarding ocean observatories. These include:

- The length and fragmented nature of the value chain from the scientific community through operational oceanography to commercialization;
- The diversity and growing set of users;
- Multiple levels of government bodies with different and sometimes overlapping and competing policy responsibilities and data rights;
- Differing interests between ocean scientists and ocean business;
- The relative ease of mobilizing short-term, up-front capital expenditures (CAPEX) by comparison to the relative difficulty of securing long-term operating expenditures (OPEX);
- The incompatibility and fragmentation of data from different sources (different formats, nomenclature, baselines, standards, etc.)

In addition, specific difficulties of quantifying benefits were highlighted, especially if the aim is to analyze the concrete commercial benefits. Some difficulties noted include the lack of or missing precise information for Maritime and Ocean Enterprise subsets form national statistical agencies.

Potential Approaches to measure the Societal Benefits
To overcome these challenges requires a combination of experience in operational oceanography and economic skills, especially at the design stage. However, it was warned that rushing this stage might be counter-productive since the future funding and management of operational oceanography will require both broad total figures, plus accurate technological and economic models of sub-sectors so that the system can be understood as it evolves. Methods must be developed for aggregating benefits and costs from separate sub-sectors in a way which avoids double counting or gaps. Ultimately, a focus for such efforts could be to calculate one “headline” figure for the best estimate of the net present value (NPV) for operational oceanography over the next 20-50 years, plus a series of different net benefits based on different assumptions and models, also broken down into sectors with different characteristics and time-frames.

In terms of looking to the potential benefits of a detailed study on the economic potential of ocean observatories, observers raised a number of questions which should be considered or indeed answered. These include:

- How are the benefits for the economy, environment or society similar or how do they differ?
- What main benefits can be envisaged for the future?
- How can industry (ship owners, wind farm operators, etc.) be mobilized to partner with publicly-funded efforts on ocean observation and mapping?
- What operational priorities should be recommended?
- How can a benefit analysis be linked to a resources-needed analysis?
- If choices have to be made, should money from research budgets be spent on observation or mapping instead?
- What are the different roles of research institutions, private sector, states and international organizations, and how can these be made to be complementary?
- What is the scope for and potential benefit of international cooperation?

On the basis of the arguments summarized above, the key partners listed at the beginning agreed that a joint AtlantOS-OECD scoping workshop on the economic potential of data from ocean observatories should be organized. This workshop was held in conjunction with the 2nd AtlantOS Annual General Meeting in Kiel from 27-28 June 2016. A report of the discussions of this workshop as well as the recommendations for next steps will be covered by Deliverable 10.4.

In addition to and on top of the commitments made in the AtlantOS Description of Activities, it is foreseen that AtlantOS will contribute as far as possible to the hosting of further expert meetings as well as a final report (planned for 2018) on the economic potential of data from ocean observatories. This report will be published by the OECD as part of its Future of the Ocean Economy project. As specified in the AtlantOS mandate, a concrete effort is being made to build long-term international partnerships which will better understand and demonstrate the utility of integrating in-situ and satellite observations both for ocean and climate change research and for informing a wide range of maritime industry and other sectors.

Annex 1

AtlantOS-OECD scoping workshop "Economic potential of data from ocean observatories"

Introduction

The aim of this short bibliography is to represent the findings and/or the results of some studies, reports, papers and articles dealing with the economic, potential value of data out of the oceans.

Each of the entries has been structured in the following way: First, the purpose of the study is described. Second, the main findings are depicted. In the end specific aspects concerning data collection, management, etc. are emphasized.

Please note that this annotated bibliography is a work in progress and will be updated regularly as the study develops.

Annotated Bibliography

1. **Kite-Powell, Hauke/Teisberg, Tom (lead authors) (2000): The Economics of Sustained Ocean Observations: Benefits and Rationale for Public Funding, NOAA and Office of Naval Research: Washington, DC**

This report summarizes the results of a cost-benefit analysis of the Integrated Sustained Ocean Observing System (ISOOS) carried out by the members of the ISOOS Economic Panel.
The cost-benefit analysis suggests that there is strong evidence that the data information from ISOOS will produce significant economic benefits for a wide range of activities like seasonal forecasts and coastal management. The contribution to the U.S. economy of industries and activities that have been identified as likely beneficiaries of ISOOS products is on the order of US $1 trillion.
The members of the ISOOS Economic Panel conclude that ISOOS benefits will significantly exceed costs and that this project should move forward. Furthermore, the network externalities (e.g. a wide and diverse group of users will be provided) and public-good characteristics of ISOOS argue for Federal support to achieve the full benefits of the system. Otherwise, e.g. the uncertainty about benefit acts as an impediment to private negotiations could hinder the development of e.g. private cost sharing agreements. The public funding should be used to provide the basic data collection and verification operations envisioned in ISOOS. In the end ISOOS would broaden and systemize the collection of ocean data, due to the integration of hundreds of thousands of measurements from the world´s oceans in conjunction with mathematical models. As a result a more sophisticated understanding of ocean-related systems become possible.

2. **Flemming, Nicholas C. (2001): Dividends from investing in ocean observations: a European perspective, in: Koblinsky, C.J. / Smith, N.R.: Observing the Oceans in the 21st Century, Southampton Oceanography Centre: Southampton, pp. 66-84.**

This paper presents a case for increasing European investment in ocean observations, although it concedes there are insufficient economic data to conduct a strictly controlled cost-benefit analysis.

The paper argues that because ocean industries and services are subject to uncertainty, loss of efficiency, and direct costs and damage caused by the unpredictable forces of the marine environment there is a need for an efficient ocean observing system. The paper pursues several questions: Why such a system is needed? How it should be paid for? And, how can the costs and benefits be measured?

In the end, the author highlights five important issues: First, an ocean observing system generates positive dividends much greater than its costs for Europe. Second, Europe has a positive incentive to support the development of such a global system. Third, ongoing economic studies indicate that the discount rate should be closer to 1 % and thus it is more worth developing long term ocean observing programs. Fourth, for Europe as an archipelago continent it is practical to develop marine observing systems at all scale from coastal to shelf scale to oceanic. Ultimately, the existing European institutions and national facilities provide many of the components needed for a Europe-wide ocean observing system.

3. **Kite-Powell, Hauke L. (2009): Economic Considerations in the Design of Ocean Observing Systems, in: Oceanography, Vol. 22 No. 2, The Oceanography Society: Rockville, MD, pp. 44 - 49**

This article summarizes and discusses a National Oceanographic Partnership Program (NOPP) study on the economics of ocean observing system information. It also presents a general framework for incorporating economic information into observing system design. The author describes the beginning of such an application process by estimating the potential benefits from the Northeast regional ocean observing system to the northeast region of the United States.

Some of the key questions the author considers in the debate concerning public investment in improved ocean observing infrastructure are: How much, and how fast, should investments be made in better ocean observing systems? What should these observing systems look like?

The answers to both questions depend, in part, on how much economic value these improvements are expected to generate. The author concludes arguing that the economic value delivered by properly designed ocean observing systems is likely to exceed their costs, and that targeted public investment in observing systems is justified.

4. **Witze, Alexandra (2013): Marine science: Oceanography`s Billion-Dollar Baby, in: Nature News, Vol. 501, Macmillan Publishers: London, pp. 480 -482**

This article describes the large-scale undersea U.S. project (U.S. Ocean Observation Initiative [OOI]), in which a 925-kilometre network of fibre-optic cable and instruments are being installed on the seabed off the coast of Washington and Oregon. The aims of the OOI is to open a permanent window onto the sea floor and to create a flood of continuous information from select sites.

The article highlights the controversy over the project, which is criticized by many U.S. oceanographers who argue that the cost of US$ 1.8 billion over 25 years it too expensive.

Proponents argue that current alternatives are simply insufficient. The project is planned to consist of several stations, which will link about 760 sensors of 47 different designs to collect data on variables ranging from water temperature, salinity and density to acidity, carbon dioxide and oxygen levels. Ultimately, OOI seeks to collect a broader selection of data than those efforts existing already.

Everyone can use the OOI data, but the data set it is not exhausted. For example, for microbiological monitoring the researchers still have to go on abandon field trips, because there is no instrument they could plug in for microbiological monitoring.

5. **United Nations Conference on Trade and Development(UNCTAD) (2014): The Oceans Economy: Opportunities and Challenges for Small Islands Developing States (SIDS), United Nations Publication: New York, NY**

This study aims to clarify the nascent and developing concept of the oceans economy, especially for SIDS. The authors identify the main trade and development opportunities and challenges in the ocean space, evaluate the role of the multilateral trading system (MTS), and provide an overview of the current multilateral trade negotiations regarding the oceans economy.

The authors argue that oceans are facing significant existential ecological risks that can negatively affect social and economic prospects, particularly of SIDS and coastal states. The study concludes that, in general, the ocean economy offers significant development opportunities, but also raises challenges for SIDS, especially in sectors such as sustainable fisheries and aquaculture, renewable marine energy, marine bio-prospecting, maritime transport and marine and coastal tourism. One more specific conclusion is that trade in marine products can create opportunities for economic growth, export diversification and new investments. Due to the development of new technology, marine resources become more accessible and new economic and trade sectors could emerge generating for example new job opportunities.

6. **Integrated Ocean Observation System (2016): The Ocean Enterprise – A study of US business activity in ocean measurement, observation and forecasting, ERISS Corporation: Carlsbad, CA**

The aim of this study is to determine the extent of United States private sector, commercial activity in support of ocean measurement, observation and forecasting and the sale of ocean information to underpin safety, economic and environmental benefits. It is a contribution to our understanding of the ocean enterprise, especially for the US, but also for countries around the world, by investigating e.g. the visibility, importance and measurement in this field. Additionally, it seeks to provide a baseline against which to measure future developments in this field and as a support to future studies of the wider ocean economy.

The study defines “ocean enterprise” in this field as encompassing both for-profit and not-for-profit businesses and institutions which support ocean measurement, observation and forecasting. Two main categories of ocean enterprise firms are identified: (i) providers of infrastructure for ocean observation, measurement, or forecasting and (ii) intermediaries that make use of ocean, coastal and inland water measurements, observations as well as models as input to the creation of value-added information products in support of particular end-uses. End-users (including the science community and marine industry sectors) of ocean information are not included in the scope of the study.

The results of this study indicate a diverse and dynamic sector, with large potential for growth and innovation. The study concludes that the revenue of ocean enterprise organizations in the US could range as high as $58 billion. Moreover, potential for new business for existing firms is tremendous, because the expanding infrastructure needs and the need for new applications using ocean observation data become magnified in conjunction with the growth and demand from the sectors the ocean enterprise directly underpins.

Annex 2

OECD Ocean Economy Group / AtlantOS project

Scoping Workshop
Exploring the Economic Potential of Data from Ocean Observatories

Information for Participants

27 - 28 June 2016
Kiel, Germany

This workshop has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633211

OECD Ocean Economy Group / AtlantOS project
Workshop
Exploring the Economic Potential of Data from Ocean Observatories

27 - 28 June 2016
Kiel, Germany

(Version 21 June 2016)

Many countries have made over the years large public-sector investments to collect data about various aspects of the ocean, including climate-ocean-land interactions, environmental and physical oceanographic changes, geological risk assessments, etc. Are such investments a cost-effective means for improving our understanding, use and protection of the oceans? Which case studies exist to demonstrate value for money? What established methodologies should be used to provide evidence to policy-makers?

Building on the work conducted at the OECD in a wide range of ocean-related policy areas, this workshop, co-organised with the AtlantOS EU project, will start scoping the role and impacts of ocean observations in the wider economy. The event will bring together invited experts from ministries, industry and international organisations.

14.00 WELCOME AND OPENING SESSION

- Claire Jolly, Head, OECD Ocean Economy Group
- Jan-Stefan Fritz, Head Brussels Office, Konsortium Deutsche Meeresforschung (KDM)

14.15 SESSION I. SETTING THE SCENE: OVERVIEW OF KEY OCEAN OBSERVATORIES

This session will define "ocean observatories" and provide an overview of the main types of ocean observation systems and data. The objective is to scope relevant programmes, and give an indication of the breadth of technologies and information infrastructure involved in ocean observations, so that participants develop a common vocabulary.

- Martin Visbeck (GEOMAR Helmholtz Centre for Ocean Research): *Overview of the main ocean observing systems*
- Matt Mowlem (UK National Oceanography Centre): *What major innovations are on the horizon that could impact existing systems?*

15.15 SESSION II. BASICS ABOUT SOCIO-ECONOMIC EVALUATION OF OCEAN OBSERVATORIES

This session introduces the basics of socio-economic evaluation of ocean observatories. What methods have been used so far? What are the benefits that can be expected from ocean observations?

- Claire Jolly (OECD): *Introduction with OECD perspectives on evaluation*
- Ralph Rayner (LSE): *An overview of the expected economic benefits of ocean observations*

16.00-16.30 NETWORKING PAUSE

16.30 SESSION III. CASE STUDIES: HOW HAVE SELECTED OCEAN OBSERVATORIES BEEN EVALUATED SO FAR?

This session will provide findings from relevant case studies on socio-economic impact assessment of ocean observatories conducted all over the world. The objective is to review past and current practices in trying to evaluate specific programmes or systems, and compare the studies' results and key challenges.

- Zdenka Willis (NOAA): *Lessons learned from NOAA's Integrated Ocean Observing System*
- Albert Fischer (IOC-UNESCO): *Evaluating the Global Ocean Observing System (GOOS)*
- Glenn Nolan (EuroGOOS): *Case studies from the European Ocean Observation System*
- Iain Shepherd (EC): *Evaluation practices from an EC perspective*

18.00 CLOSE OF FIRST DAY

Tuesday, 28 June 2016

9.00 SESSION III. CASE STUDIES: HOW HAVE SELECTED OCEAN OBSERVATORIES BEEN EVALUATED SO FAR? *(continuing)*

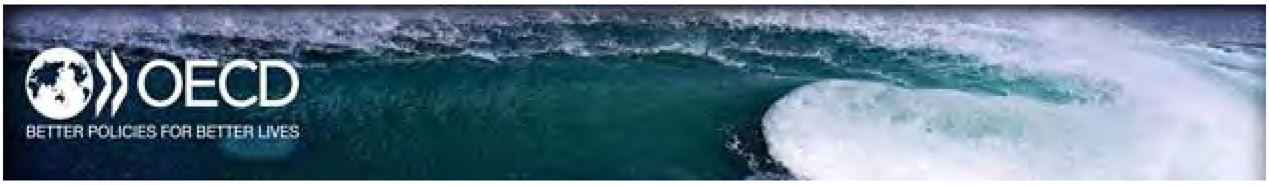
- Jim Hanlon (IORE): *Lessons learned from Canadian experiences*

9.30 SESSION IV. THE WAY FORWARD IN EVALUATING OCEAN OBSERVATORIES

This session will focus on the next steps in terms of economic evaluation of ocean observations. A number of international initiatives are underway (e.g. Galway Statement on Atlantic Ocean Cooperation, the EU flagship project AtlantOS...), and many national projects are also taking place in parallel. The objective of the session will be to identify current initiatives to foster increased co-ordination of efforts.

12.00 CLOSE OF THE WORKSHOP

12.15 LUNCH



Directorate for Science, Technology and Innovation
http://oe.cd/oceaneconomy

OECD Ocean Economy Group / AtlantOS project
Scoping Workshop
Exploring the Economic Potential of Data from Ocean Observatories

27 - 28 June 2016
GEOMAR West Campus, Düsternbrooker Weg 20
Kiel, Germany

Preliminary List of Participants
Organisations listed by country / international organisations or networks
(as of 23 June 2016)

Co- Chairs:

Claire Jolly Head, OECD Space Forum / Ocean Economy Group Directorate for Science, Technology and Innovation OECD	Jan-Stefan Fritz Head, Brussels Office German Marine Research Consortium KDM

Canada

Jim Hanlon
CEO
Institute for Ocean Research Enterprise (IORE)

France

René Garello
Professor at Télécom Bretagne
Fellow, Institute of Electrical and Electronics Engineers
Head of the Transverse Programme ICTO (ICT and OCEANS), within the CNRS research unit Lab-STICC

Germany

Jan-Stefan Fritz
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Martin Visbeck
Professor and Head, Physical Oceanography
GEOMAR Helmholtz Centre for Ocean Research Kiel
Speaker Cluster of Excellence "The Future Ocean"

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Senior Scientist
MARUM Centre for Marine Environmental Science, University of Bremen
Project Manager CMOVE

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Caroline Cusack
Oceanographic Services, Ocean Science and Information Services
Marine Institute

Italy

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Department of Physics and Astronomy, Environmental Sciences
University of Bologna

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Balearic Islands Coastal Ocean Observing and Forecasting System

United Kingdom

Chris Hill
Director, GeoData
Southampton Marine and Maritime Institute

Gus Jeans
Director, Oceananalysis
Co-chair, IMarEST Operational Oceanography Special Interest Group

Matt Mowlem
Professor Head, Ocean Technology and Engineering Group
National Oceanography Centre

Ralph Rayner
Professorial Research Fellow, Centre for Analysis of Time Series
London School of Economics and Political Science
Sector Director of Energy and Environment, BMT Group
Chairman, Sonardyne International
Industry Liaison for the NOAA Integrated Ocean Observing System

United States

Hauke Kite Powell
Research Specialist, Marine Policy Center
Woods Hole Oceanographic Institution
Lecturer, Massachusetts Maritime Academy

Zdenka Willis
Director, U.S. Integrated Ocean Observing System (IOOS) Program
National Oceanic and Atmospheric Administration (NOAA)

International Organisations / Networks

EMODNET
European Marine Observation and Data Network

Jan-Bart Calewaert
Head, EMODnet Secretariat

EuroGOOS
European Global Ocean Observing System

Erik Buch
Chairman

Glenn Nolan
Secretary General

UNESCO
Intergovernmental Oceanographic Commission

Albert Fischer
Head, Ocean Observations and Services Section
IOC/UNESCO
Director, GOOS Project Office

European Commission
Directorate General for Maritime Affairs and Fisheries (DG MARE)

Iain Shepherd
Acting Head of Unit
Maritime Policy Atlantic, outermost regions and Arctic

OECD

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Project Co-ordinator
Directorate for Science, Technology and Innovation

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Junior Economist/Policy Analyst
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Barrie Stevens
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Directorate for Science, Technology and Innovation

Annex 3

OECD Ocean Economy Group / AtlantOS project
Scoping Workshop

Exploring the Economic Potential of Data from Ocean Observatories

PRESENTATIONS

27 - 28 June 2016
Kiel, Germany

Programme

14.00 Welcome and Opening Session

- Claire Jolly, Head, OECD Ocean Economy Group
- Jan-Stefan Fritz, German Marine Research Consortium (KDM)

14.15 SESSION I. Setting the Scene: Overview of key ocean observatories

- Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research
  Overview of the main ocean observing systems
- Matt Mowlem´, UK National Oceanography Centre
  What major innovations are on the horizon that could impact existing systems?

15.15 Session II. Basics about socio-economic evaluation of ocean observatories

- Claire Jolly, OECD
  Introduction with OECD perspectives on evaluation

☞ Ralph Rayner, London School of Economics
An overview of the expected economic benefits of ocean observations

16.00-16.30 Networking Pause (and family photo)

16.30 Session III. Case Studies: How have selected ocean observatories been evaluated so far?

☞ Zdenka Willis, NOAA
Lessons learned from NOAA's Integrated Ocean Observing System

☞ Albert Fischer, IOC-UNESCO
Evaluating the Global Ocean Observing System (GOOS)

☞ Glenn Nolan, EuroGOOS
Case studies from the European Ocean Observation System

☞ Iain Shepherd, European Commission
Evaluation practices from an EC perspective

18.00 Close of first day

Tuesday, 28 June 2016

9.00

☞ Claire Jolly, OECD
Possible ways forward

9.15 Session III. Case Studies: How have selected ocean observatories been evaluated so far? ***(continuing)***

☞ Jim Hanlon, Institute for Ocean Research Exploitation
Lessons learned from Canadian experiences

9.30 Session IV. The way forward in evaluating ocean observatories

12.00 Close of the Workshop

12.15 Lunch

AtlantOS

Overview of the main ocean observing systems

Prof. Dr. Martin Visbeck
GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

AtlantOS

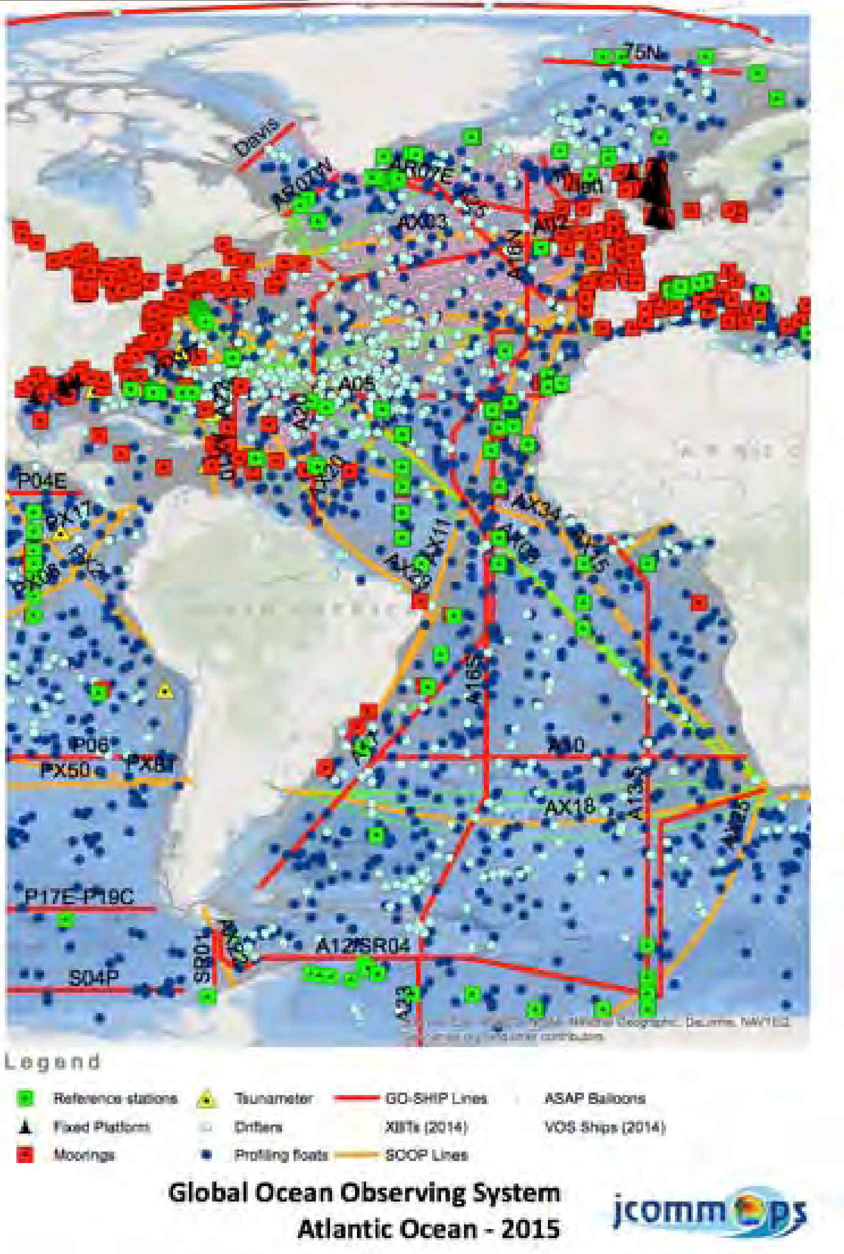
Optimizing and Enhancing the Integrated Atlantic Ocean Observing System

Budget: **21 Mio. Euros in 4 years**
Coordinator: **GEOMAR**; *Partner:* **62**

The project: **AtlantOS is a research and innovation project that proposes the integration of ocean observing activates across all disciplines for the Atlantic, considering European as well as non-European partners.**

Goal: **Integration of the so far loosely-coordinated set of existing ocean observing activities to a more sustainable, more efficient, and fit-for-purpose Integrated Atlantic Ocean Observing System.**

www.atlantos-h2020.eu



WHY observe the Ocean?

Deep Sea Discovery

Ocean and Climate

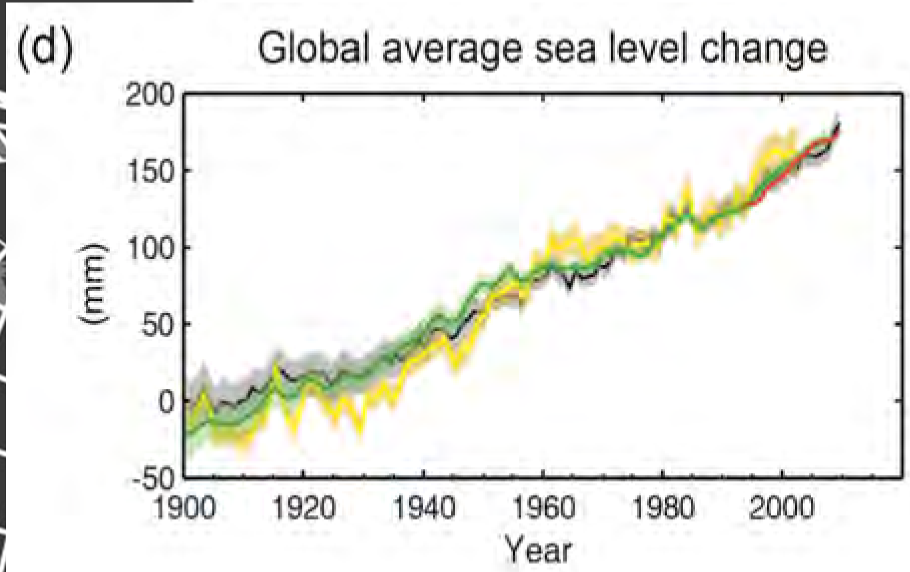
Life in the Ocean

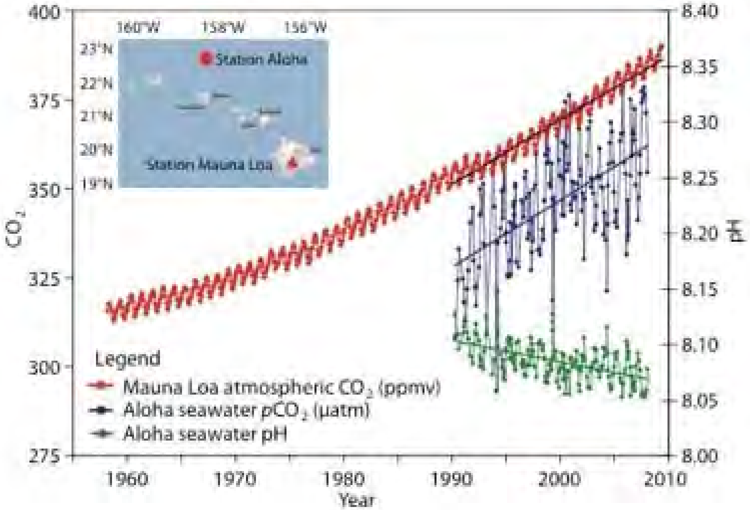
Marine Services

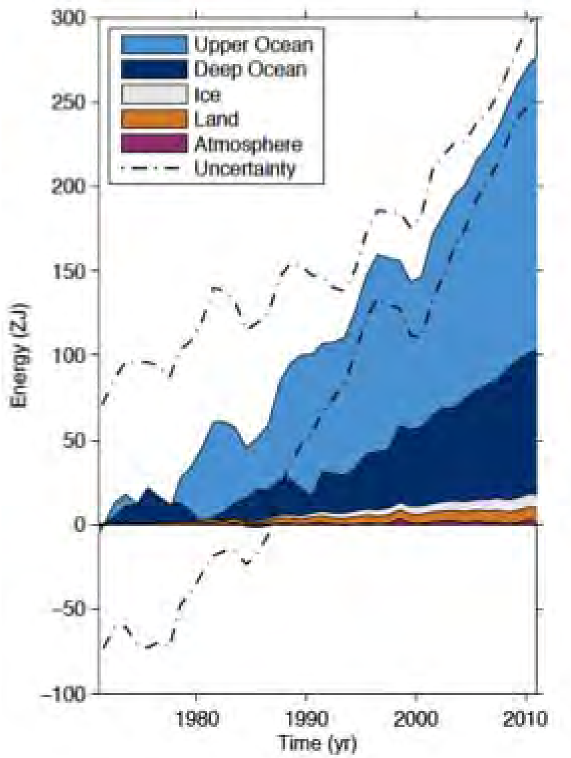
Sustainable Ocean Development

Blue/Green Economy

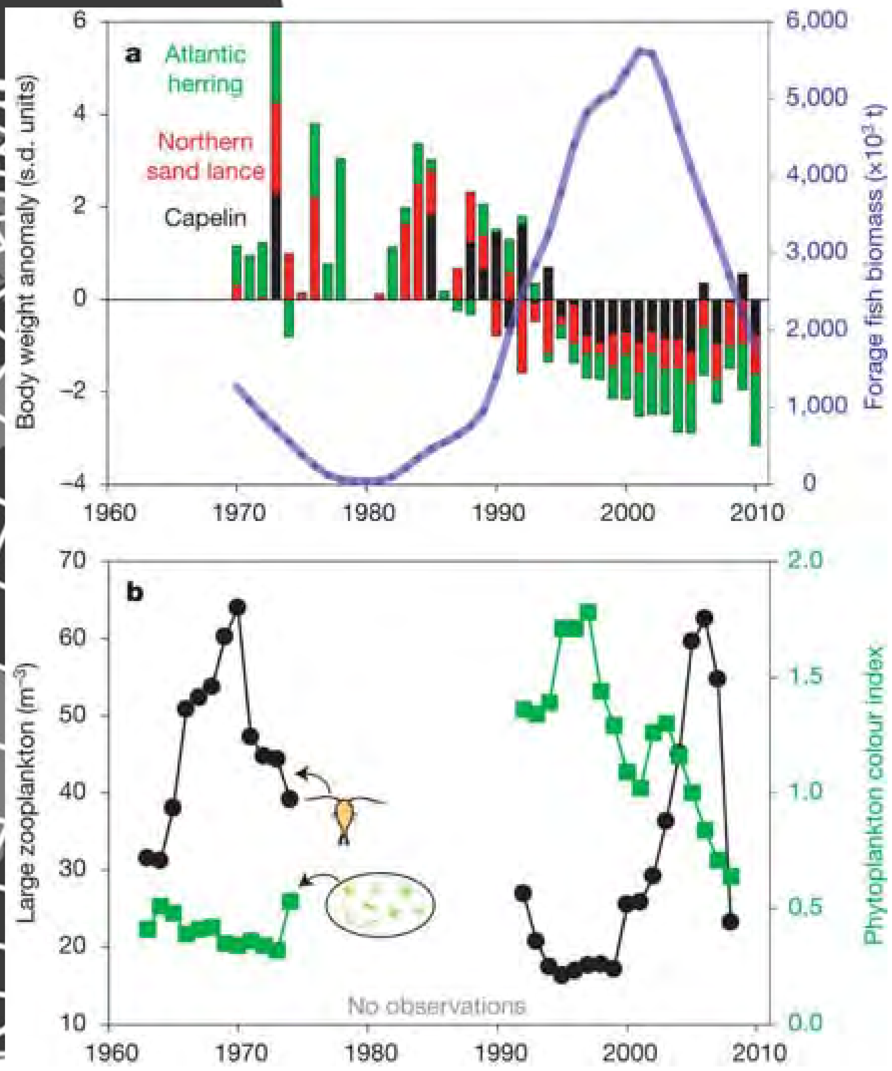
Ocean and Climate

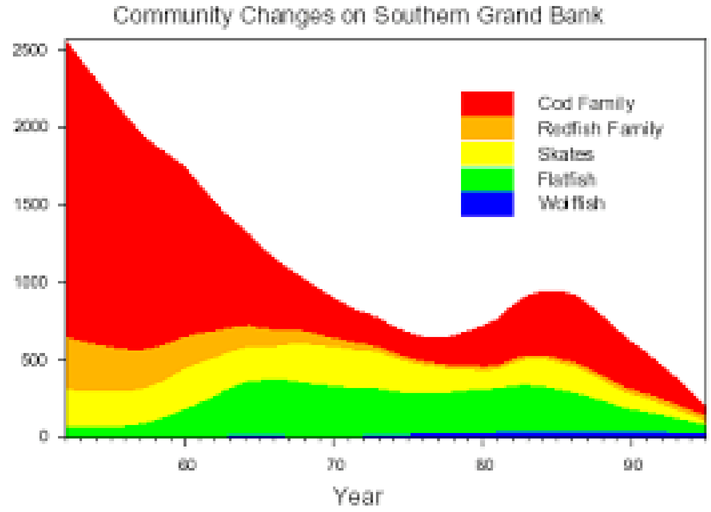


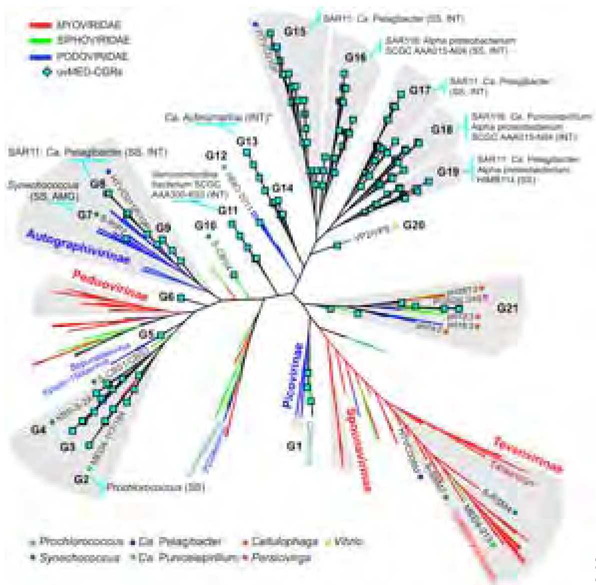




Life in the Ocean

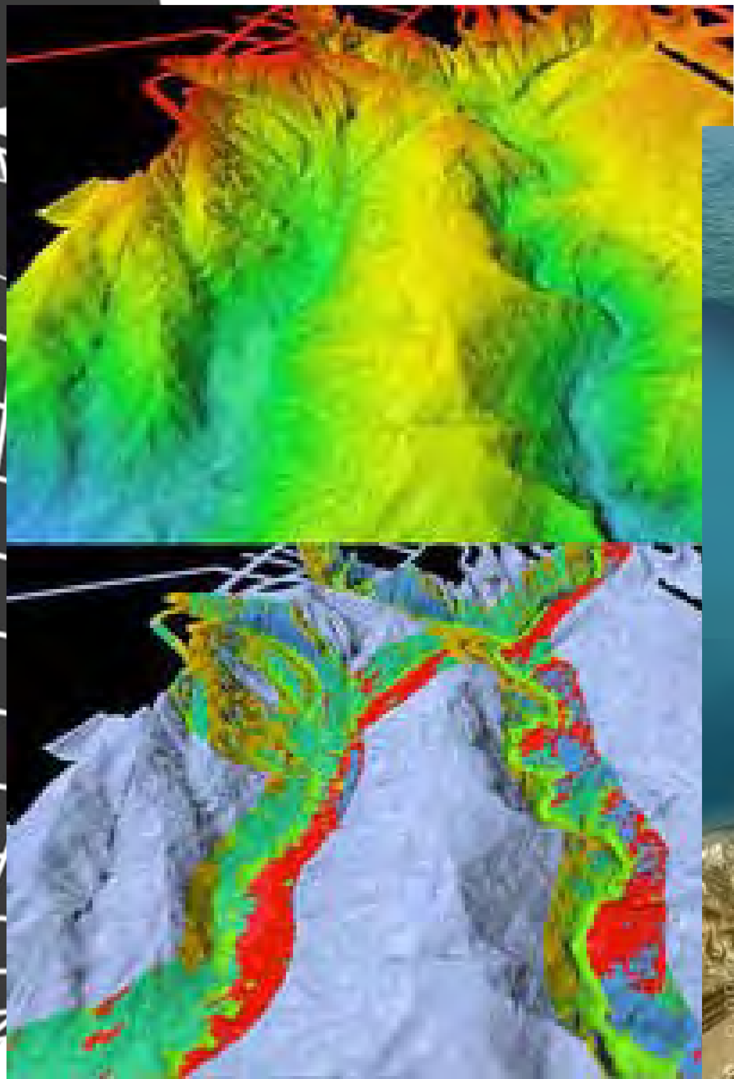


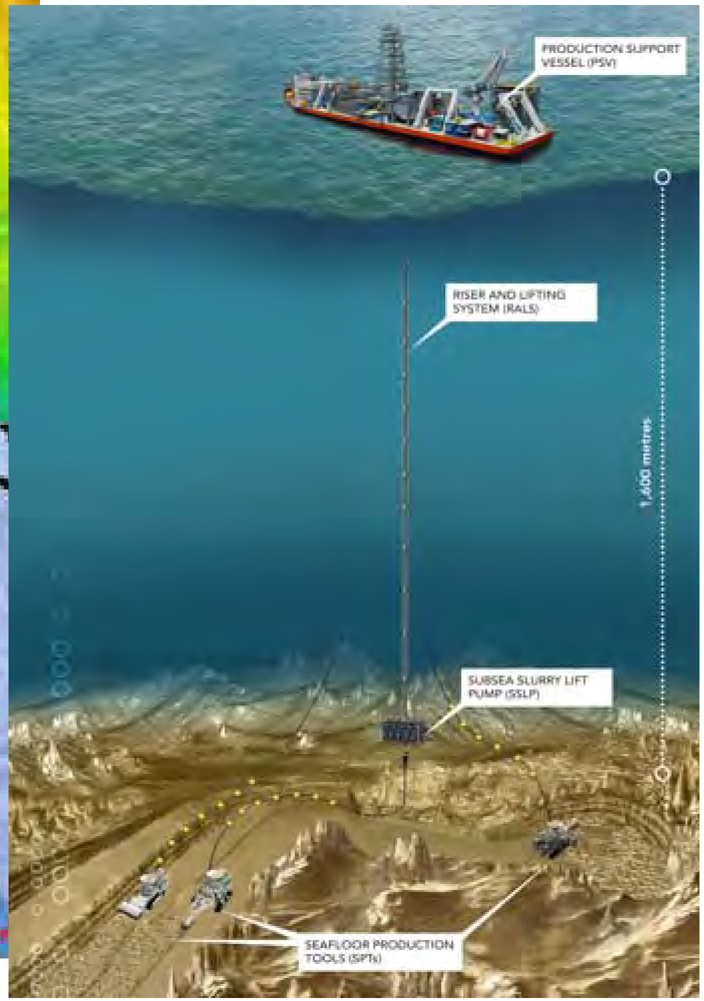




Atlantos

Deep Sea





Marine Services

Sustainable Development

Proposed goal 14: **Conserve and sustainably use the oceans, seas and marine resources for sustainable development**

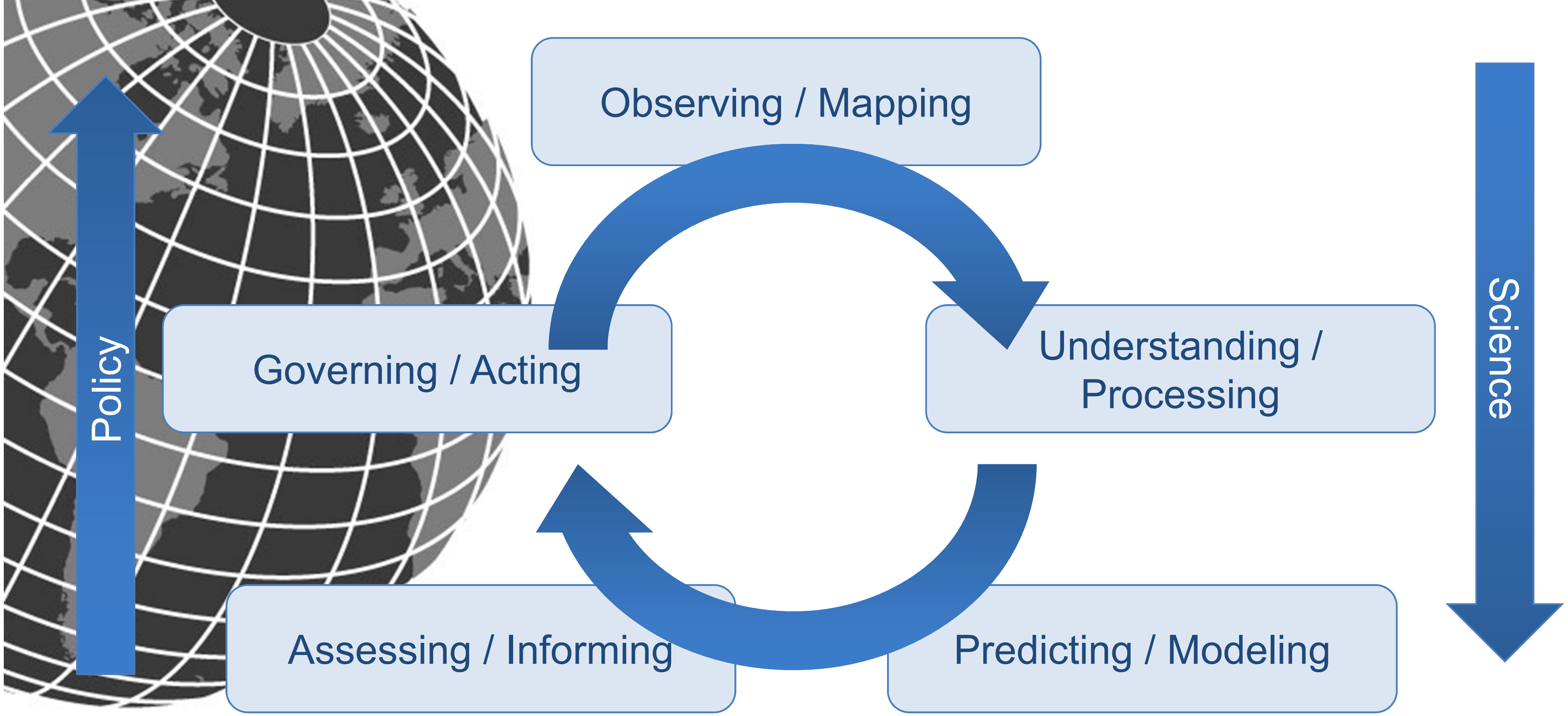
Targets are discussed and agreed to by the nations.

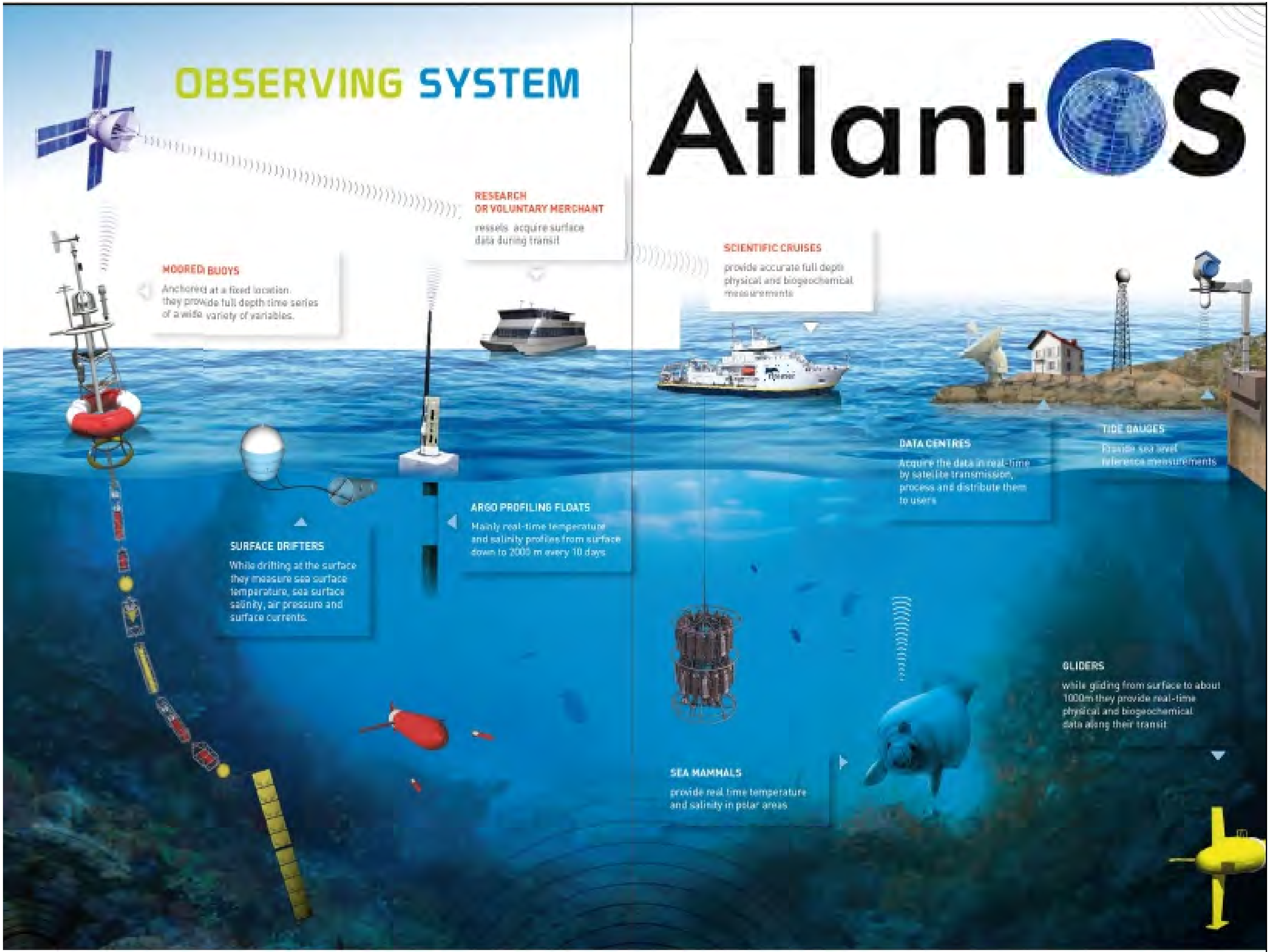
How to measure progress against targets?

The need to derive indicators building on a smart index framework, based on reliable open access ocean information.

Ocean Information – Ocean Governance

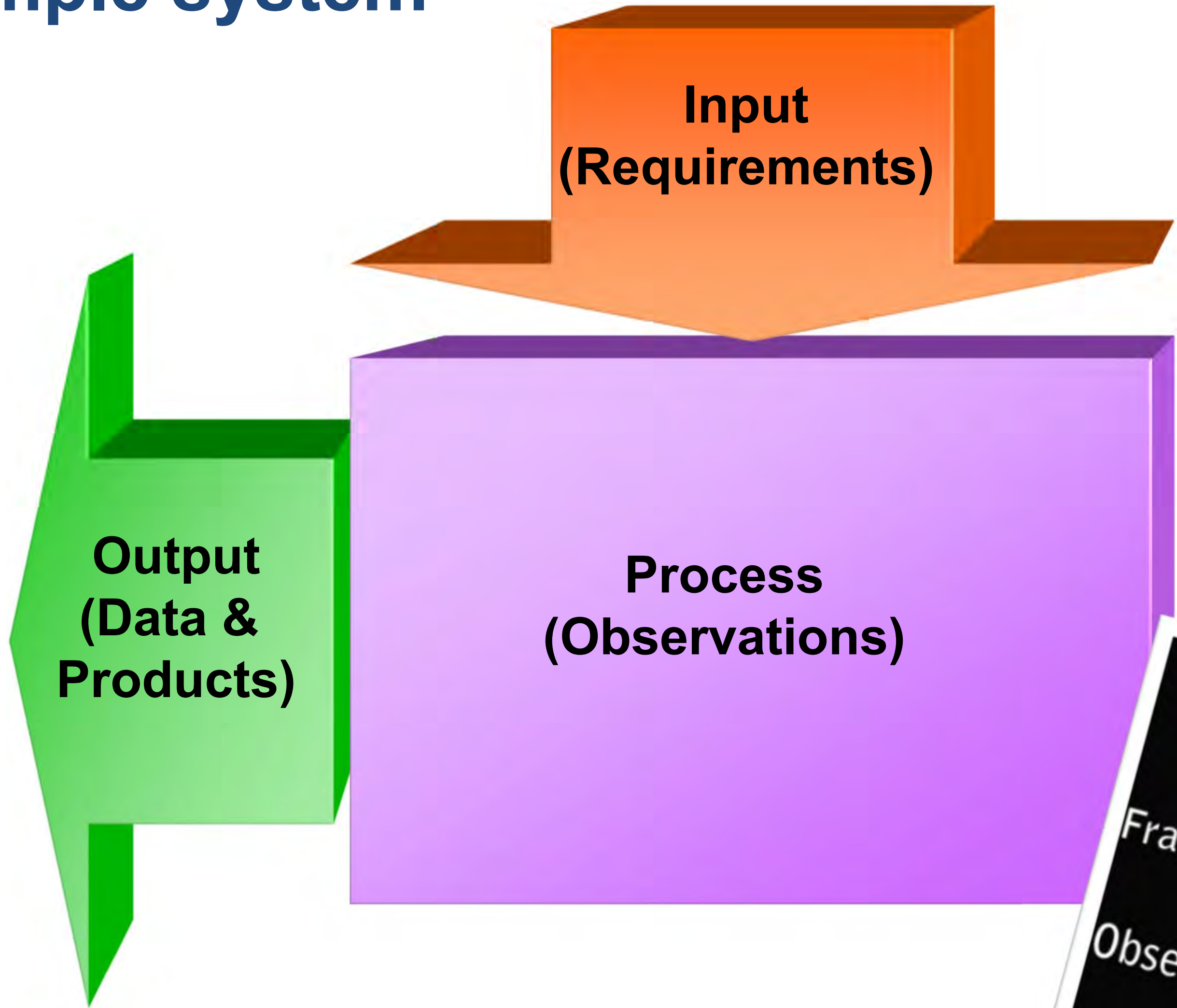
Increased need for ocean information to meet a growing range of societal needs can only be fully realized if all elements of the value chain are resourced adequately.




OBSERVING SYSTEM
AtlantOS
MOORED BUOYS
Anchored at a fixed location they provide full depth time series of a wide variety of variables.
RESEARCH OR VOLUNTARY MERCHANT
vessels acquire surface data during transit
SCIENTIFIC CRUISES
provide accurate full depth physical and biogeochemical measurements
DATA CENTRES
Acquire the data in real-time by satellite transmission, process and distribute them to users
TIDE GAUGES
Provide sea level reference measurements
SURFACE DRIFTERS
While drifting at the surface they measure sea surface temperature, sea surface salinity, air pressure and surface currents.
ARGO PROFILING FLOATS
Mainly real-time temperature and salinity profiles from surface down to 2000 m every 10 days
GLIDERS
while gliding from surface to about 1000m they provide real-time physical and biogeochemical data along their transit
SEA MAMMALS
provide real time temperature and salinity in polar areas

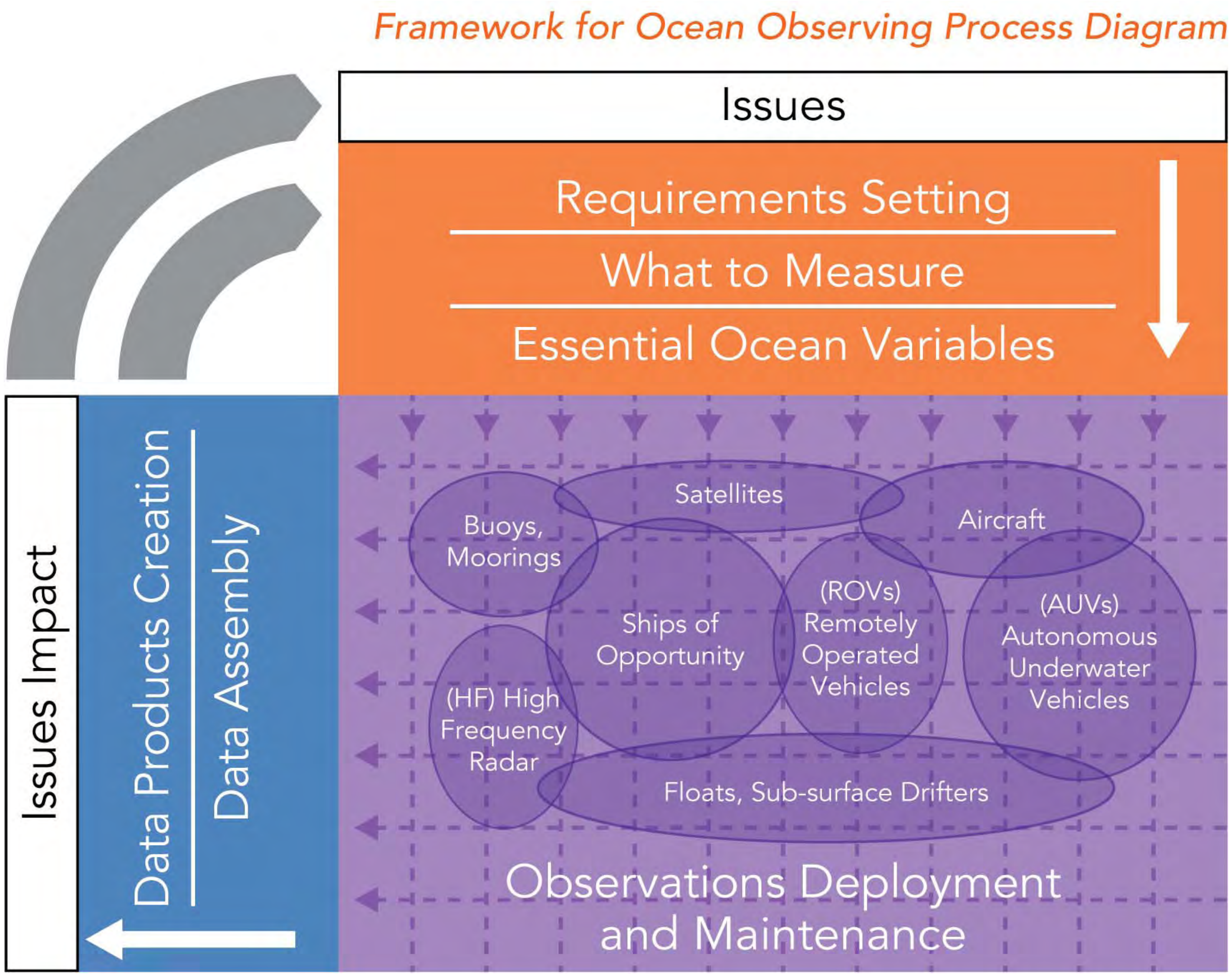
Framework for Ocean Observing

A simple system

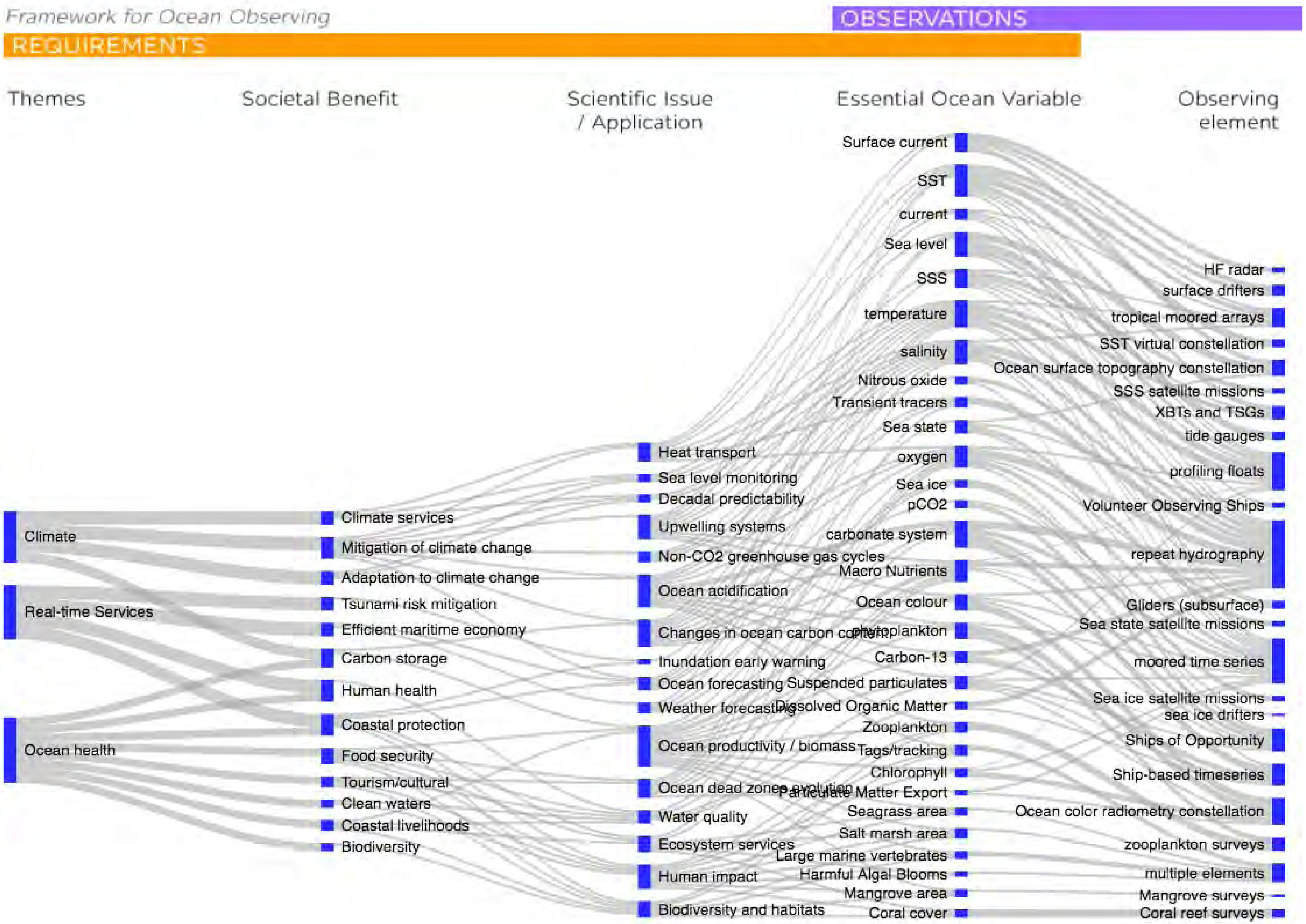


http://www.oceanobs09.net/foo/

Framework for Ocean Observing

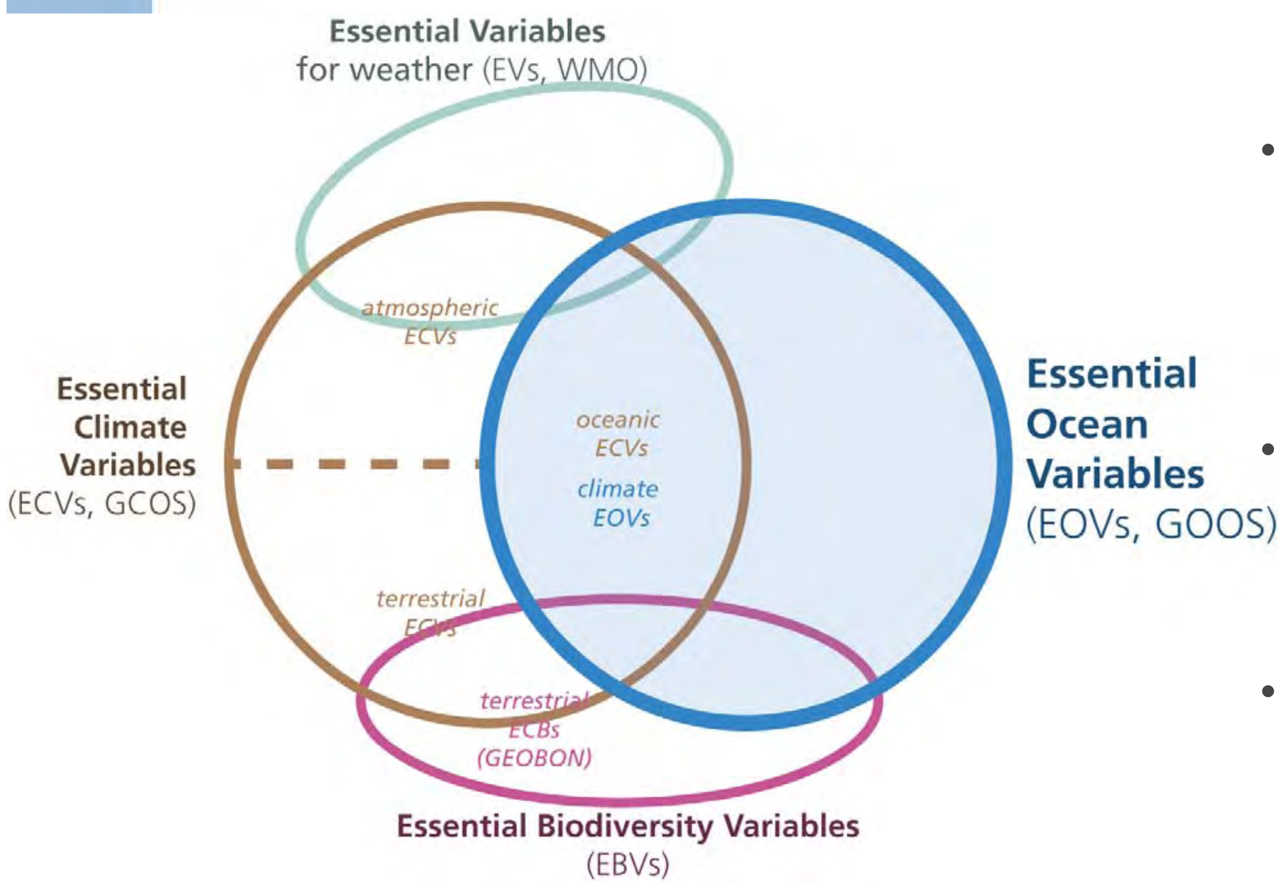


Framework for Ocean Observing



Driven by requirements, negotiated with feasibility in mind

Essential Ocean Variables



- **We cannot measure everything, nor do we need to**
- basis for including new elements of the system, for expressing requirements at a high level
- Driven by requirements, negotiated with feasibility
- Allows for innovation in the observing system over time

http://www.oceanobs09.net/foo/

Driven by requirements, negotiated with feasibility in mind

Essential Ocean Variables

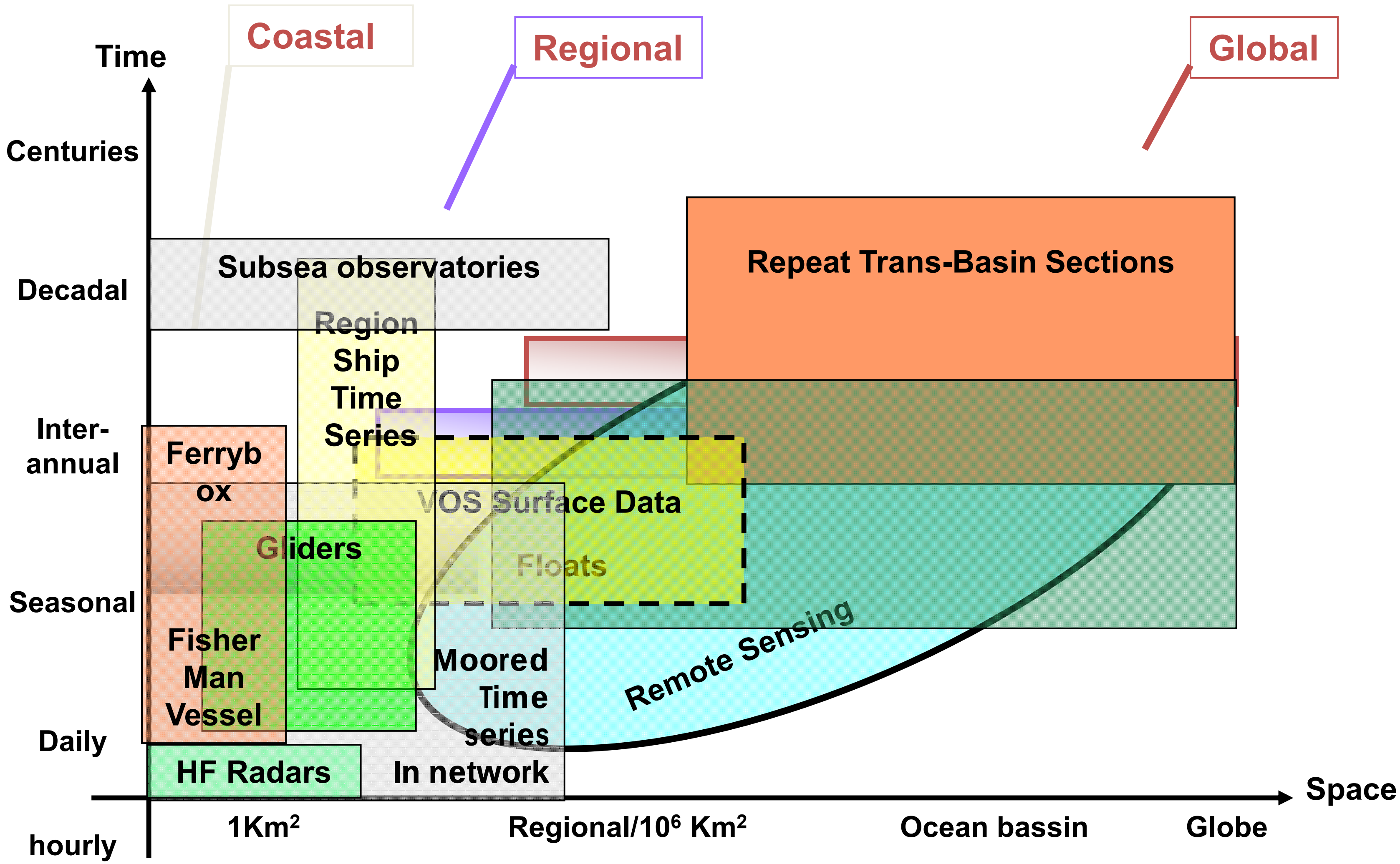
Physics	*Biogeochemical*	*Biology and Ecosystems*
Sea State*	Oxygen*	Phytoplankton* biomass and productivity
Ocean surface vector stress*	Inorganic macro nutrients*	HAB incidence
Sea Ice*	Carbonate system*	Zooplankton* diversity
Sea level*	Transient tracers*	Fish abundance and distribution
SST*	Suspended particulates	Apex predator abundance and distribution
Subsurface temperature*	Nitrous oxide*	Live coral cover*
Surface currents*	Carbon isotope (^{13}C)	Seagrass cover*
Subsurface currents*	Dissolved organic carbon	Mangrove cover*
SSS*	Ocean colour*	Macroalgal canopy cover*
Subsurface salinity*		Microbes
Heat flux*		

* also an Essential Climate Variable [sometimes aggregated]

Concept Pilot Mature

IOC UNESCO

Global to Regional to Coastal



esa space for europe

Copernicus
The European Earth Observation Programme

The Current Global Ocean Observing System

Integrated system designed to meet many requirements:

- Climate
- Weather prediction
- Global and coastal ocean prediction
- Marine hazards warning
- Transportation
- Marine environment and ecosystem monitoring
- Naval applications
- 8 of 9 Societal Benefits

- Tide gauge stations
- Drifting Buoys
- Tropical Moored Buoys
- Profiling Floats
- Ships of Opportunity
- Ocean Reference Stations
- Ocean Carbon Networks
- Dedicated Ship Support
- Data & Assimilation Subsystems
- Management and Product Delivery
- Satellites -- SST, Surface Topography, Wind, Color, Sea Ice

Germany's Research Vessels

Globally operating vessels


POLARSTERN / *AWI*


METEOR


SONNE

Ocean-class vessels


MERIAN


POSEIDON / *GEOMAR*

Regionally operating vessels


ALKOR / *GEOMAR*


HEINCKE / *AWI*

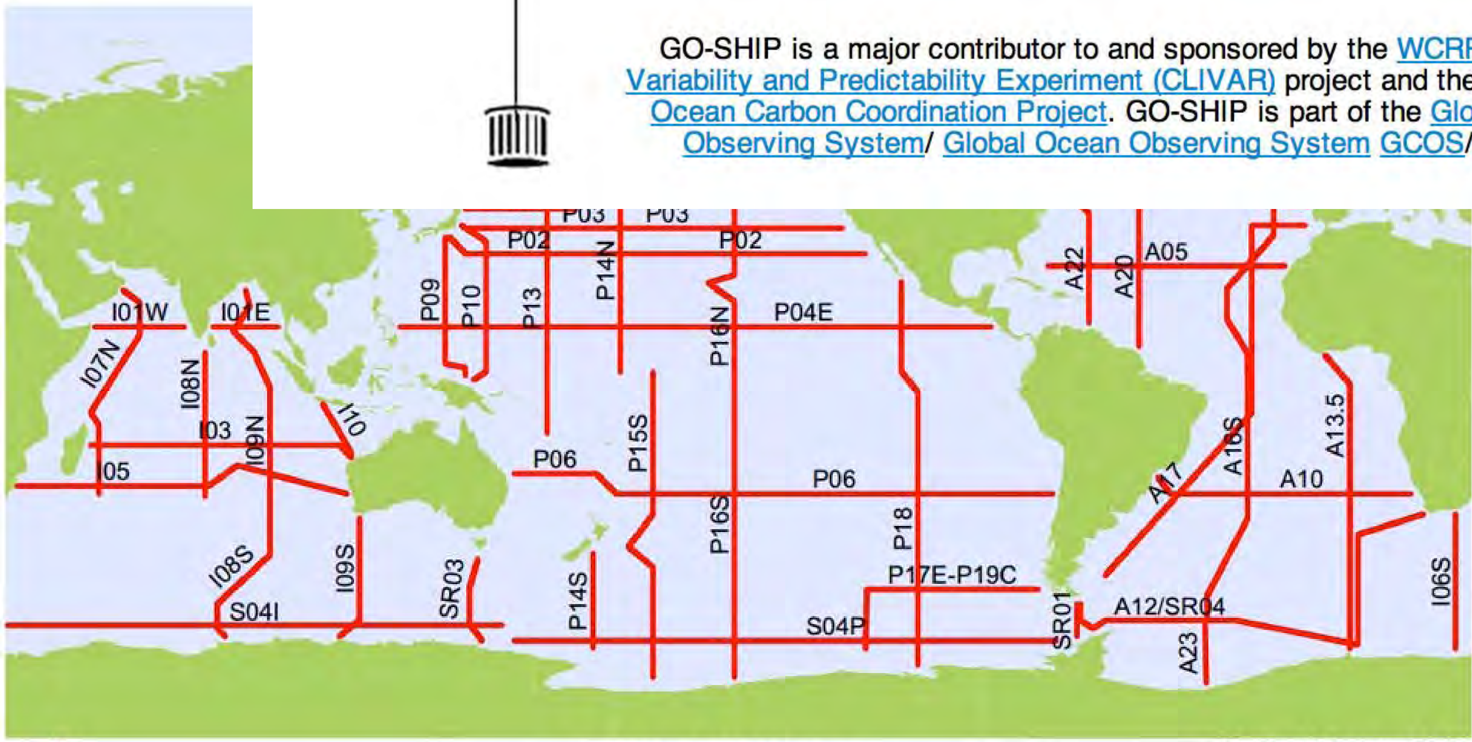
THE GLOBAL OCEAN SHIP-BASED HYDROGRAPHIC INVESTIGATIONS PROGRAM

GO - SHIP

TOWARDS A SUSTAINED GLOBAL SURVEY OF THE OCEAN INTERIOR

GO-SHIP brings together scientists with interests in physical oceanography, the carbon cycle, marine biogeochemistry and ecosystems, and other users and collectors of hydrographic data to develop a globally coordinated network of sustained hydrographic sections as part of the global ocean/climate observing system.

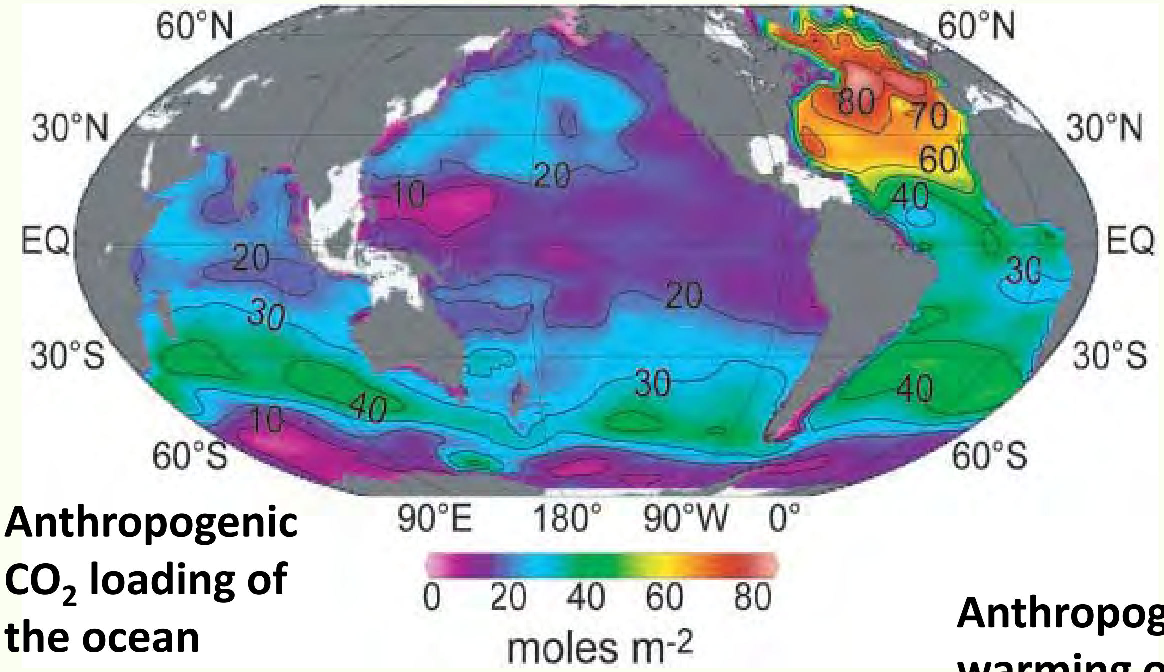
GO-SHIP is a major contributor to and sponsored by the WCRP's Climate Variability and Predictability Experiment (CLIVAR) project and the International Ocean Carbon Coordination Project. GO-SHIP is part of the Global Climate Observing System/ Global Ocean Observing System GCOS/ GOOS .



GO-SHIP 2012-2023 Survey

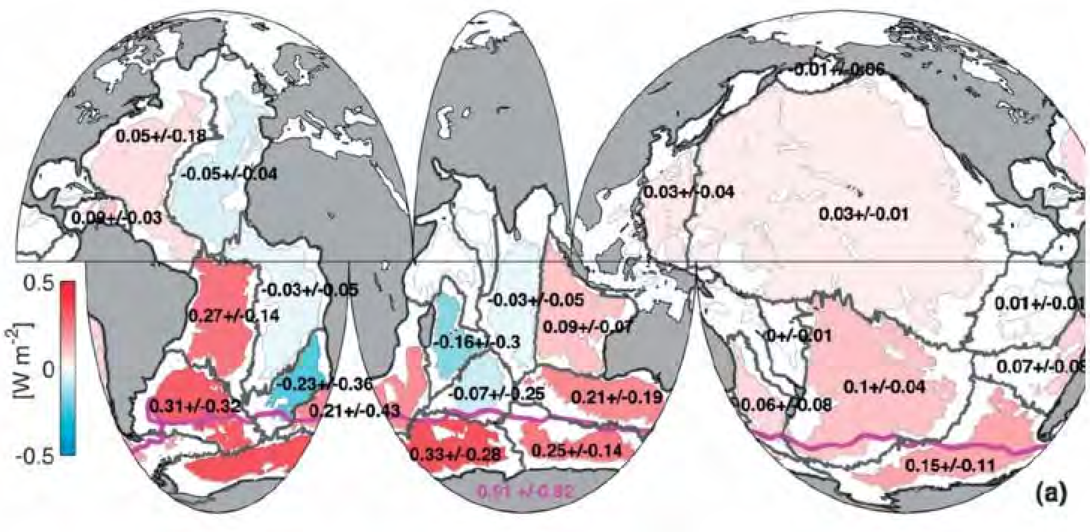
Status February 2014

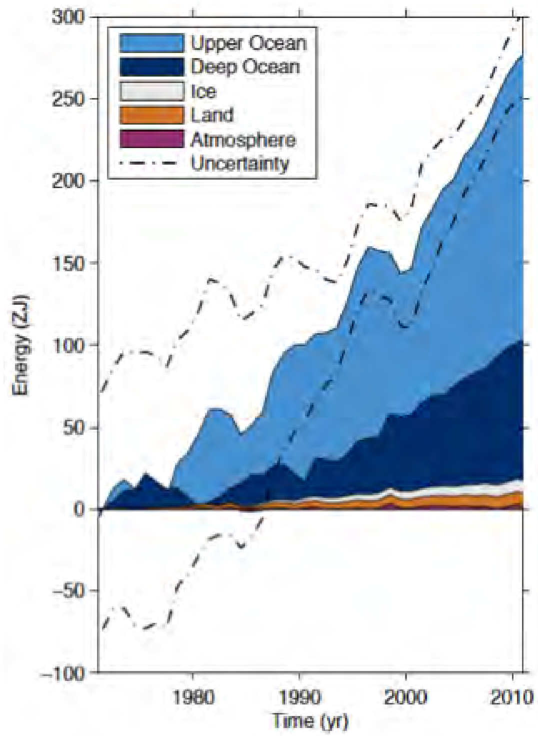
jcommops

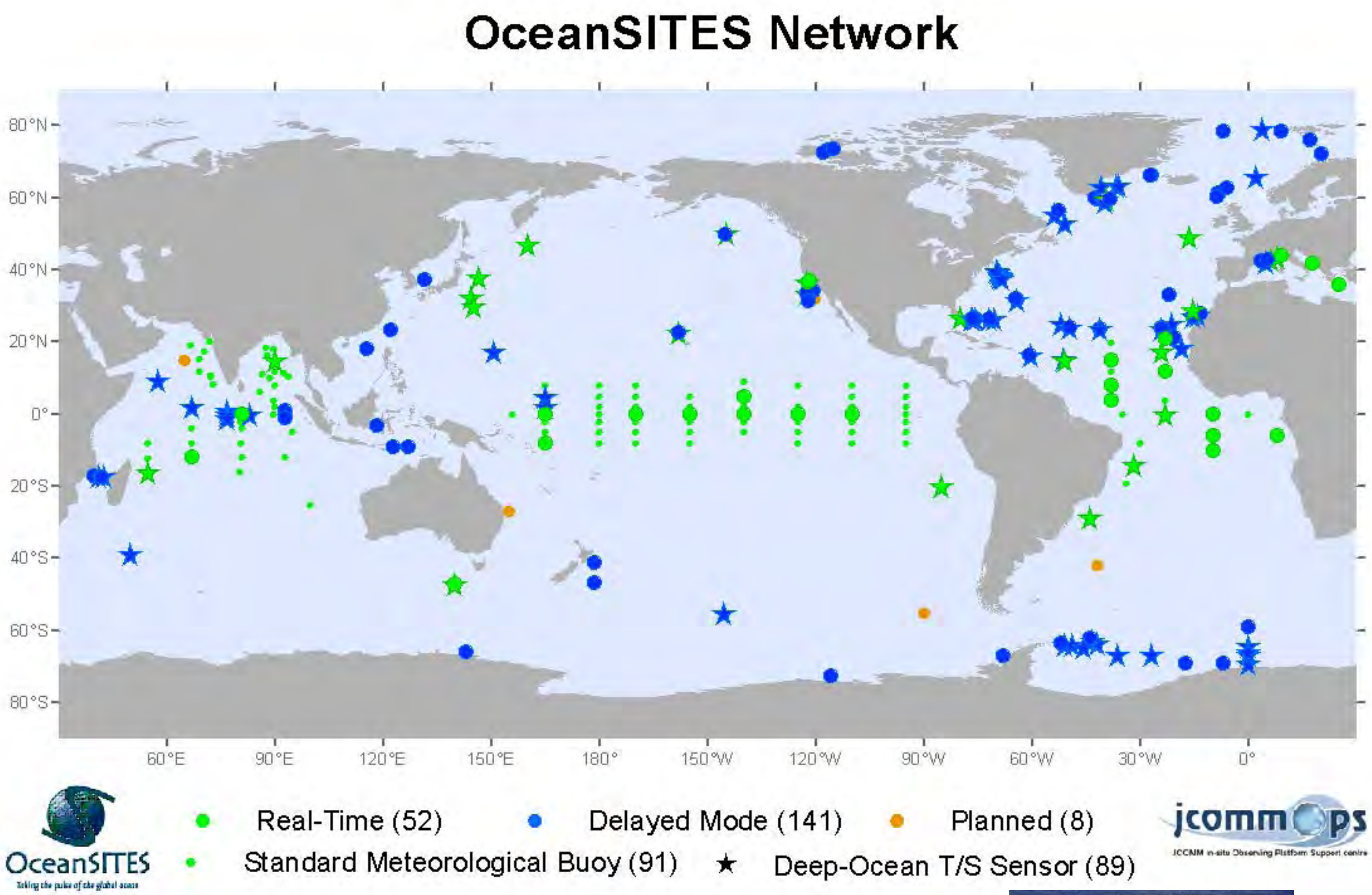


Anthropogenic CO_2 loading of the ocean

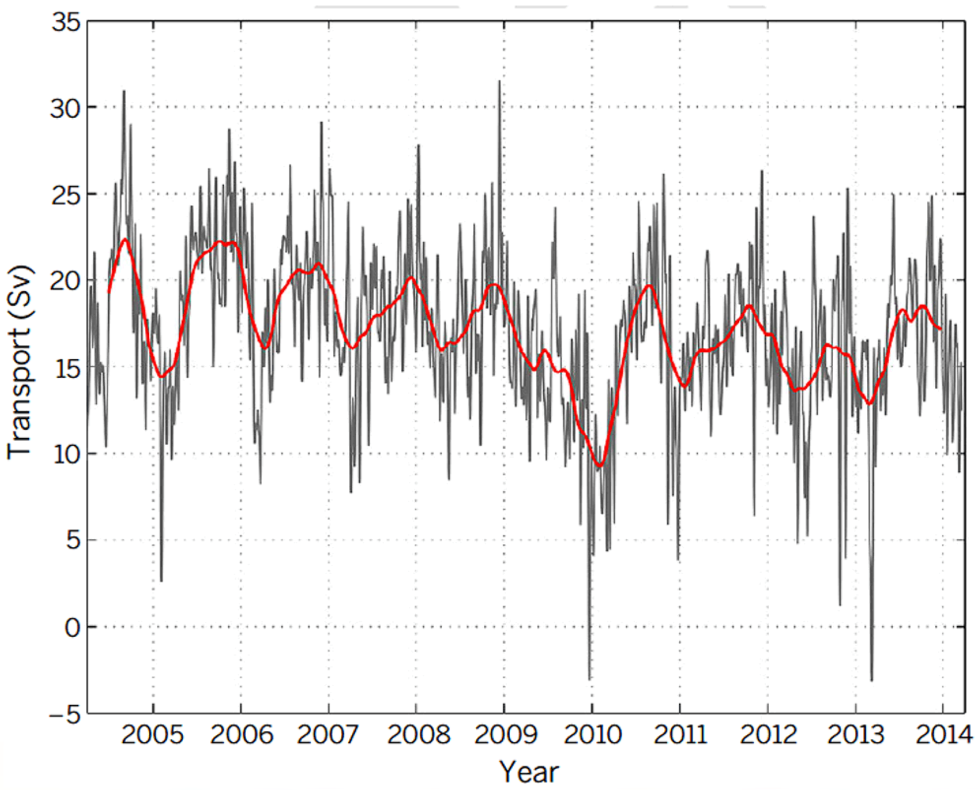
Anthropogenic warming of the ocean






OceanSITES Network
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W
0°
Real-Time (52)
Delayed Mode (141)
Planned (8)
Standard Meteorological Buoy (91)
Deep-Ocean T/S Sensor (89)
OceanSITES
jcommops

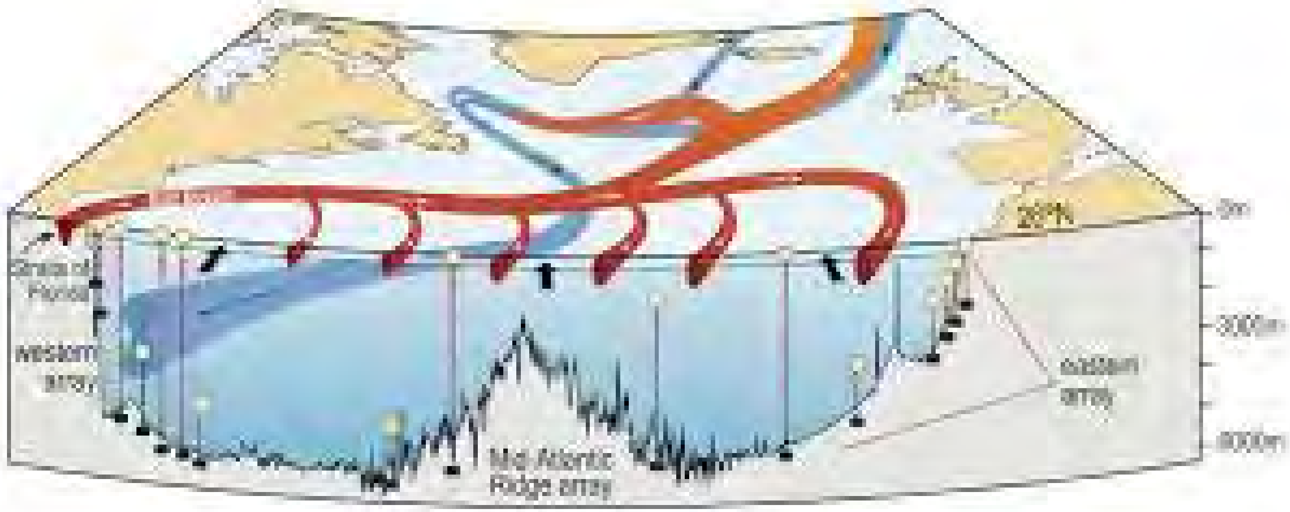

ATLAS

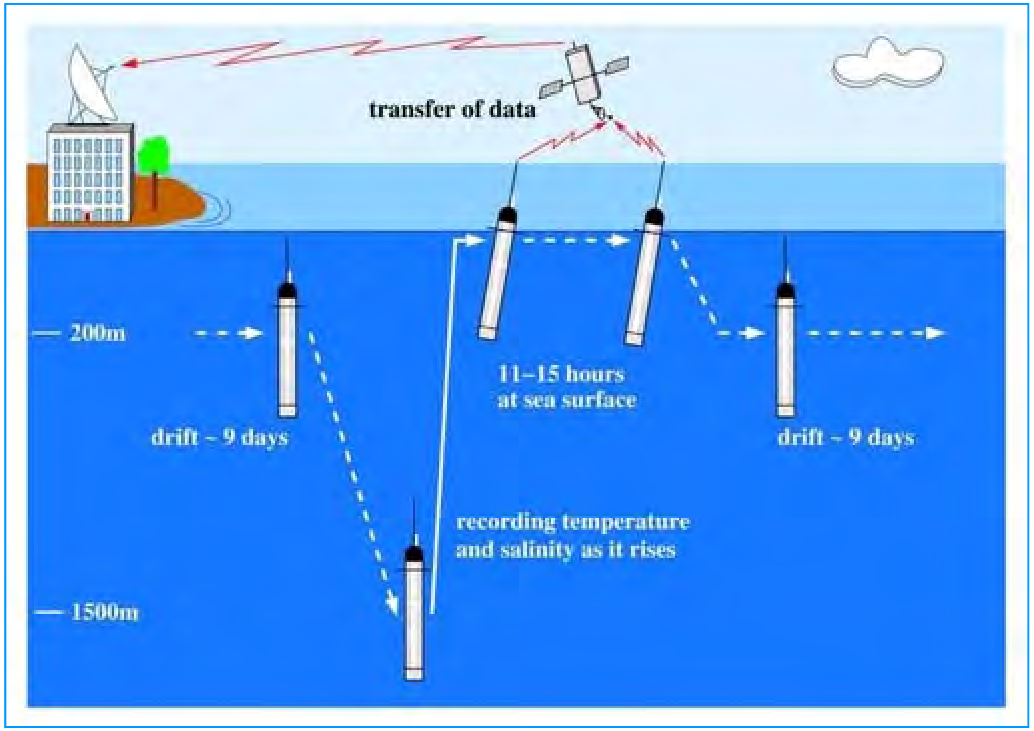


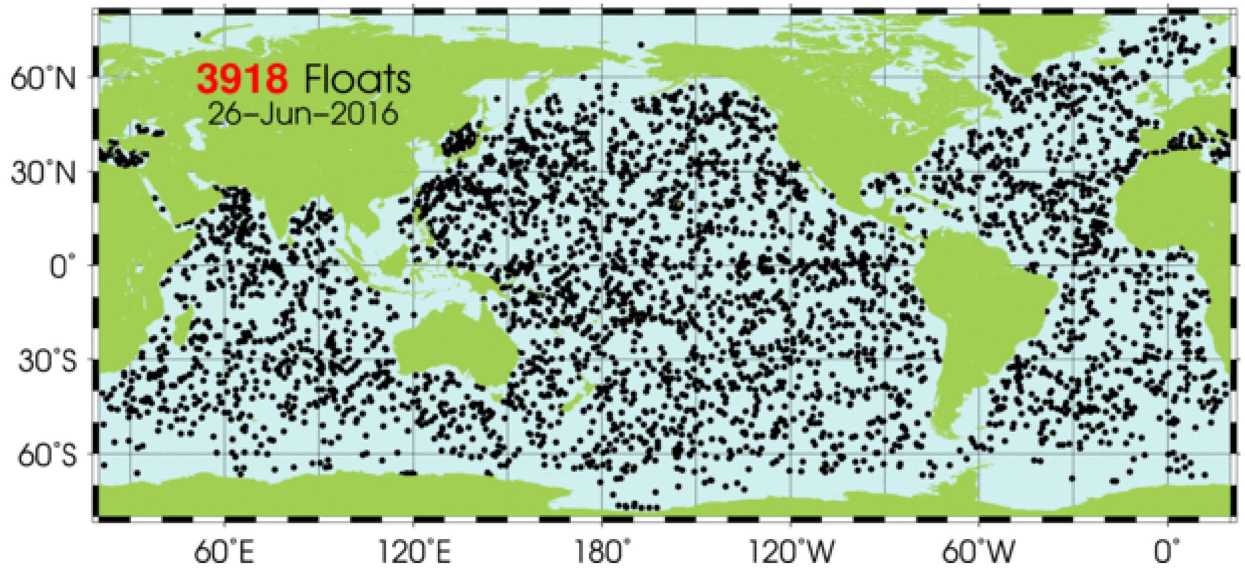
OceanSITES

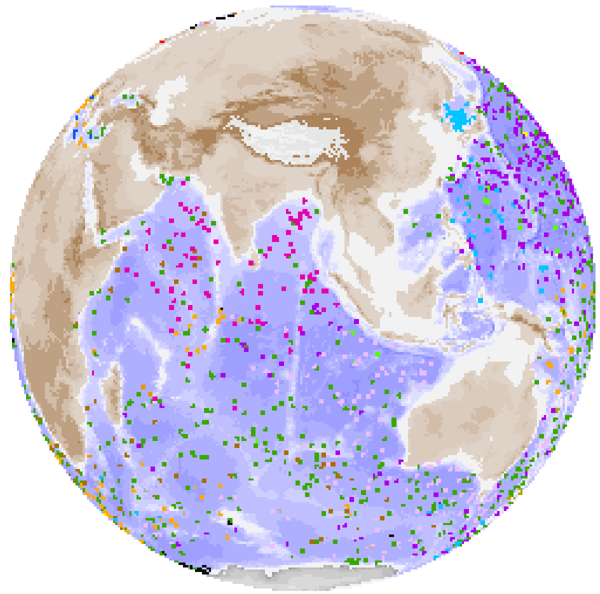
Taking the pulse of the global ocean

Ocean Overturning Transport

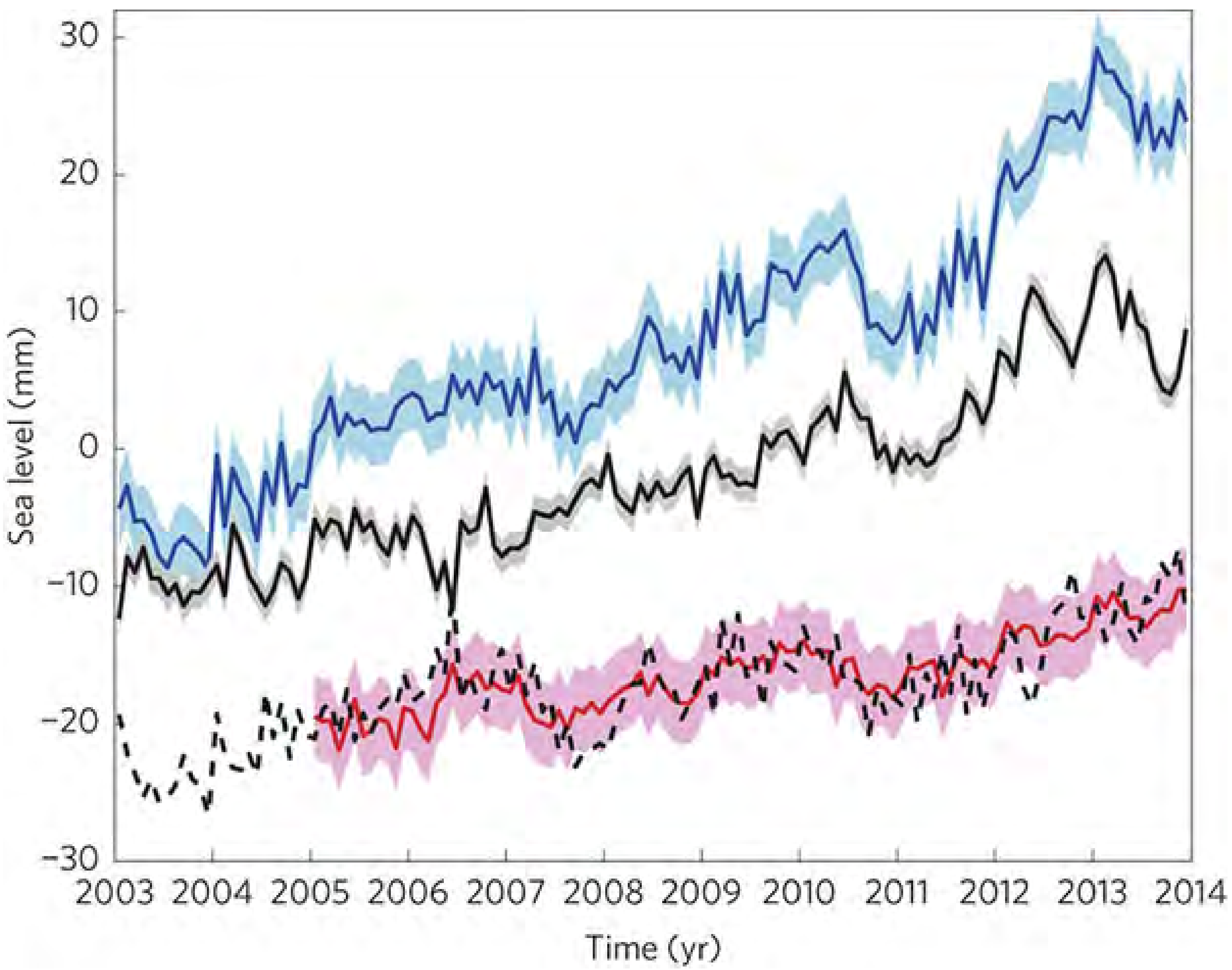



transfer of data
200m
drift ~ 9 days
11–15 hours
at sea surface
drift ~ 9 days
recording temperature
and salinity as it rises
1500m


3918 Floats
26–Jun–2016
60°N
30°N
0°
30°S
60°S
60°E
120°E
180°
120°W
60°W
0°



Sea Level Change

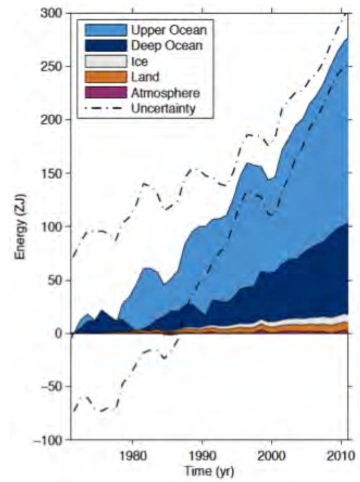


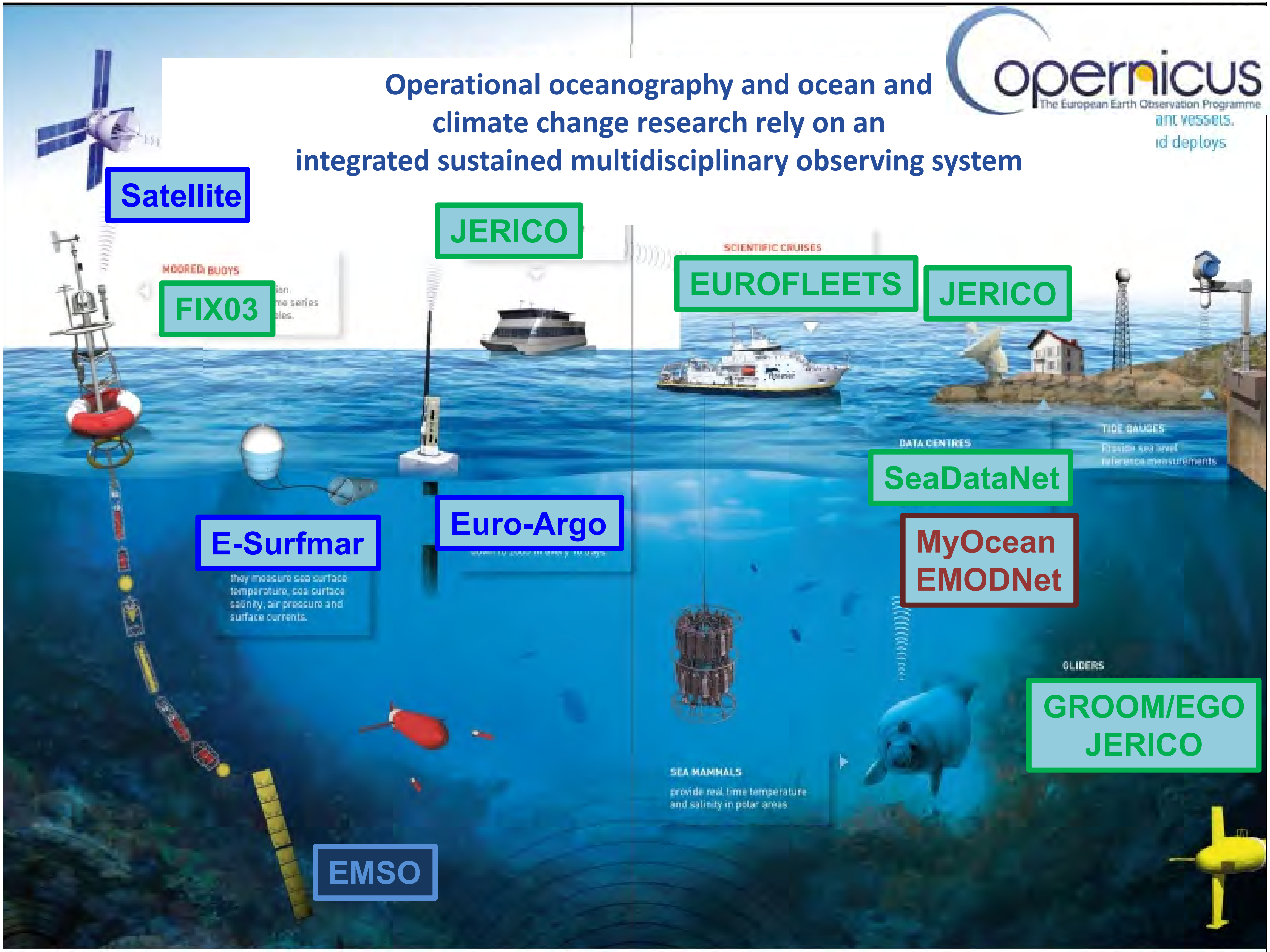
The estimates are observed variations by satellite altimetry (blue), ocean mass contributions based on GRACE data (solid black) and steric sea level based on in situ observations (red).

Total Sea level (Altimeter)

Ice Mass Change (GRACE)

Ocean Expansion (Argo)




Operational oceanography and ocean and
climate change research rely on an
integrated sustained multidisciplinary observing system
Copernicus
The European Earth Observation Programme
Satellite
MOORED BUOYS
FIX03
JERICO
SCIENTIFIC CRUISES
EUROFLEETS
JERICO
TIDE GAUGES
Provide sea level reference measurements
DATA CENTRES
SeaDataNet
MyOcean
EMODNet
E-Surfmar
they measure sea surface temperature, sea surface salinity, air pressure and surface currents.
Euro-Argo
GLIDERS
GROOM/EGO
JERICO
SEA MAMMALS
provide real time temperature and salinity in polar areas
EMSO

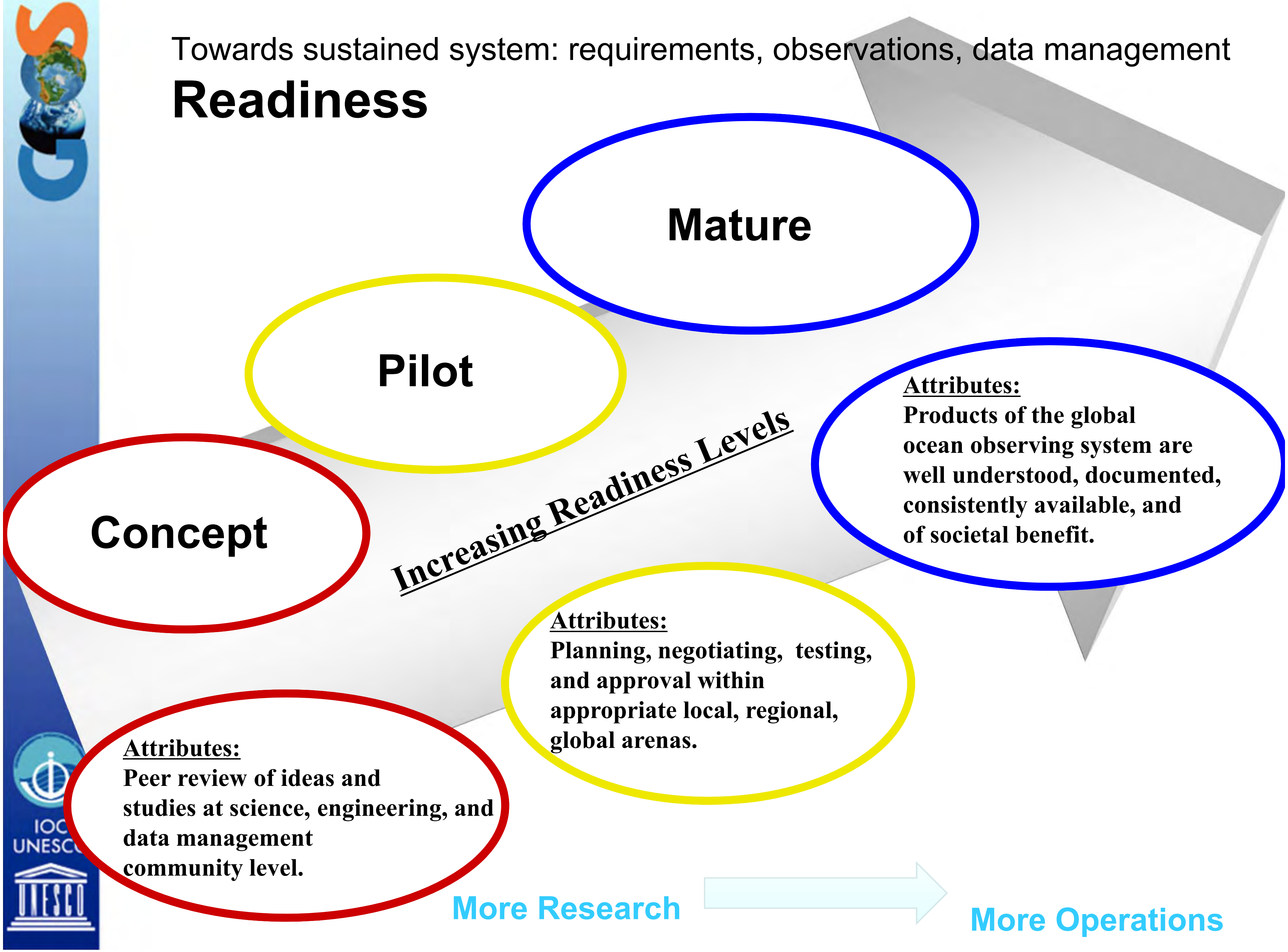
Essential Ocean Variables

Observing Networks

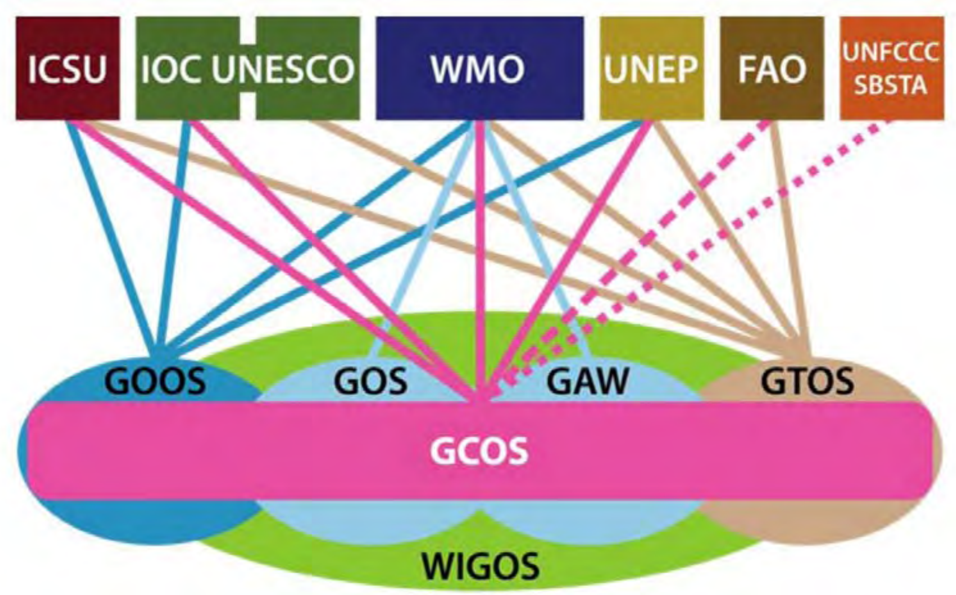
Essential Ocean Variables	Satellites	HF Radar	Moorings	Boundary Current Arrays	Ice tethered profilers	Sea Level Gauges	Argo profilers	Deep Argo	Gliders	Surface gliders	Drifting buoys	Marine Meteorology	XBT and TSGs	Ships of Opportunity	Ship Based Time Series	Ship Based Sampling; Repeat Hydrography	Animal CTD	Acoustic Network	Coastal Surveys	Nets CPR	Particulate Export flux
Sea state	X	-	-	X	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-
OSVS	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sea ice	X	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-
Sea level	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SST	-	-	-	X	-	-	-	-	X	X	X	X	-	X	X	-	-	-	-	-	-
Subsurface Temperature	-	-	X	X	X	-	X	X	X	-	-	X	X	-	X	X	X	-	-	-	-
SSS	X	-	X	X	-	-	-	-	-	X	X	X	-	X	X	X	-	-	-	-	-
Subsurface Salinity	-	-	X	X	X	-	X	X	X	-	-	X	X	-	X	X	X	-	-	-	-
Surface current	X	X	X	-	-	-	-	-	-	X	X	X	-	X	-	-	-	-	-	-	-
Subsurface Currents	-	-	X	X	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-
Heat fluxes	X	-	X	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-
Oxygen	-	-	-	-	-	-	X	-	X	-	-	X	-	-	X	X	-	-	-	-	-
Inorganic Macro Nutrients	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
Carbonate system	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
Transient tracers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
Suspended Particulates	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	X
Nitrous oxide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
Carbon Isotopes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	X
Dissolved Organic Carbon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
Phytoplankton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	X	X
HAB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Zooplankton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	X	-
Status Fish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
Apex Predators	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	-	-	-
Coral Cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Seagrass Cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Mangrove Cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Macroalgal cover	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
Microbes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
Salt Marsh area	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Tags/tracking	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	X	-	-	-

Towards sustained system: requirements, observations, data management

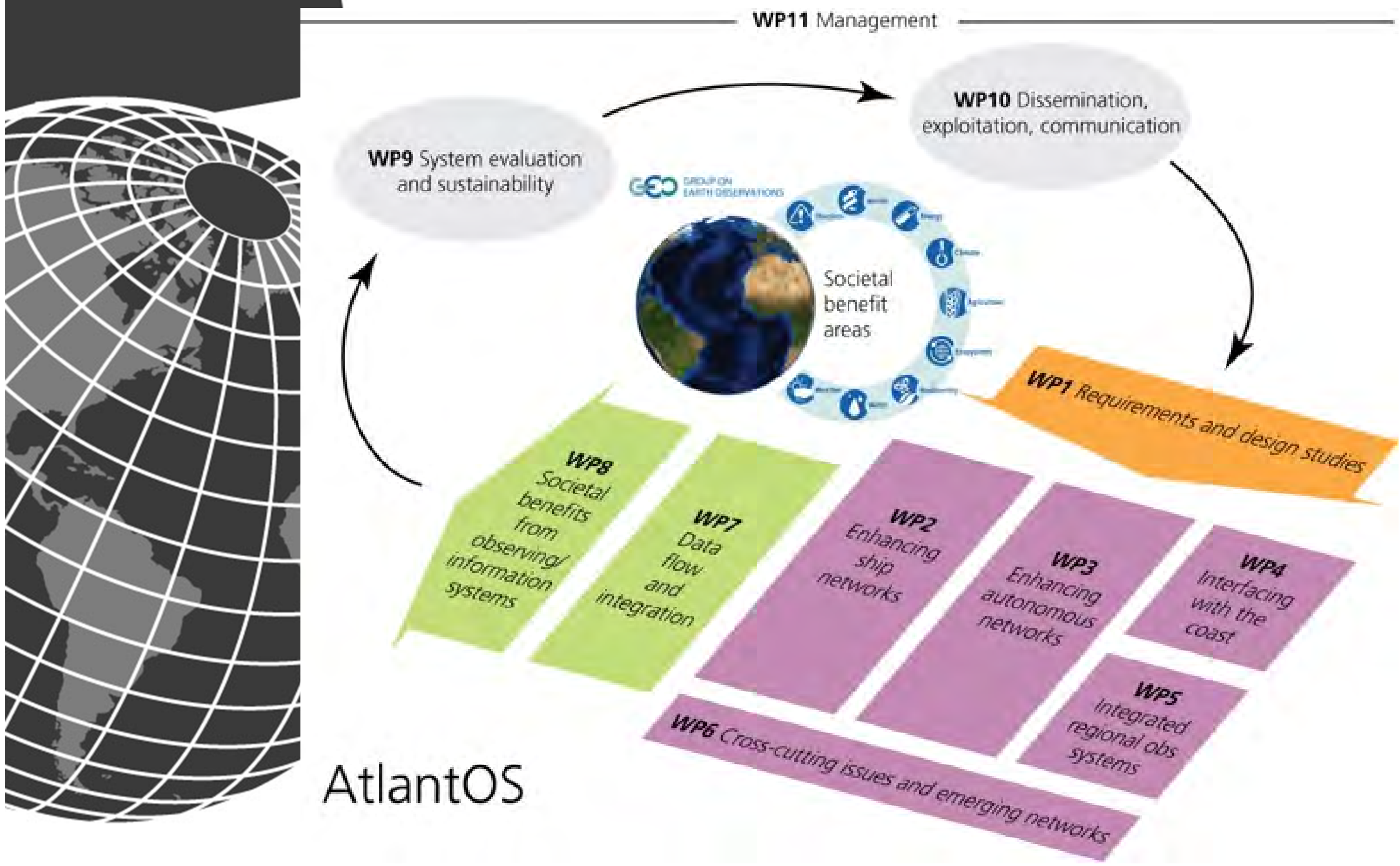
Readiness



Contribution to GEO, GCOS



Project Structure



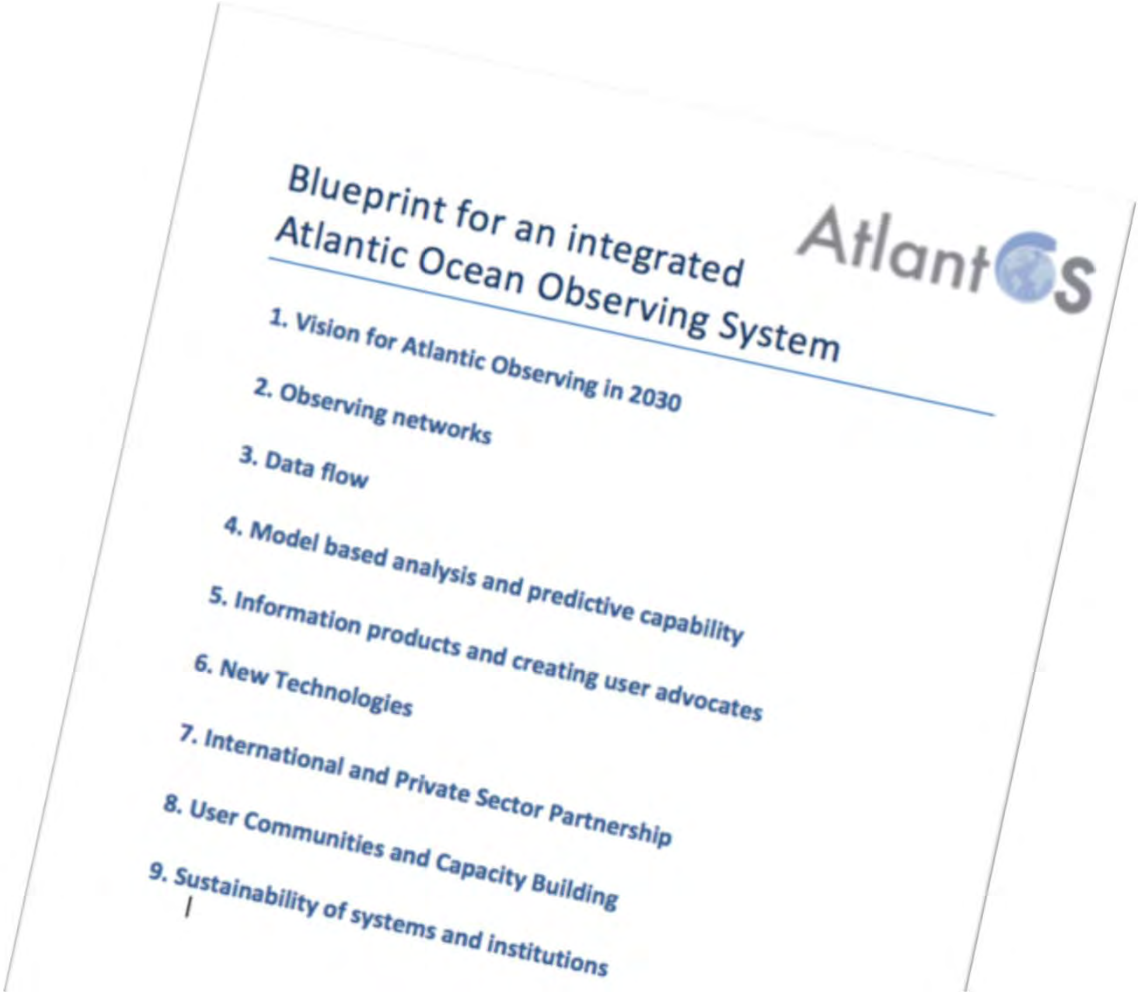
AtlantOS Work Packages

WP1: Observing system requirements and design studies
WP2: Enhancement of ship-based observing networks
WP3: Enhancement of autonomous observing networks
WP4: Interfaces with coastal ocean observing systems
WP5: Integrated regional observing systems
WP6: Cross-cutting issues and emerging networks
WP7: Data flow and data integration
WP8: Societal benefits from observing/information systems
WP9: System evaluation and sustainability
WP10: Engagement, Dissemination and Communication
WP11: Management

#AtlantOS

AtlantOS

Outcome:
Blueprint to be ready for OceanObs19



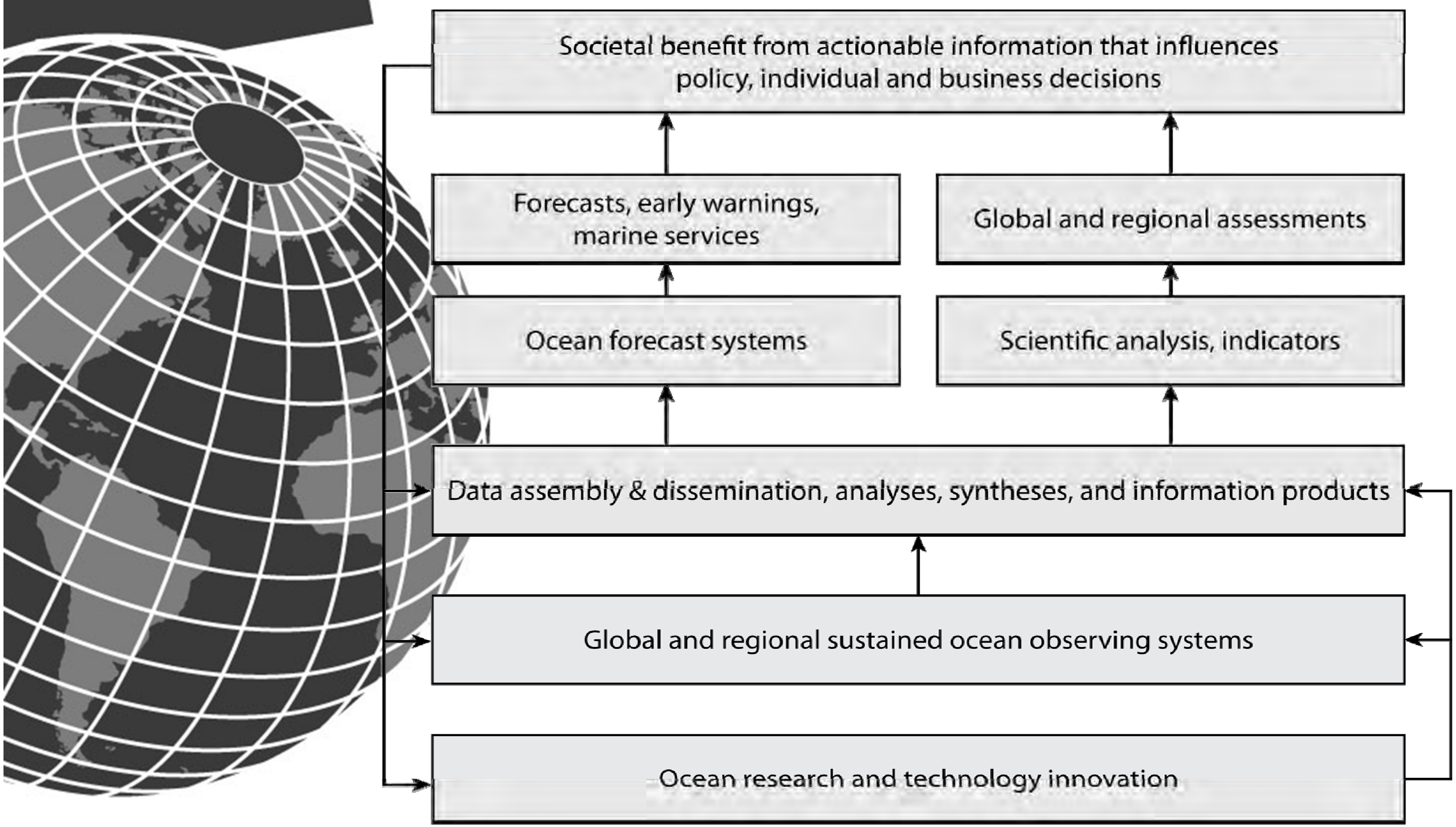
Blueprint for an integrated Atlantic Ocean Observing System

AtlantOS

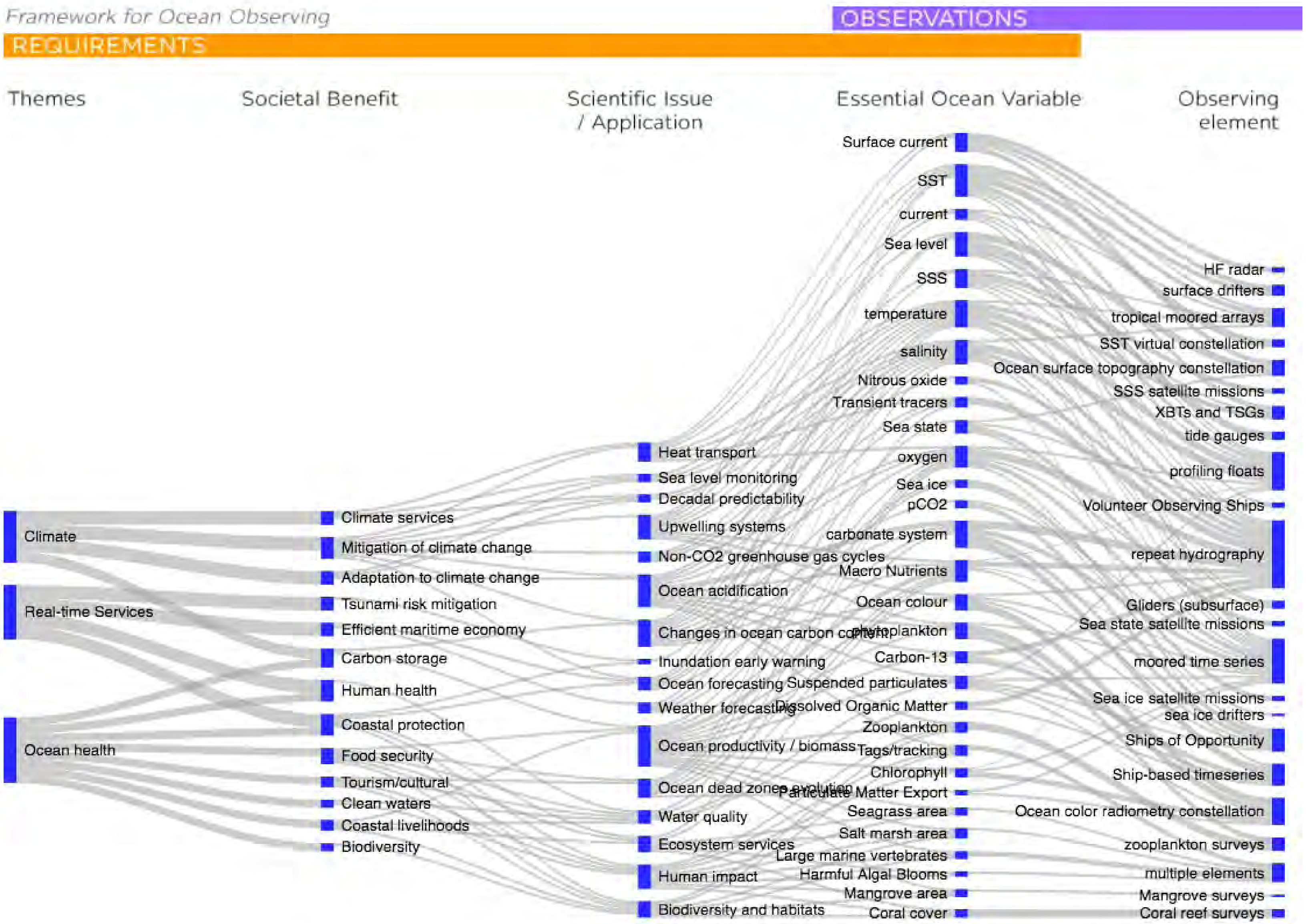
1. Vision for Atlantic Observing in 2030
2. Observing networks
3. Data flow
4. Model based analysis and predictive capability
5. Information products and creating user advocates
6. New Technologies
7. International and Private Sector Partnership
8. User Communities and Capacity Building
9. Sustainability of systems and institutions

www.atlantos-h2020.eu

Ocean Information Value Chain



Framework for Ocean Observing



Innovations for future observing systems

MATT MOWLEM
HEAD OF OCEAN TECHNOLOGY AND ENGINEERING
RUSSELL WYNN
MARINE AUTONOMOUS AND ROBOTIC SYSTEMS (MARS) CHIEF SCIENTIST
MAATEN FURLONG
HEAD OF MARS

http://www.iooc.us/

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

noc.ac.uk

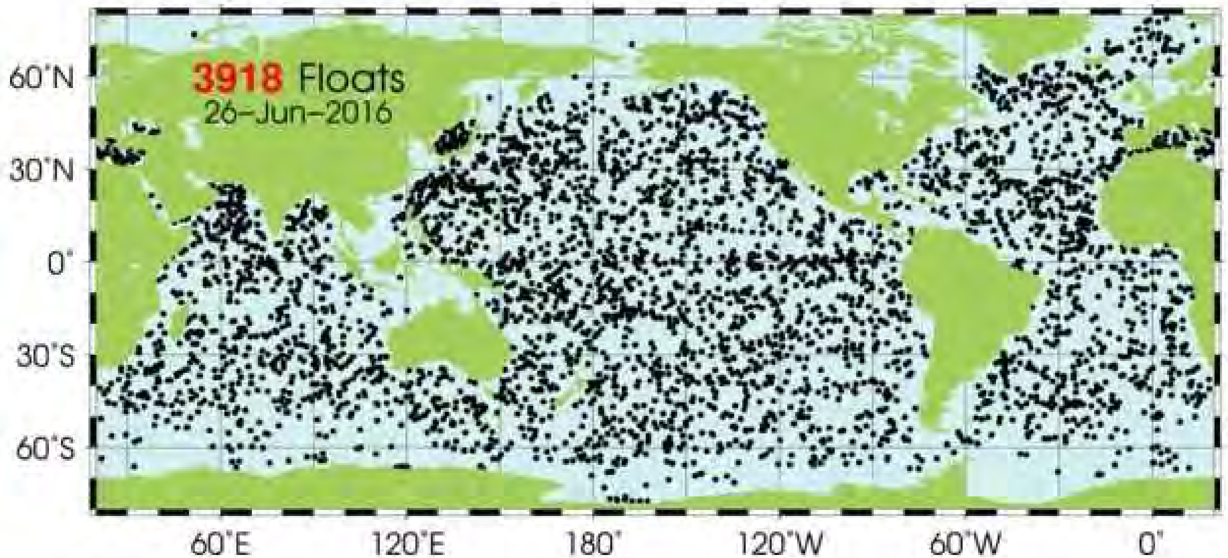
NERC SCIENCE OF THE ENVIRONMENT

Essential Ocean Variables

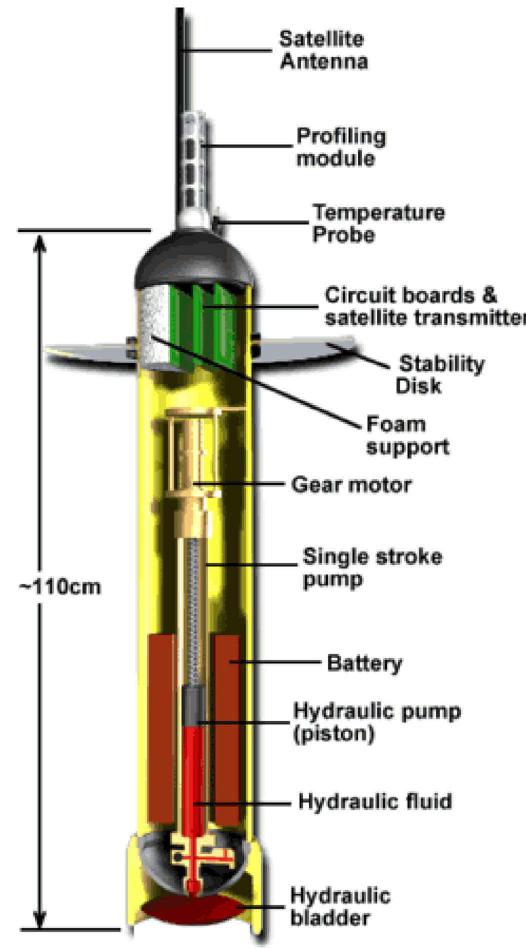
PHYSICS	BIOGEOCHEMISTRY	BIOLOGY AND ECOSYSTEMS
Sea state	Dissolved Oxygen	Phytoplankton biomass and productivity
Ocean surface vector stress	Inorganic macro nutrients	Harmful Algal Bloom (HAB) incidence
Sea ice	Carbonate System	Zooplankton diversity
Sea surface height	Transient tracers	Fish abundance and distribution
Sea surface temperature	Suspended particulates	Apex predator abundance and distribution
Subsurface temperature	Nitrous oxide	Live coral cover
Surface currents	Carbon isotope (^{13}C)	Sea grass cover
Subsurface currents	Dissolved organic carbon	Mangrove cover
Sea surface salinity		Macroalgual canopy cover
Subsurface salinity		
Heat flux / radiation		

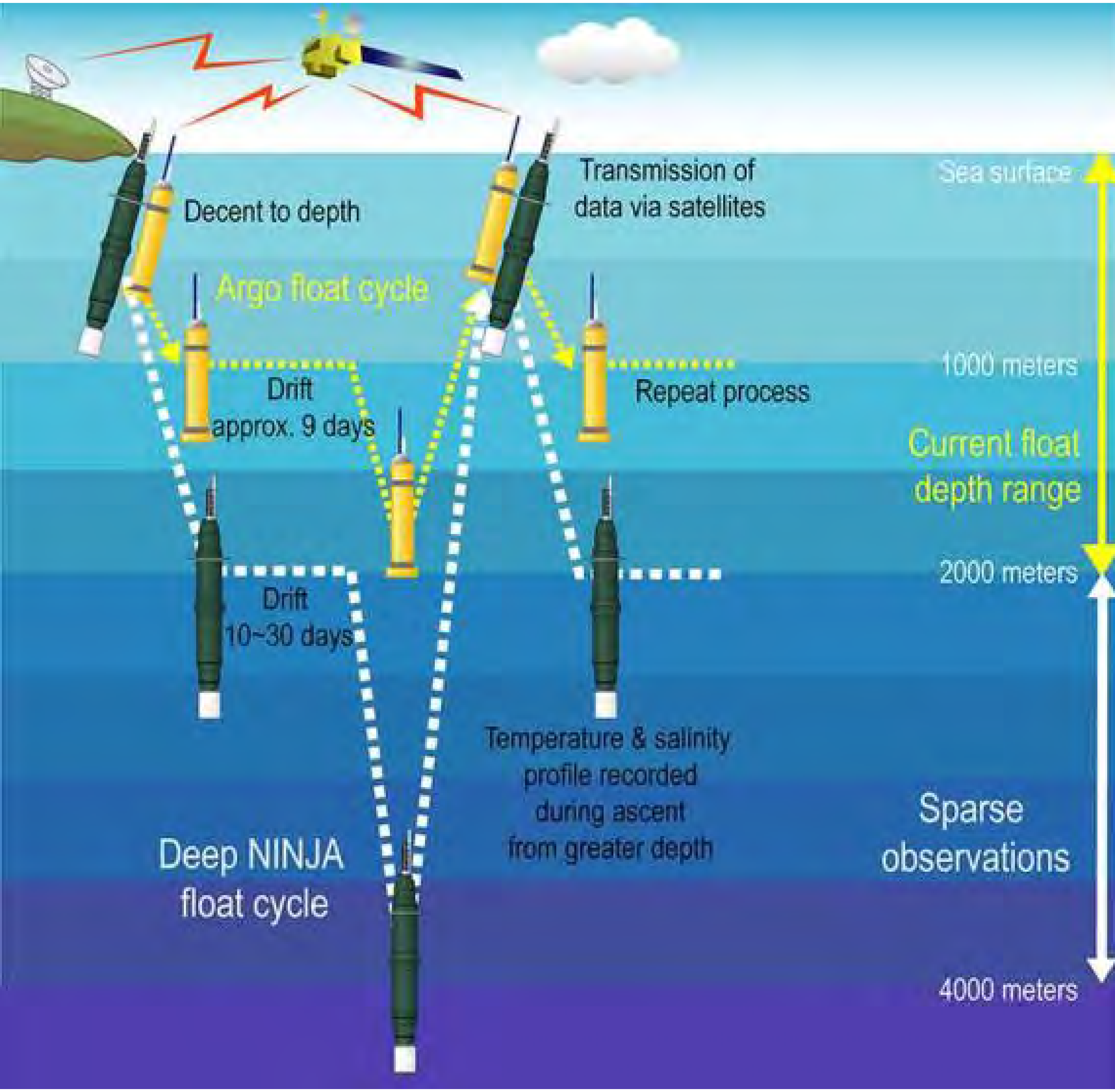
Mature, Pilot, Concept

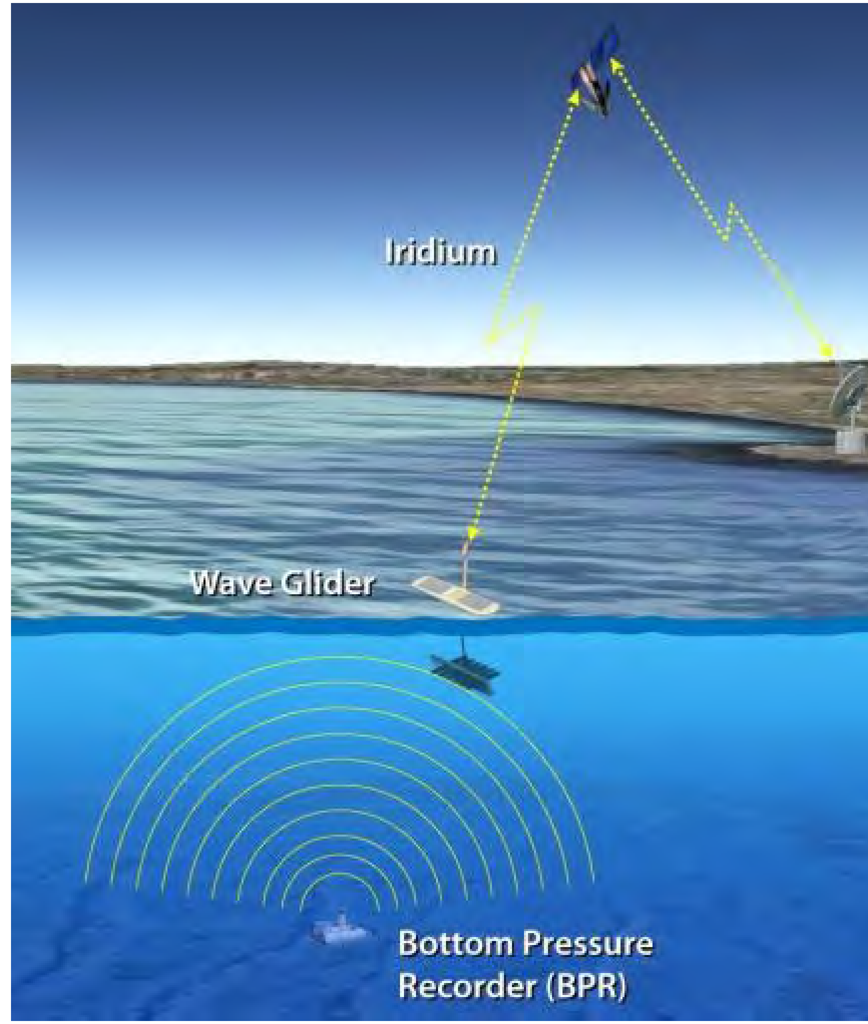

DISCOVERY



http://www.argo.ucsd.edu/index.html

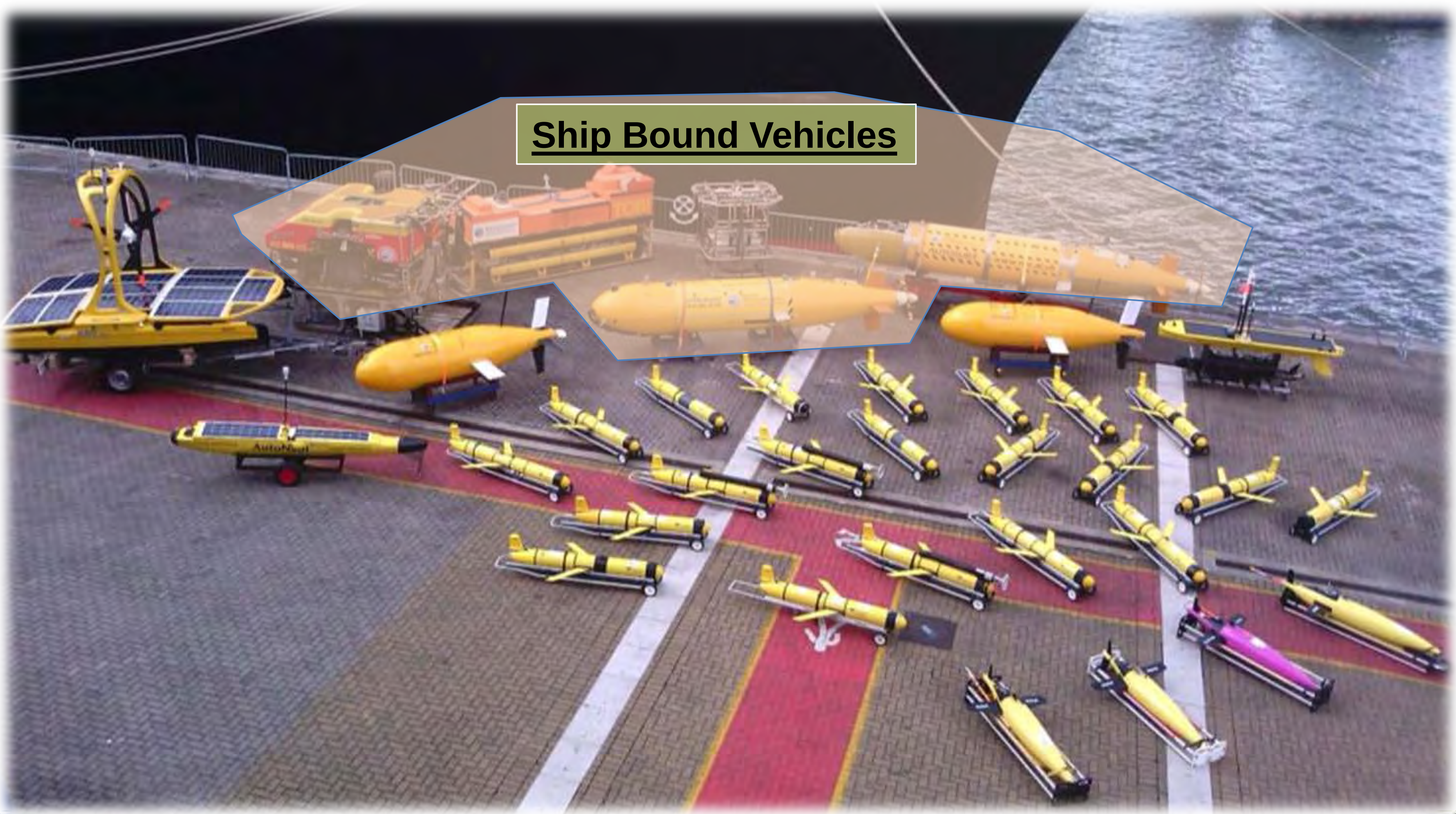



Transmission of data via satellites
Decent to depth
Argo float cycle
Drift approx. 9 days
Repeat process
Drift 10~30 days
Temperature & salinity profile recorded during ascent from greater depth
Deep NINJA float cycle
Sea surface
1000 meters
Current float depth range
2000 meters
Sparse observations
4000 meters


Iridium
Wave Glider
Bottom Pressure
Recorder (BPR)

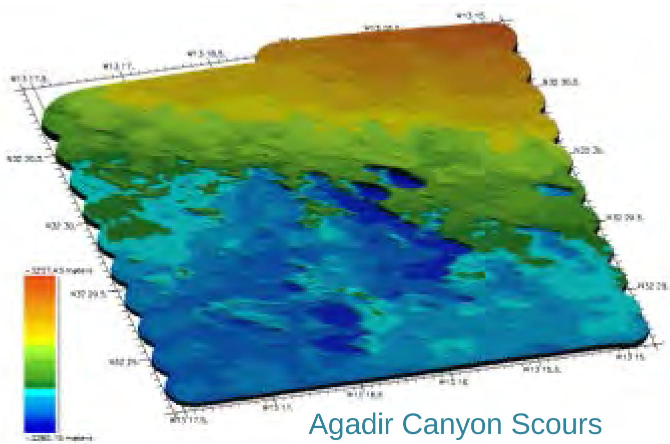
WHAT IS "THE OCEAN OF TOMORROW 2013"?

Long Range & Persistent Presence



High Powered AUV's Missions

Bathymetric Surveys



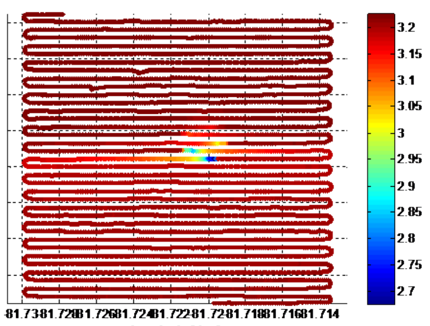
Agadir Canyon Scours
Cruise JC027 [2008]
Altitude 50 – 100m

Sidescan Surveys

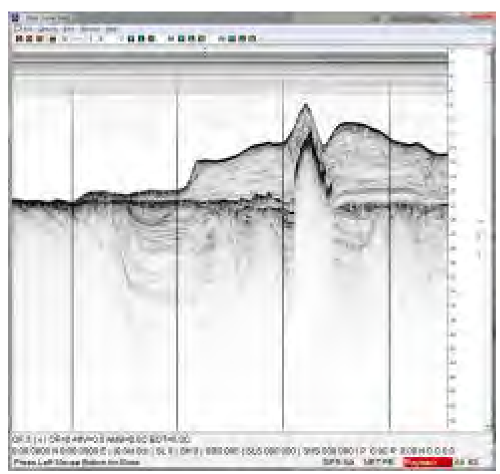
Darwin Mounds (Rockall)
Cruise JC060 [2011]
Altitude 15 – 50 m

Photographic Surveys

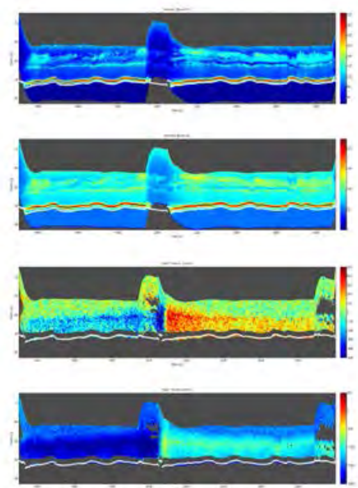
Celtic Sea
Cruise DY008 [2014]
Altitude 2.2m



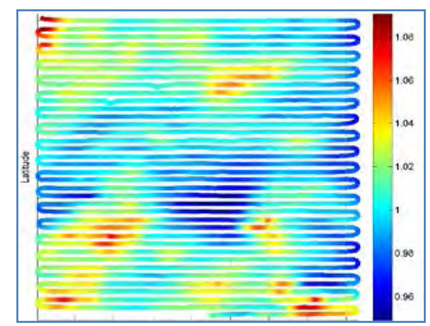
EH signal from JC44



Sub bottom profiler data
Pelagia 2013



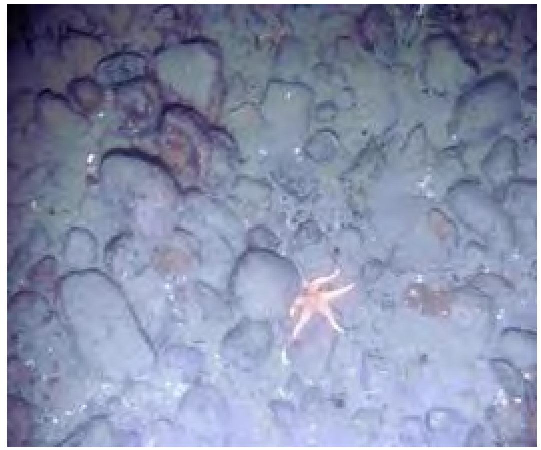
ADCP data
Pelagia 2013



Magnetometer total field (normalised).

High Powered AUV’s Missions

Photographic Surveys

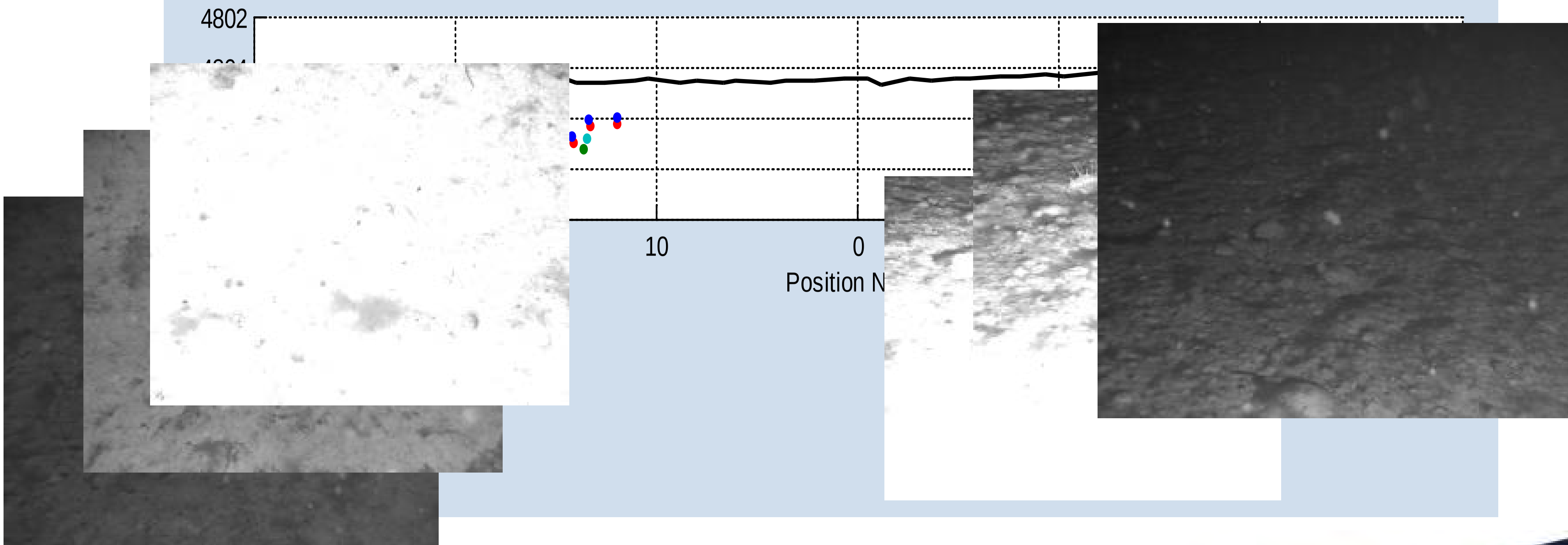


Celtic Sea Cruise DY008 [2014]

60 km of camera survey
capturing ~37,000 images
Altitude of 2.2m

Photographic Surveys are not always easy

The problem with this work is that you have a very good chance of colliding with the seabed



Multi-Vehicle Operations (Nested Survey)

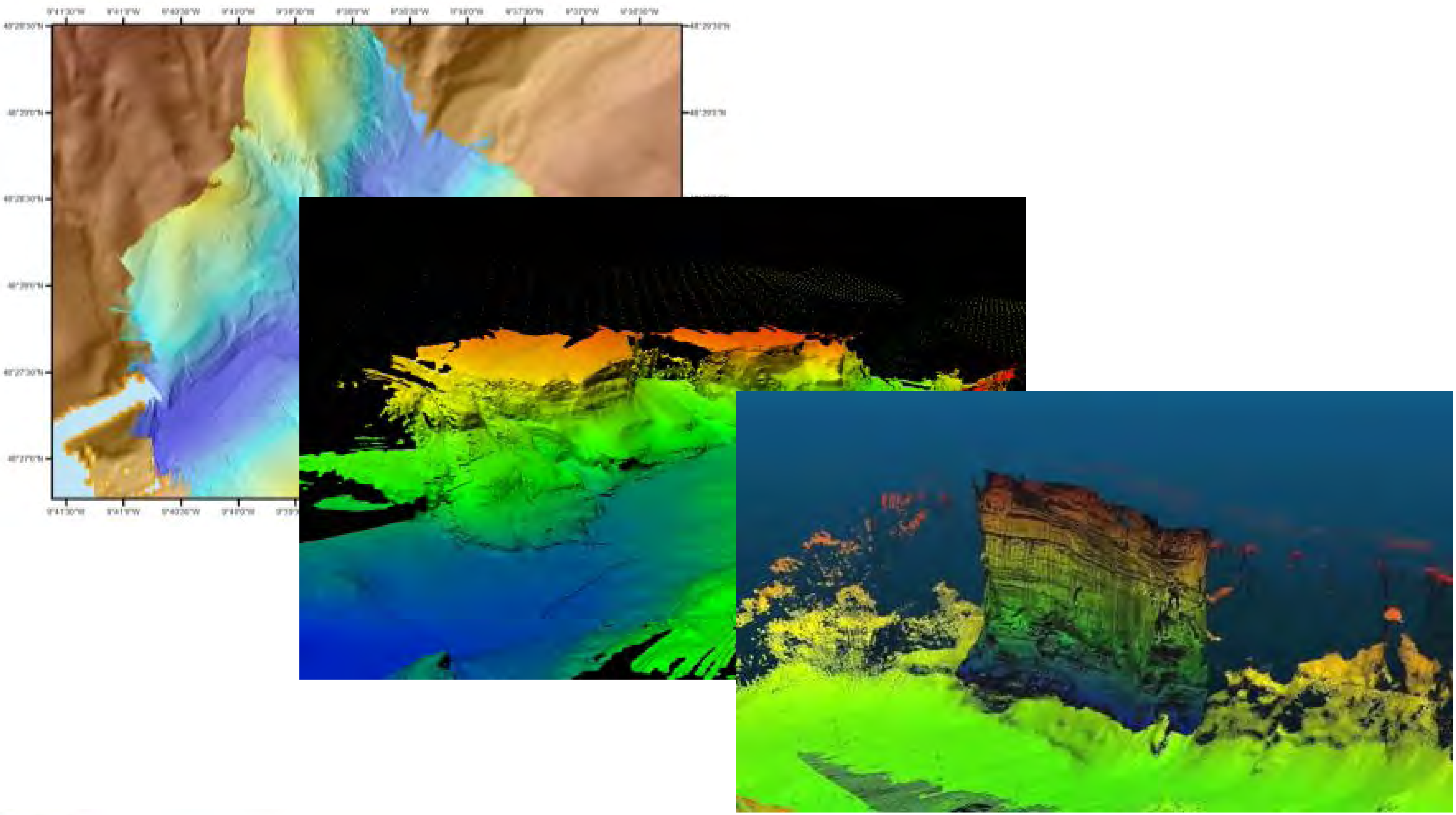
Transport to th
Base of operat
Large area (co

High resolution multi
sensor survey of sites

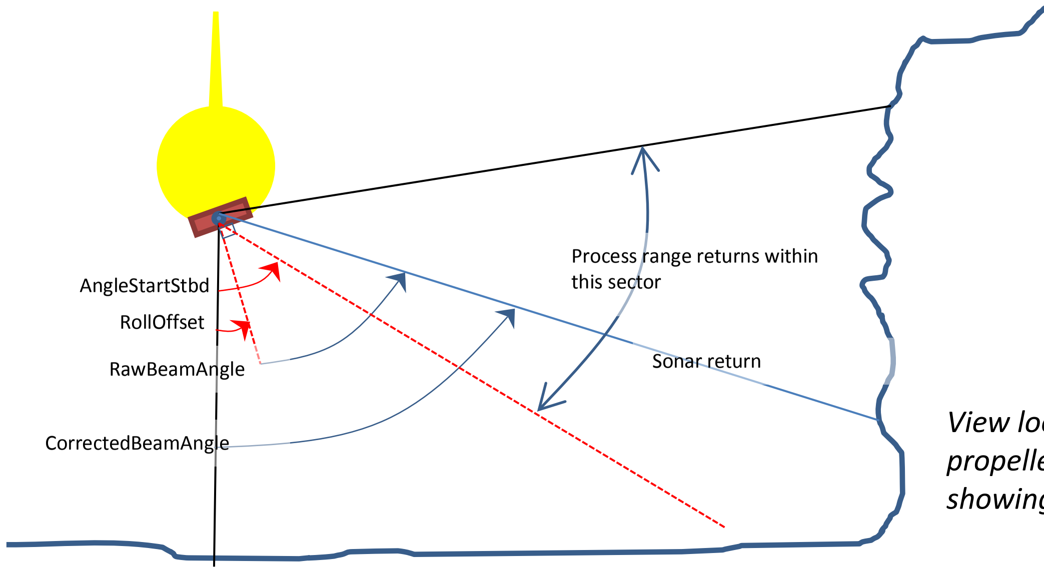
Range scales

High resolution close up photography, intervention and sampling from the seabed

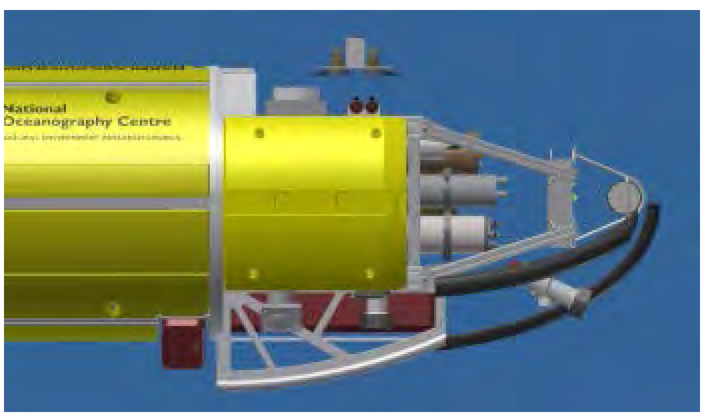
Results of the Nested Survey (JC125 – CODEMAP)

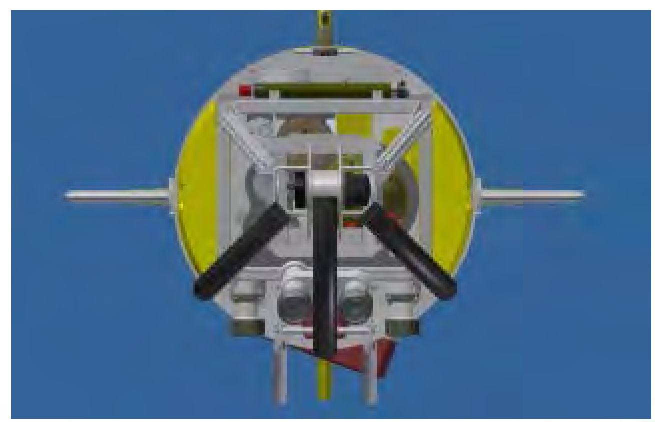


Surveying Canyon Walls (Adapting the EM2040)

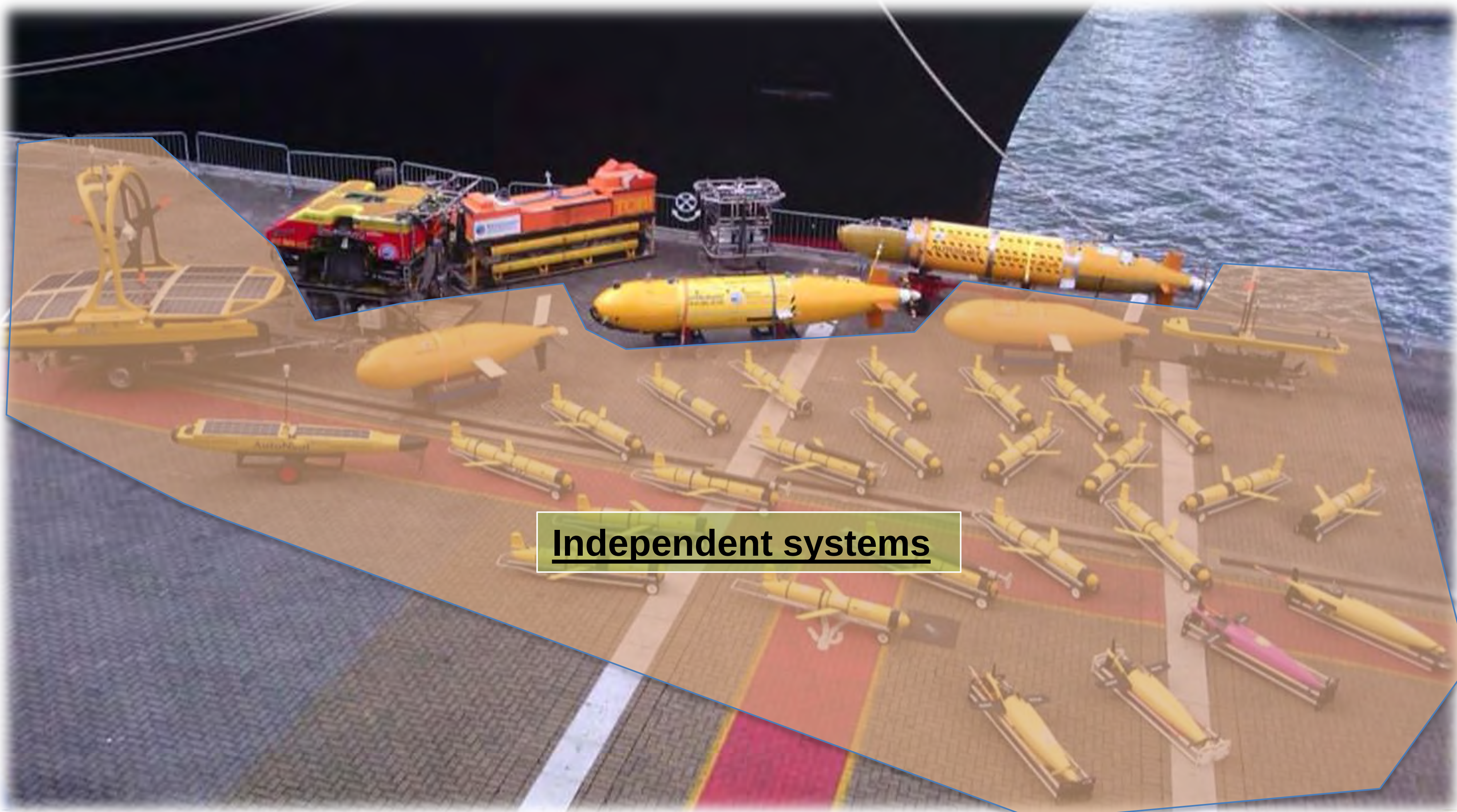


View looking into the propeller of the AUV showing offset receive head.





Long Range & Persistent Presence

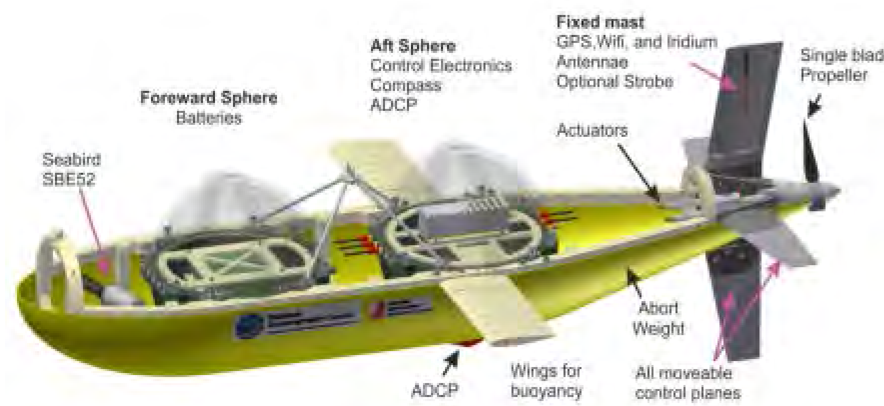


Autosub Long Range

Mass	600 kg
Maximum Depth	6000 m
Maximum Range	6000 km, 6 months
Speed range	0.35 to 0.8 ms^{-1}
On-board energy	29 kWhrs (primary lithium)
Hotel power	1 W (target)
Flight Modes	Depth, Altitude, Profiling
Communications	Iridium & WiFi at surface
Standard Payload	CTD (SBE 52), 300 kHz ADCP
Payload volume	30 litres
Payload weight	10 kg in water

Optional Sensors:

- 600 kHz ADCPs (up / down)
- Microrider turbulence probe
- Wetlabs flourometer
- Magnetometer
- *Others???*



Shore or Ship launched

Hardware (1 x 20’ container)

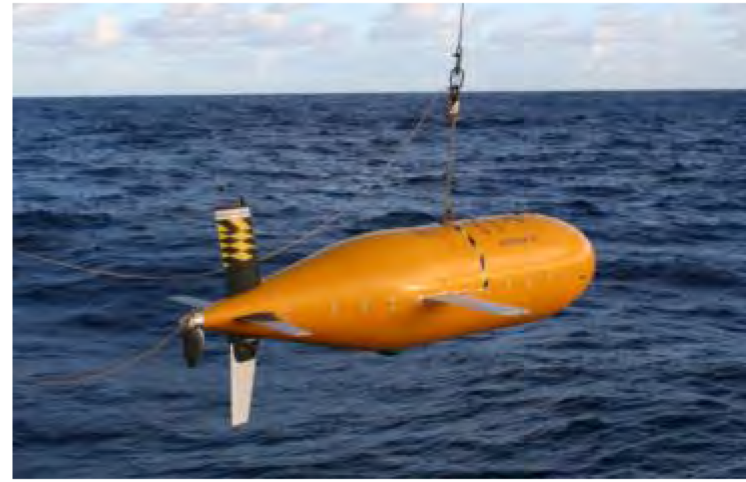
- Autosub Long Range
- Launch and Recovery trailer
- Spares and consumable

Shore Launch

- 1 eng. + 2 assistants launch & recovery
- Small rib to tow out to / recover from safe location
- 2 people on shifts for piloting

Ship Launch

- 1 eng. + ships crew launch & recovery
- 2 people on shifts for piloting



Autonomous surface / sub-surface survey system

funded through Innovate UK

The Problem

When sub-surface long range accurate navigation and vehicle monitoring is difficult, requiring regular vehicle surfacing.

Our Solution

Acoustically couple a surface vehicle to act as a communication gateway and a navigational aid

Primary Project Deliverable

By 2018 demonstrate a coupled long range USV & AUV which can operated as a squad

Project Partners

ASV unmanned marine systems

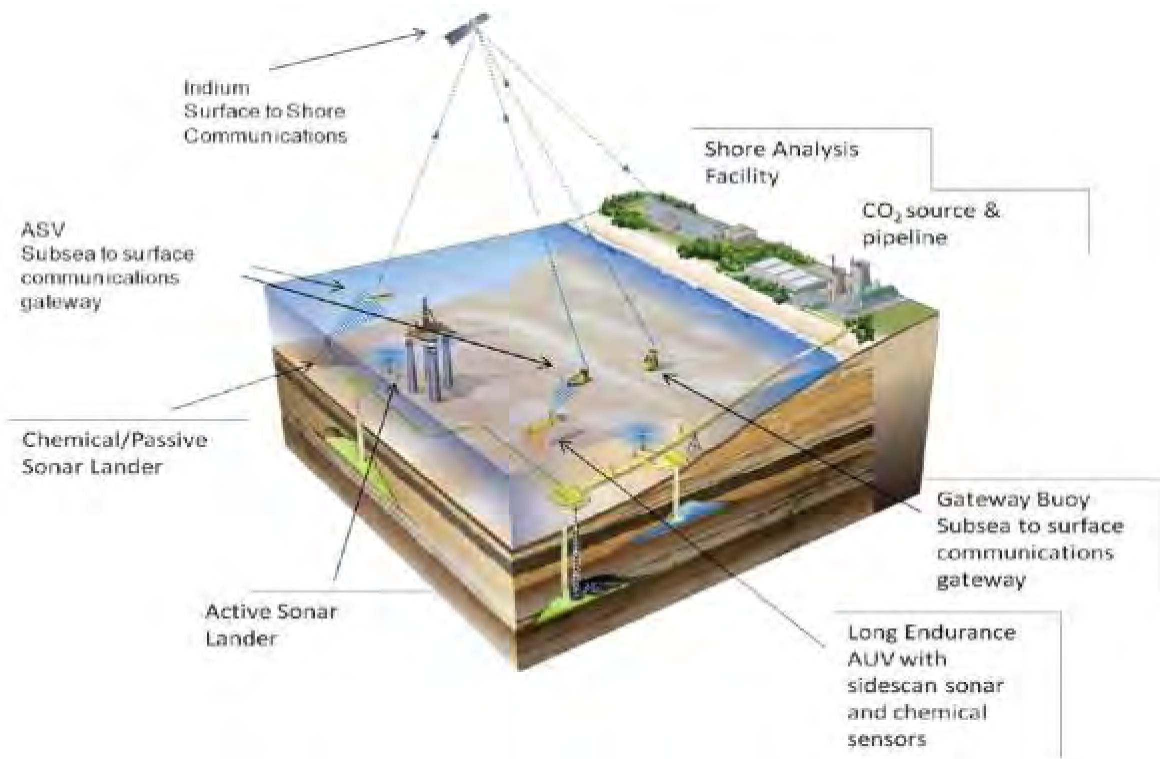
Sonardyne SOUND IN DEPTH

seebyte

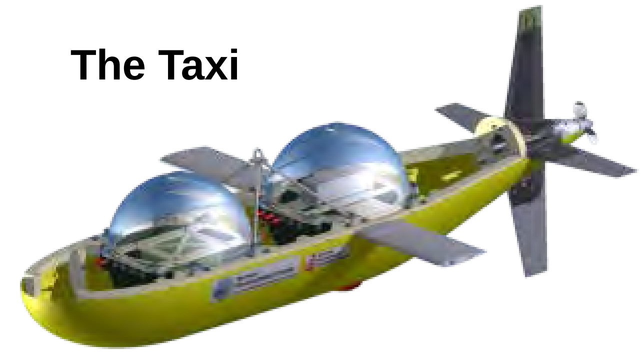
National Oceanography Centre NATURAL ENVIRONMENT RESEARCH COUNCIL

ETI CCSMV - Project

The Concept

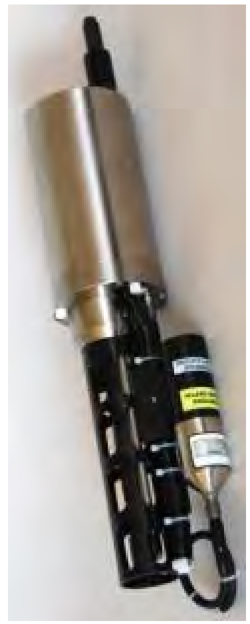


The Taxi



The sensors

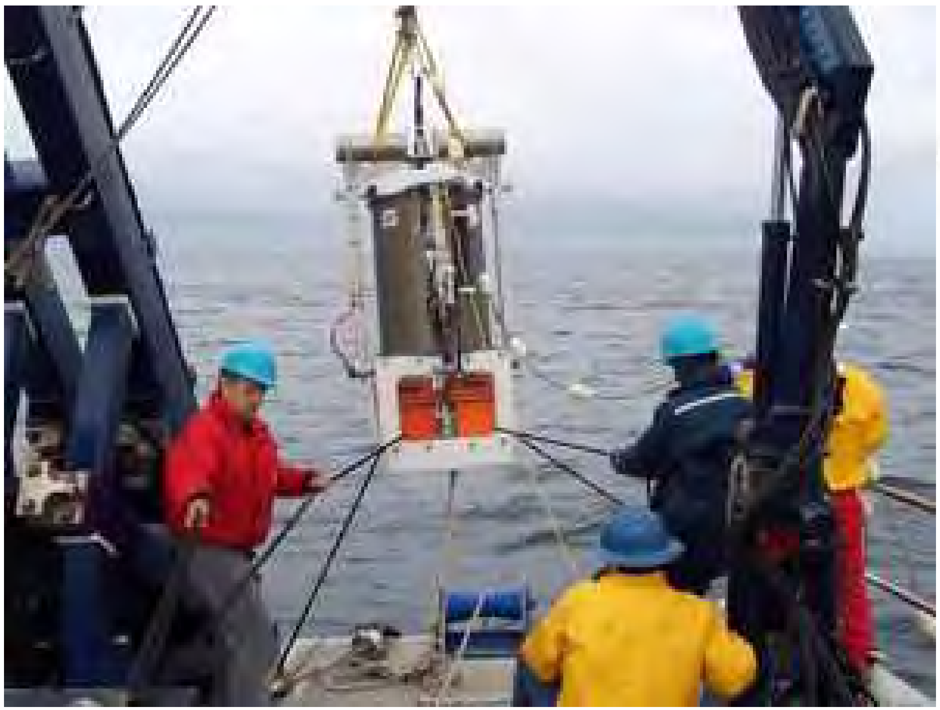
ETI Sensors package: commercial

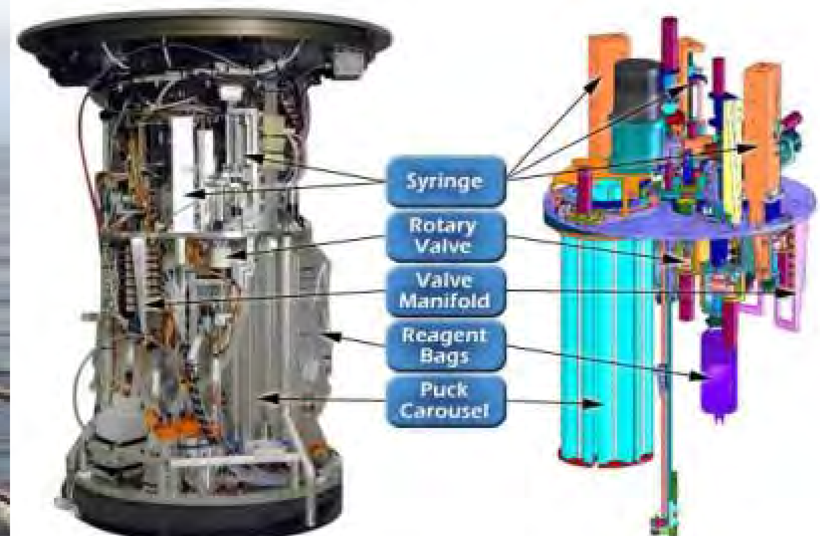


SeapHOx SBE52 CTD SEAFET SBE43F DO

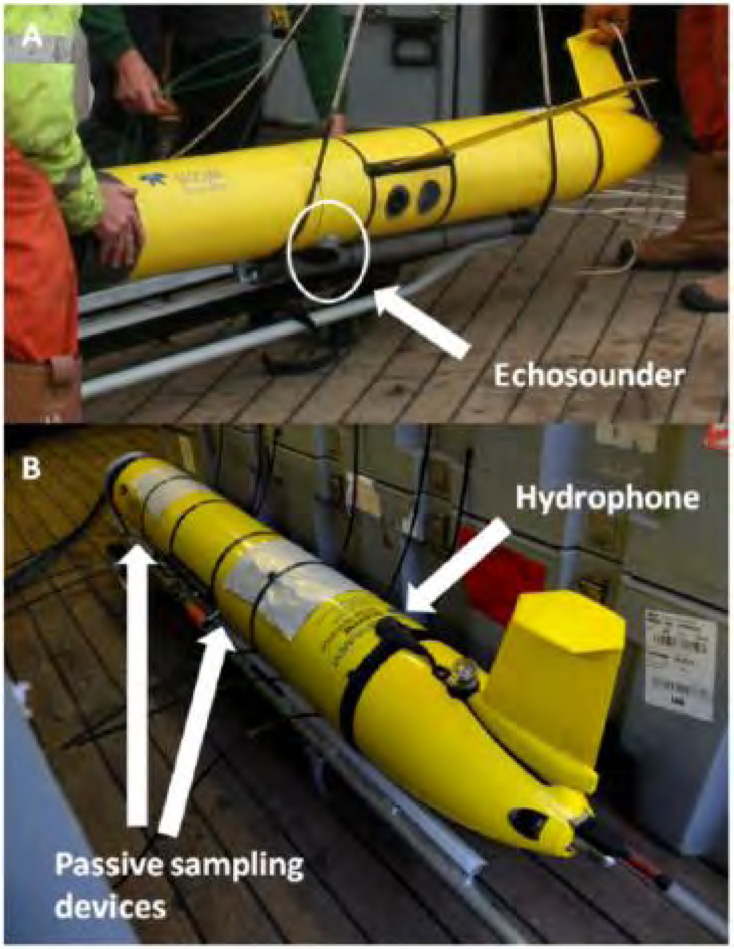
Active sonar (Sonardyne), eH, methane, pCO2, Nitrate, Phosphate

In situ genomic / molecular samplers and sensors





Environmental Sample Processor (MBARI/McLANE)



Contents lists available at ScienceDirect

Methods in Oceanography

journal homepage: www.elsevier.com/locate/mio

Full length article

Assessing the potential of autonomous submarine gliders for ecosystem monitoring across multiple trophic levels (plankton to cetaceans) and pollutants in shallow shelf seas

Lavinia Suberg[a,*], Russell B. Wynn[a], Jeroen van der Kooij[b], Liam Fernand[b], Sophie Fielding[c], Damien Guihen[c], Douglas Gillespie[d], Mark Johnson[d], Kalliopi C. Gkikopoulou[d], Ian J. Allan[e], Branislav Vrana[f], Peter I. Miller[g], David Smeed[a], Alice R. Jones[a,h]

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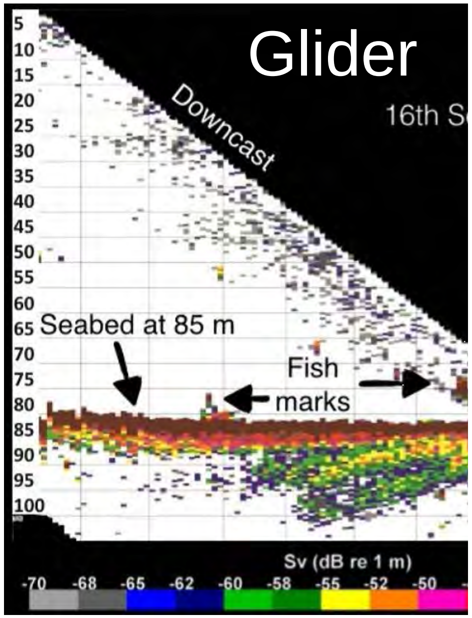
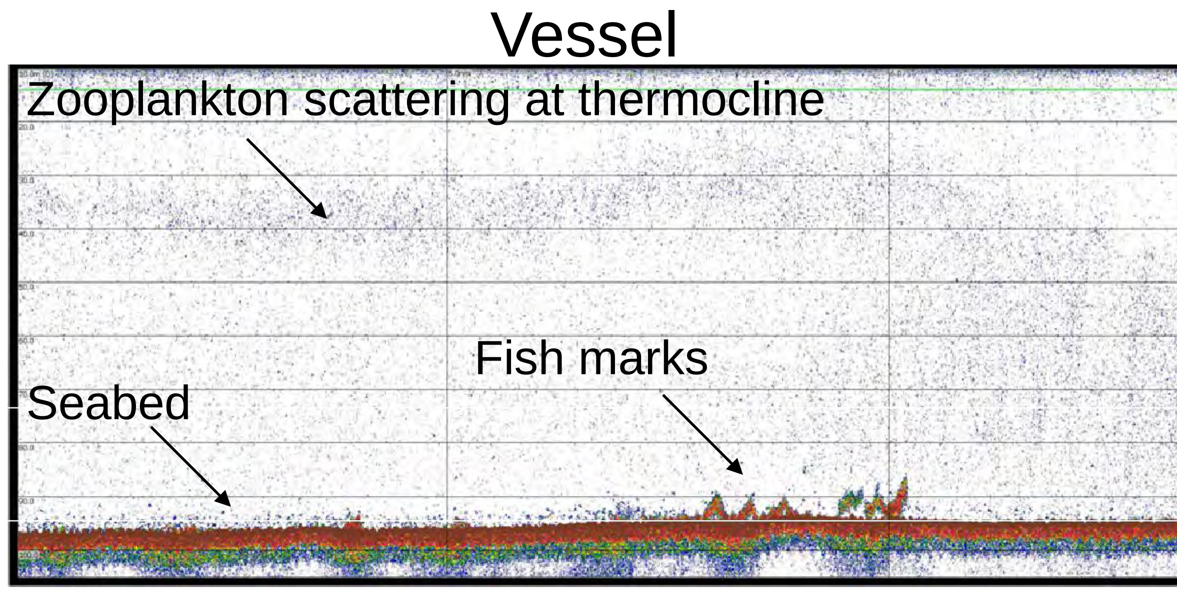
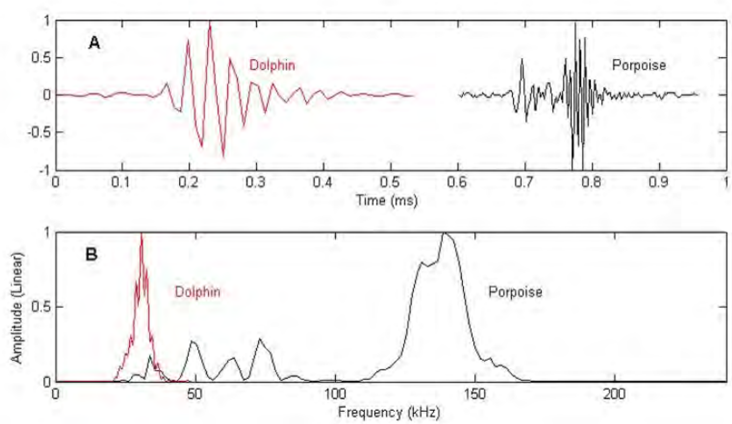
[b] Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
[c] British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK
[d] Scottish Oceans Institute, East Sands, University of St Andrews, St Andrews, Fife, KY16 8LB, UK
[e] Norwegian Institute of Water Research, Oslo Centre Interdisciplinary Environmental & Social Research, Gaustadalléen 21, NO-0349 Oslo, Norway
[f] Masaryk University, Research Centre for Toxic Compounds in the Environment (RECETOX), Kamenice 753/5, 62500 Brno, Czech Republic
[g] Remote Sensing Group, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, UK
[h] The Environment Institute & School of Ocean and Earth Sciences, University of Adelaide, South Australia 5005, Australia

2D echosounder profiles comparing glider and vessel-based data





Examples of cetacean acoustic data collected using the glider-mounted PAM



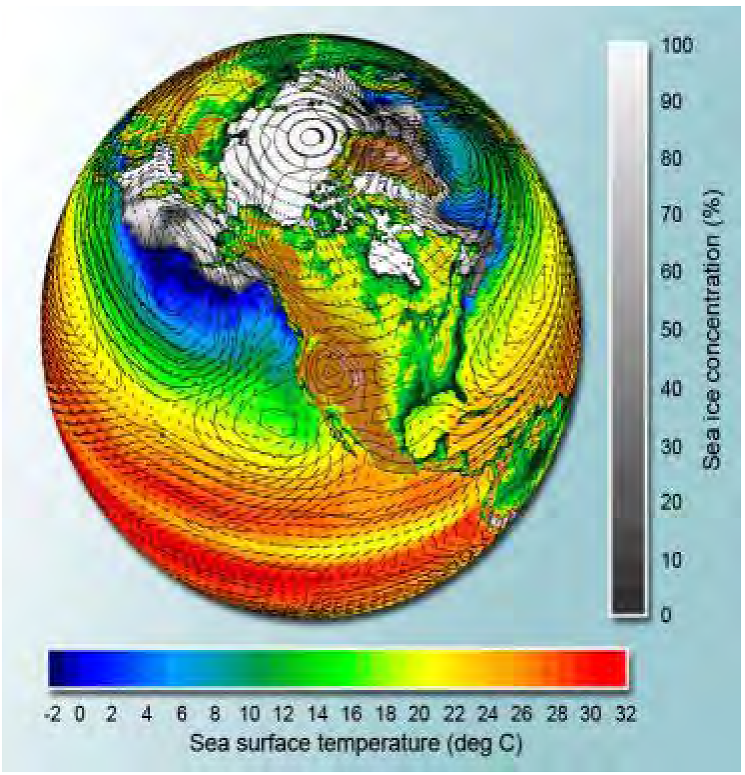
Waveforms (A) and power spectra (B) of detected dolphin and porpoise clicks using the modified d-tag

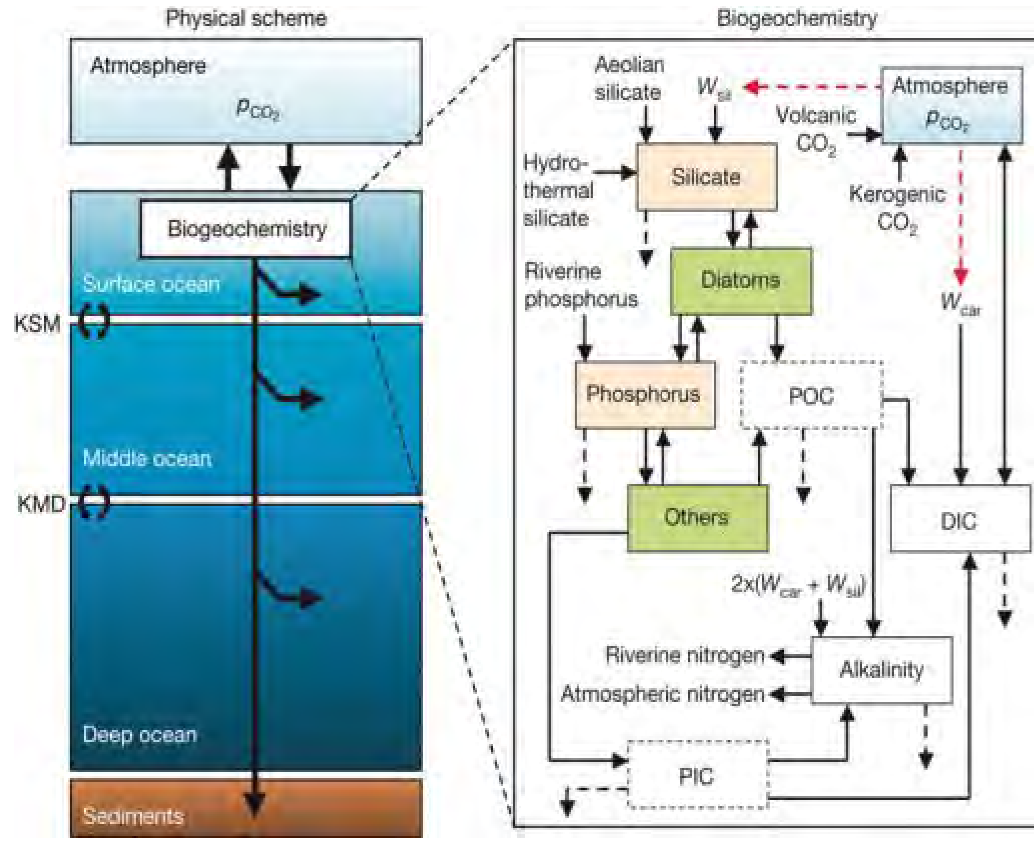
Ocean Technology and Engineering Group

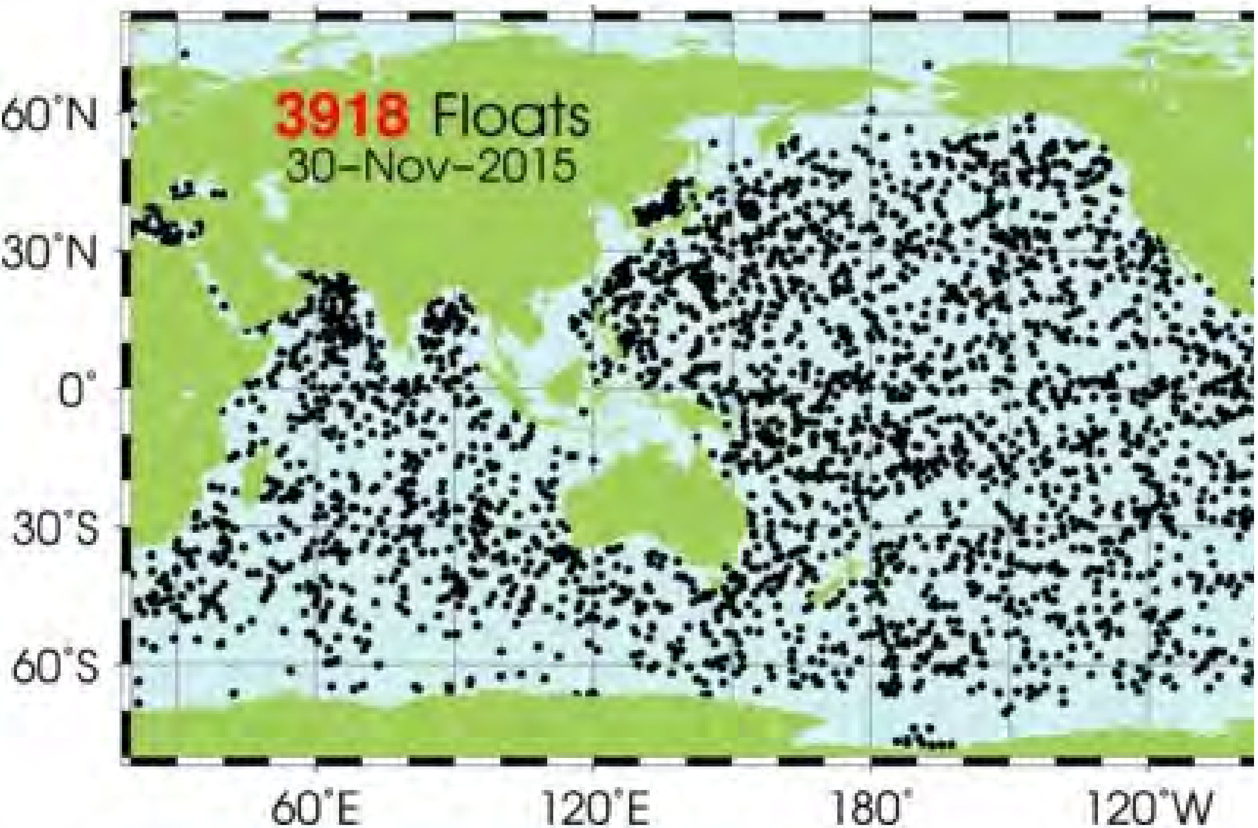
- Sensors
- Water physics (CTD)
- Water chemistry
- Water biology
- Sediment flow and properties
- Wave height / breaking
- Sea surface fluxes

- Samplers
- Continuous water
- Gas tight water
- Particles
- Genomics
- Landers and benthic systems
- Communication systems
- Sterile probes / vehicles (subglacial)

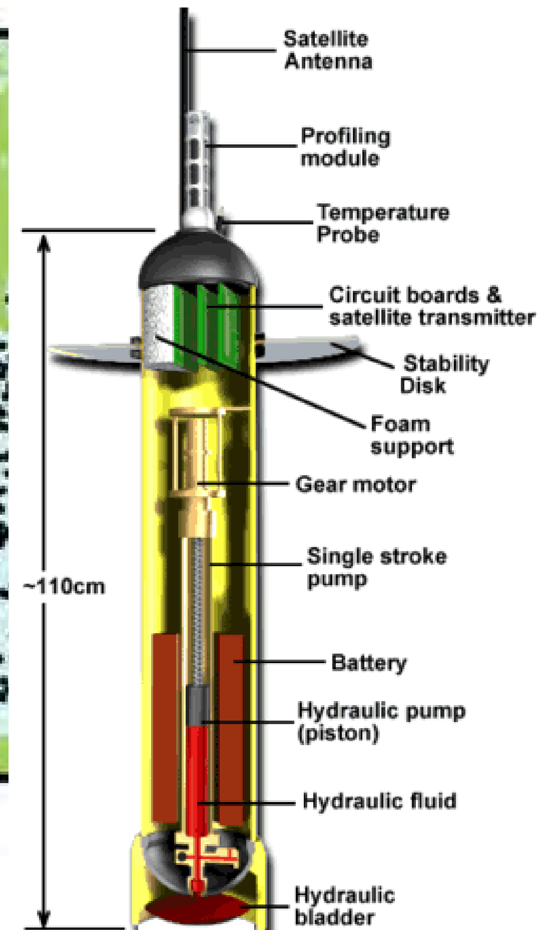
Biogeochemistry: Global impact, hard to measure







3918 Floats
30-Nov-2015
60°N
30°N
0°
30°S
60°S
60°E
120°E
180°
120°W



Satellite Antenna
Profiling module
Temperature Probe
Circuit boards & satellite transmitter
Stability Disk
Foam support
Gear motor
Single stroke pump
Battery
Hydraulic pump (piston)
Hydraulic fluid
Hydraulic bladder
~110cm

Marine Sensors Analytical Targets

- Salinity (microsensors, 0.002psu)
- Nutrients (uM coastal / deep, nM open ocean)
- Trace metals (f-nM)
- Gases (n-uM)
- Carbonate system (0.001 pH equiv)
- Hydrocarbons (f-nM)

- Small organics, e.g. PAH, PCBs (f-pM)
- Proteins and large organics (copies / L)
- Nucleic Acids: organisms, eDNA (copies / L)
- Whole cells (cytometry)
- Radionuclide

Marine Sensors Technologies and TRL

Microfabricated Solid State / Electrochemistry:

- Salinity 7
- Dissolved oxygen 7

Optodes / optical sensors

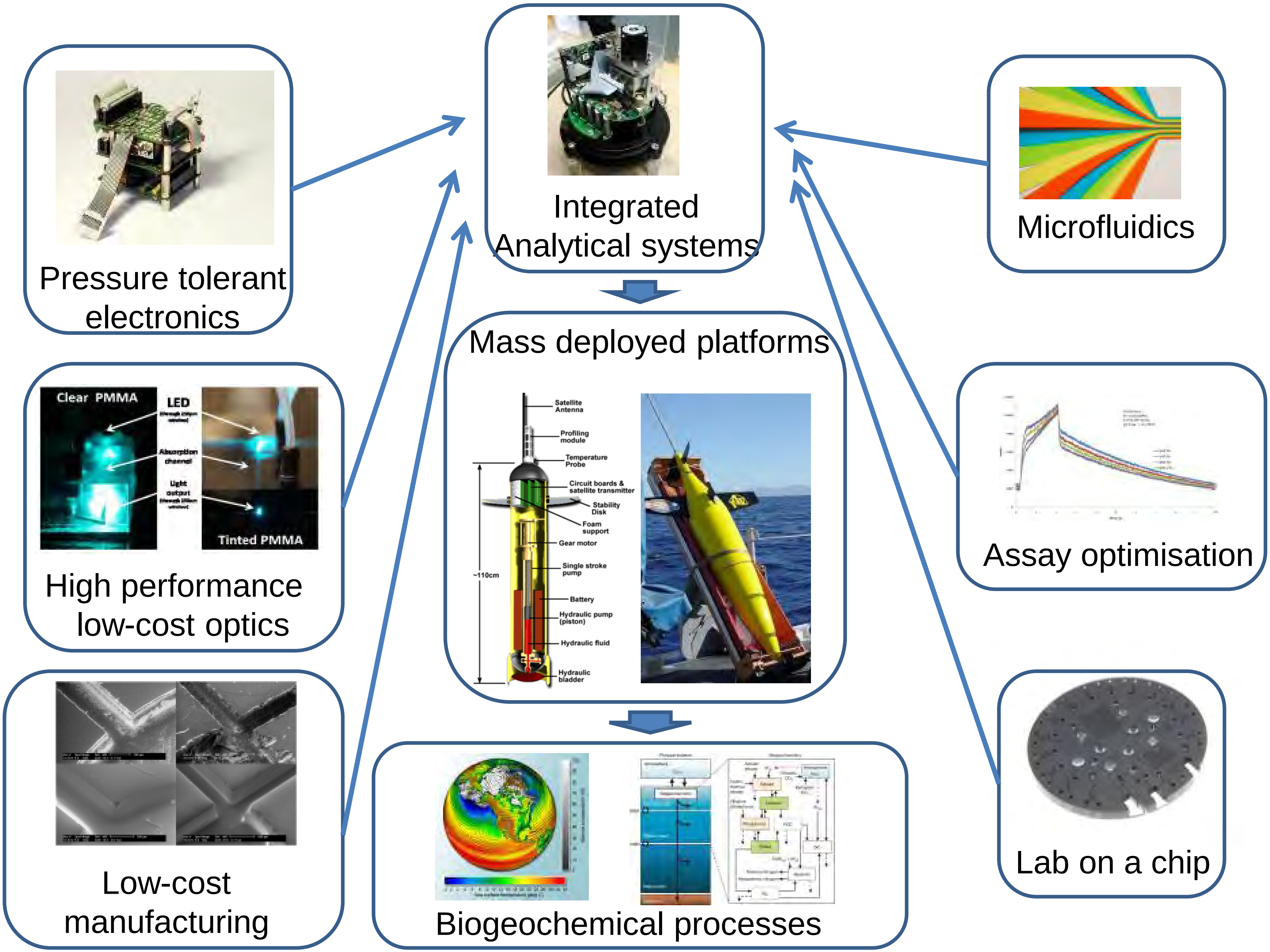
- Gases / Hydrocarbons 6
- pH, pCO_2 7
- Radionuclide 3

Cytometer

- Whole cells (label free) 5
- Labelled cells 5
- Microplastics 4
- Bead assays 3

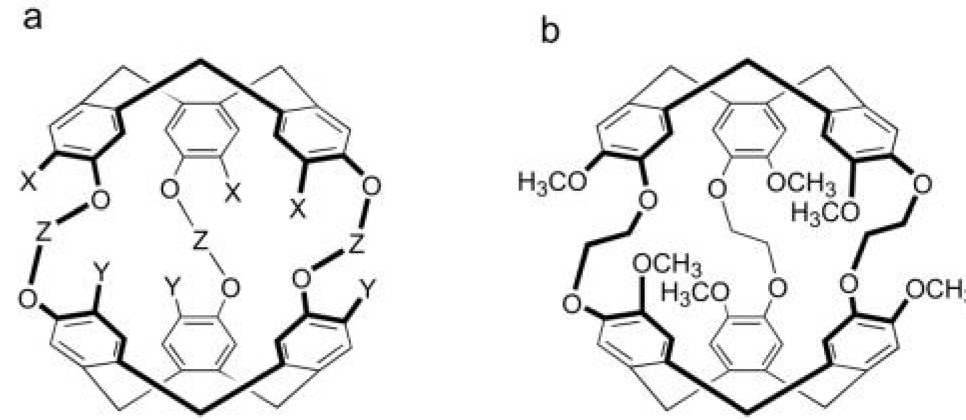
Lab on Chip

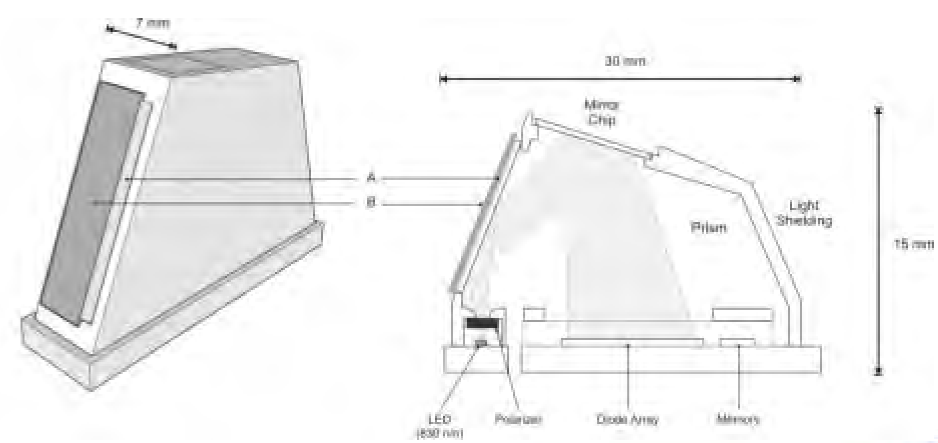
- Inorganic Nutrients 8
- Organic Nutrients 5
- Trace metals 7
- pH 7, TA 4, DIC 3, pCO_2 4
- Small organics, e.g. PAH, PCBs 5
- Proteins and large organics 4
- Nucleic Acids 6
- Radionuclide 3


Pressure tolerant electronics
Clear PMMA
LED
Absorption channel
Light output
Tinted PMMA
High performance low-cost optics
Low-cost manufacturing
Integrated Analytical systems
Mass deployed platforms
Satellite Antenna
Profiling module
Temperature Probe
Circuit boards & satellite transmitter
Stability Disk
Foam support
Gear motor
Single stroke pump
Battery
Hydraulic pump (piston)
Hydraulic fluid
Hydraulic bladder
~110cm
Biogeochemical processes
Microfluidics
Assay optimisation
Lab on a chip

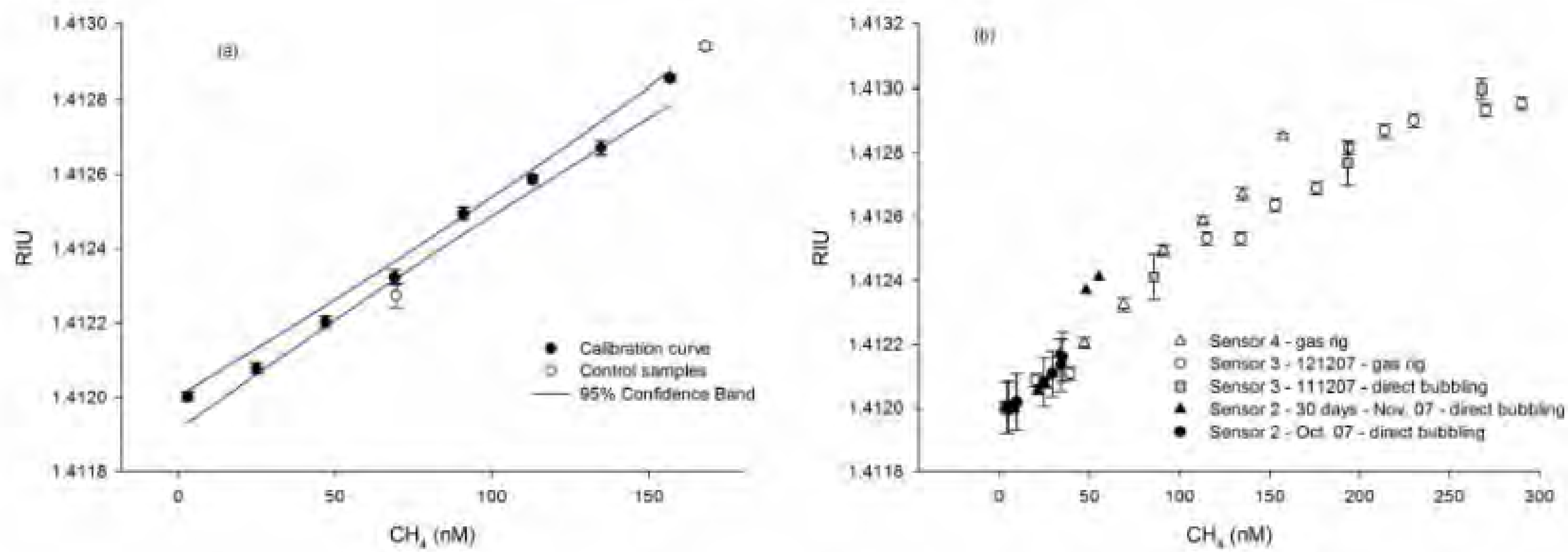
Optodes: Methane Sensor

- Ultra low limit of detection 0.2nM
- Time response ~ 3min
- Optical indicator using Cryptophane-a supramolecule
- Refractive index modulation
- Surface Plasmon Resonance detection
- Sensing element
  - 7x15x30mm
  - <200mW

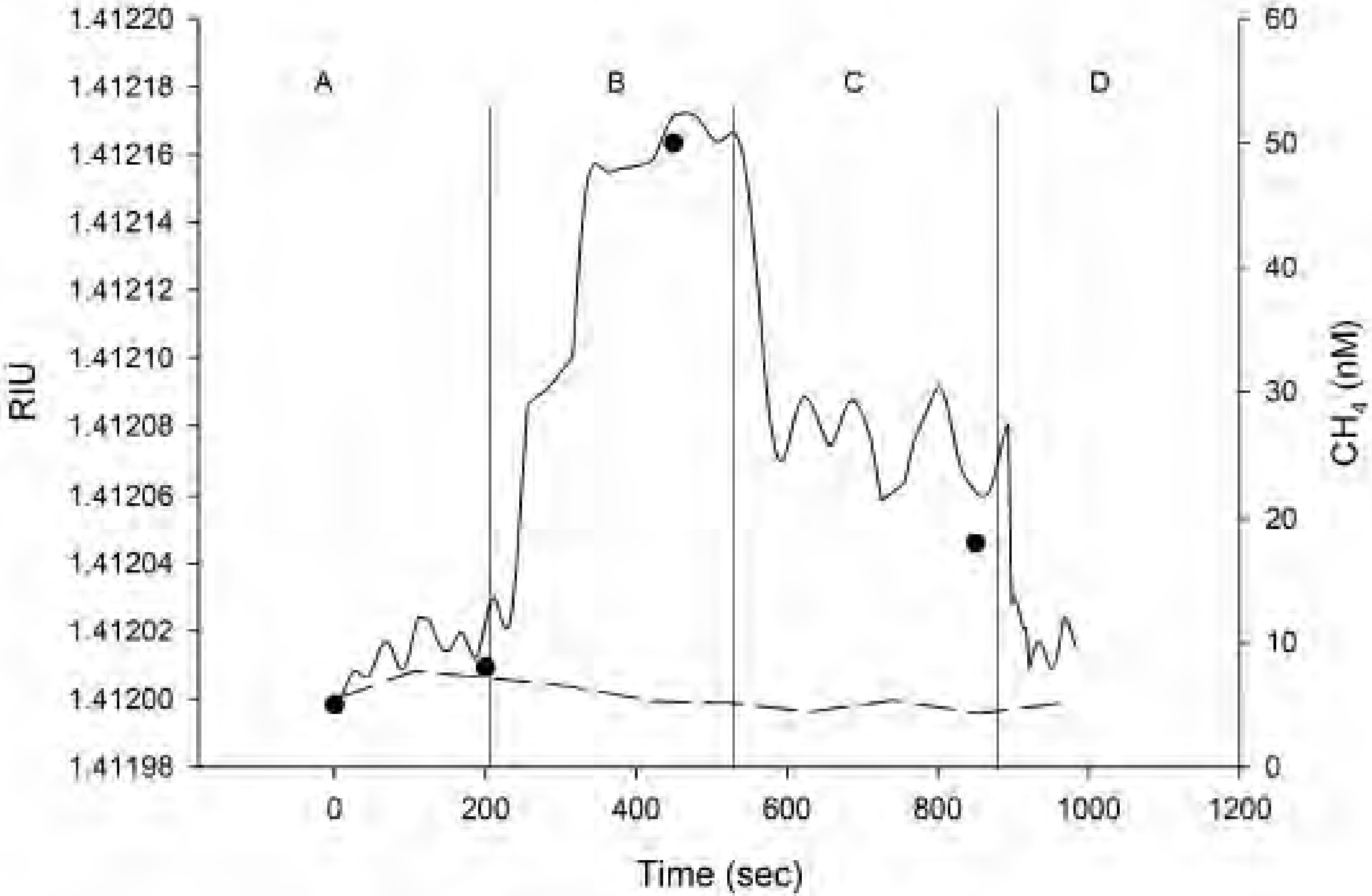




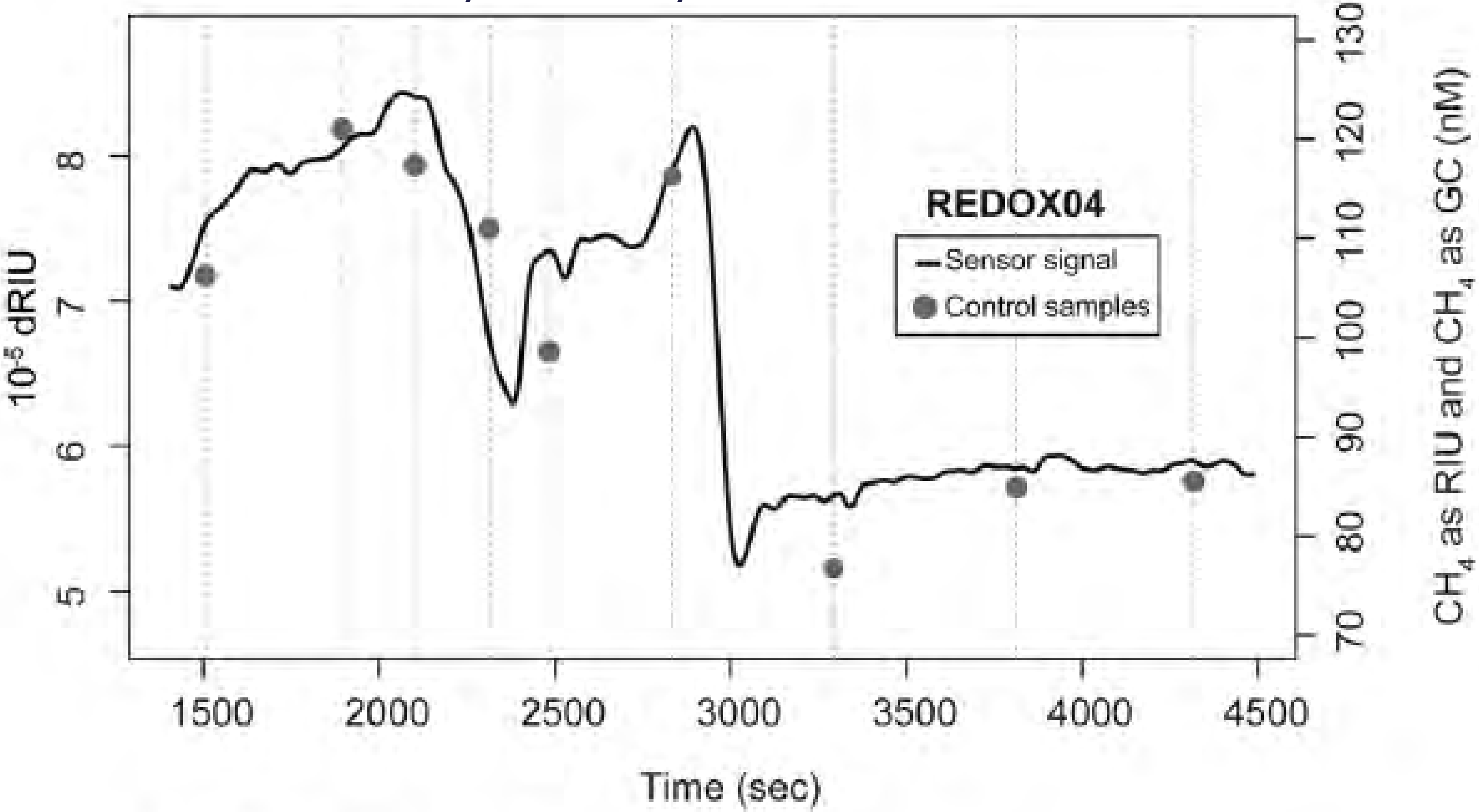
Laboratory Characterisation Data



Field data from estuary (sensor trace and spot samples represented as dots)



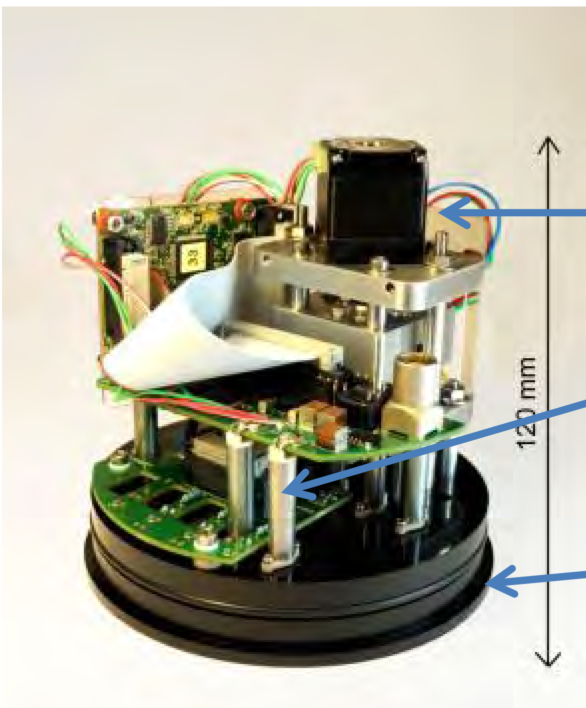
Field data, Baltic, Boulart et. al. 2013



E - Slow-motion vertical profile

Lab on chip

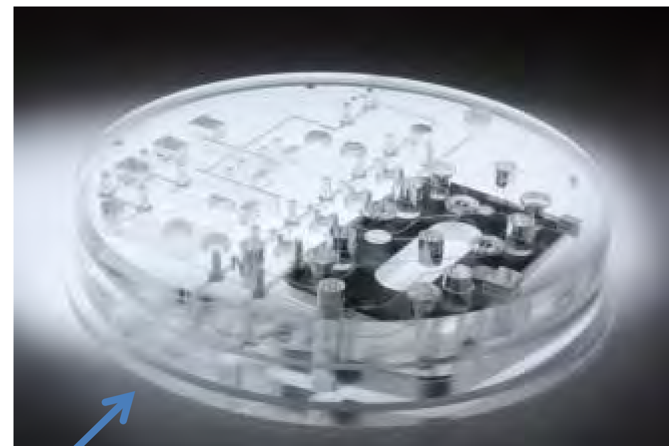
Lab on chip: Nitrate, Nitrite, pH, Phosphate, Silicate, Iron, Manganese, Total Alkalinity, Ammonia, DOP, Dissolved Inorganic Carbon, DON, PCB, PAH, organisms…..



Pump

Valves

Microfluidic Chip



Biosensing

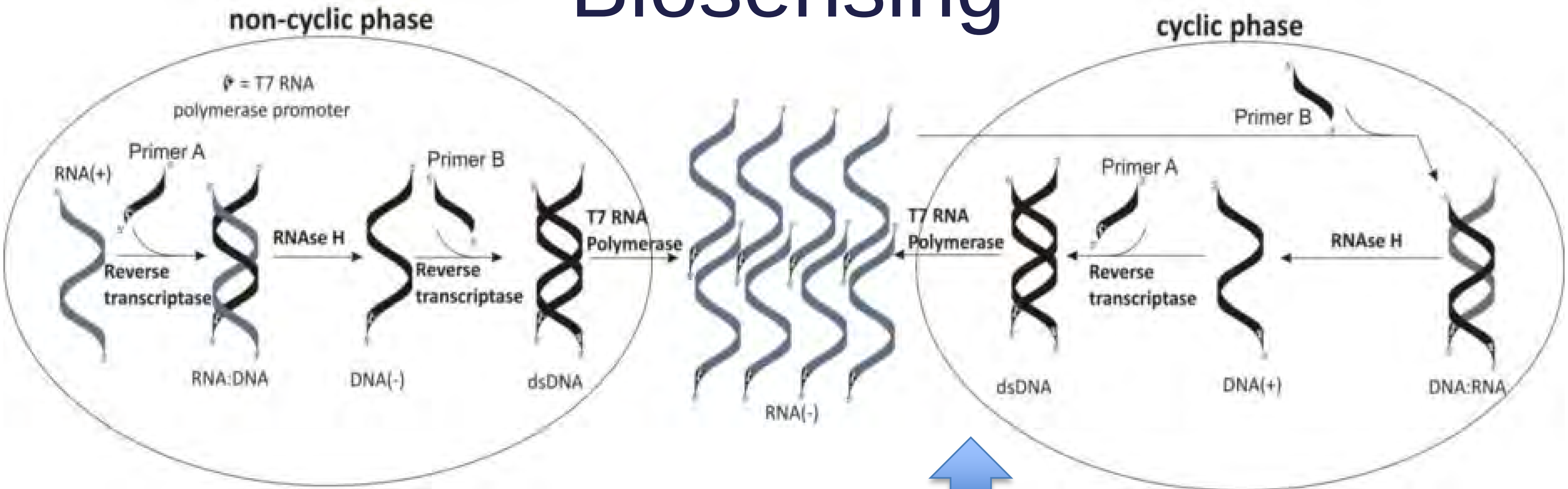


Figure and work by M.N. Tsaloglou

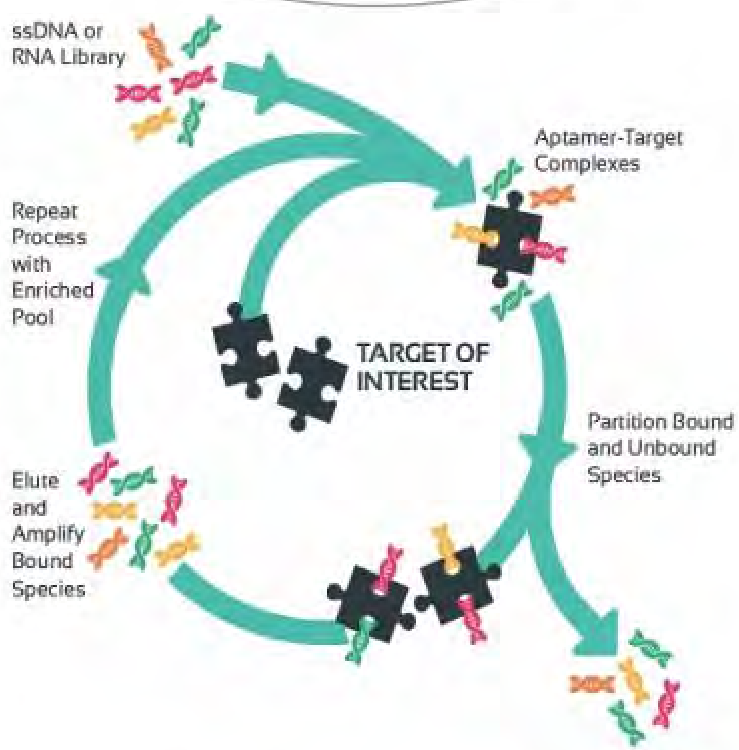
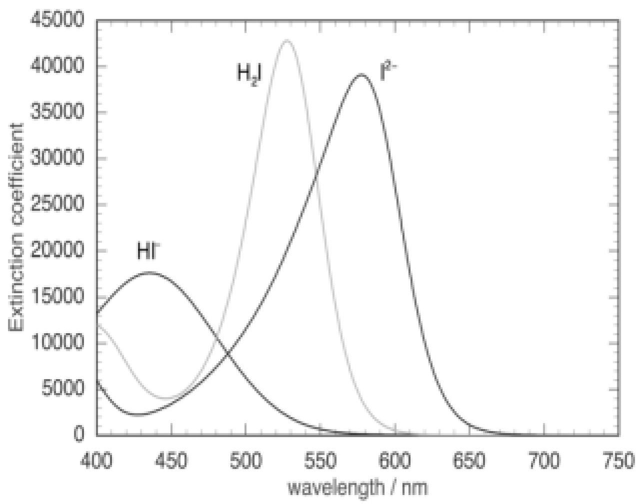
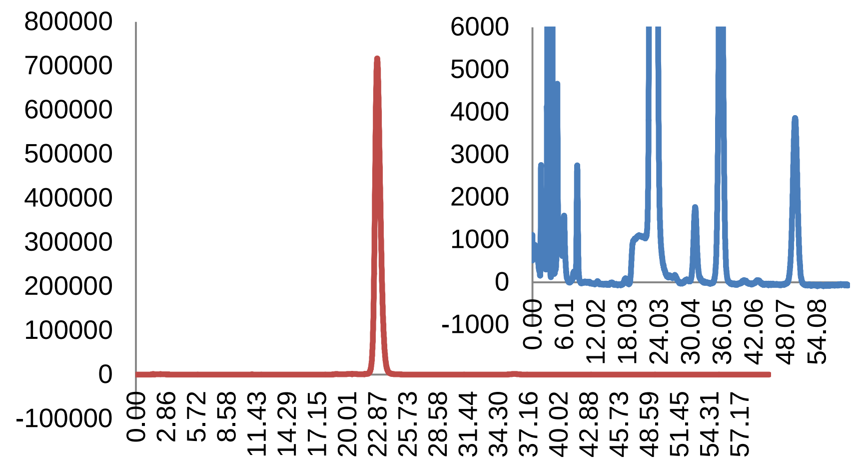


Image courtesy of our partners Aptamer solutions
http://www.aptamersolutions.co.uk/

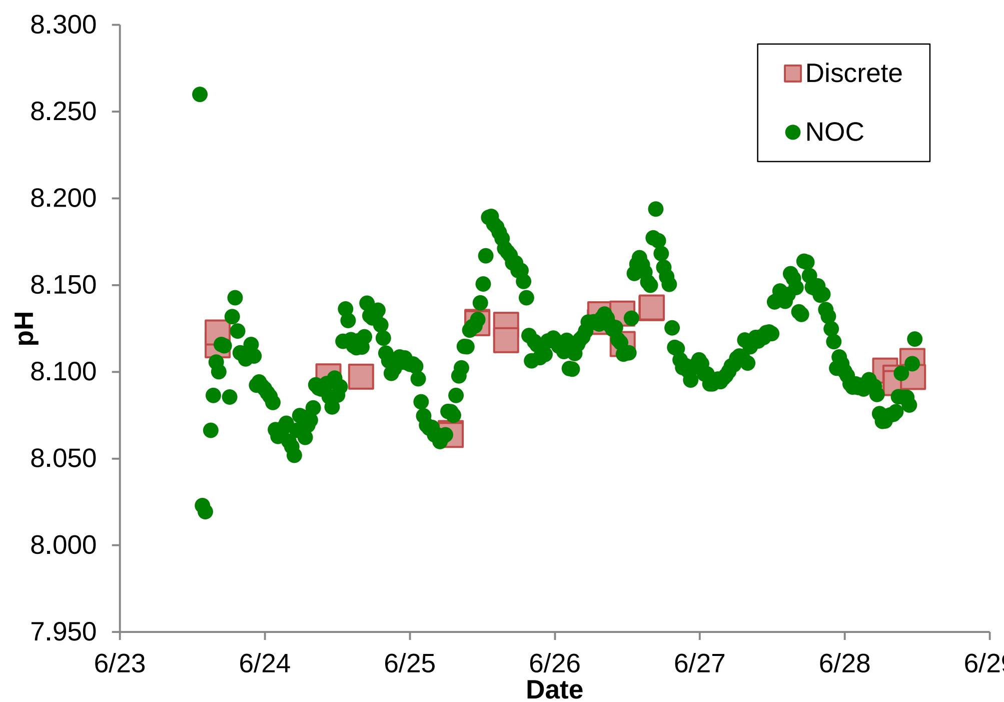
High precision pH m-Cresol Purple

pH 4 → pH 12





pH deployment in Gullmar fjord in Sweeden (June, 2015)
5-Day deployment at 30 min sampling frequency



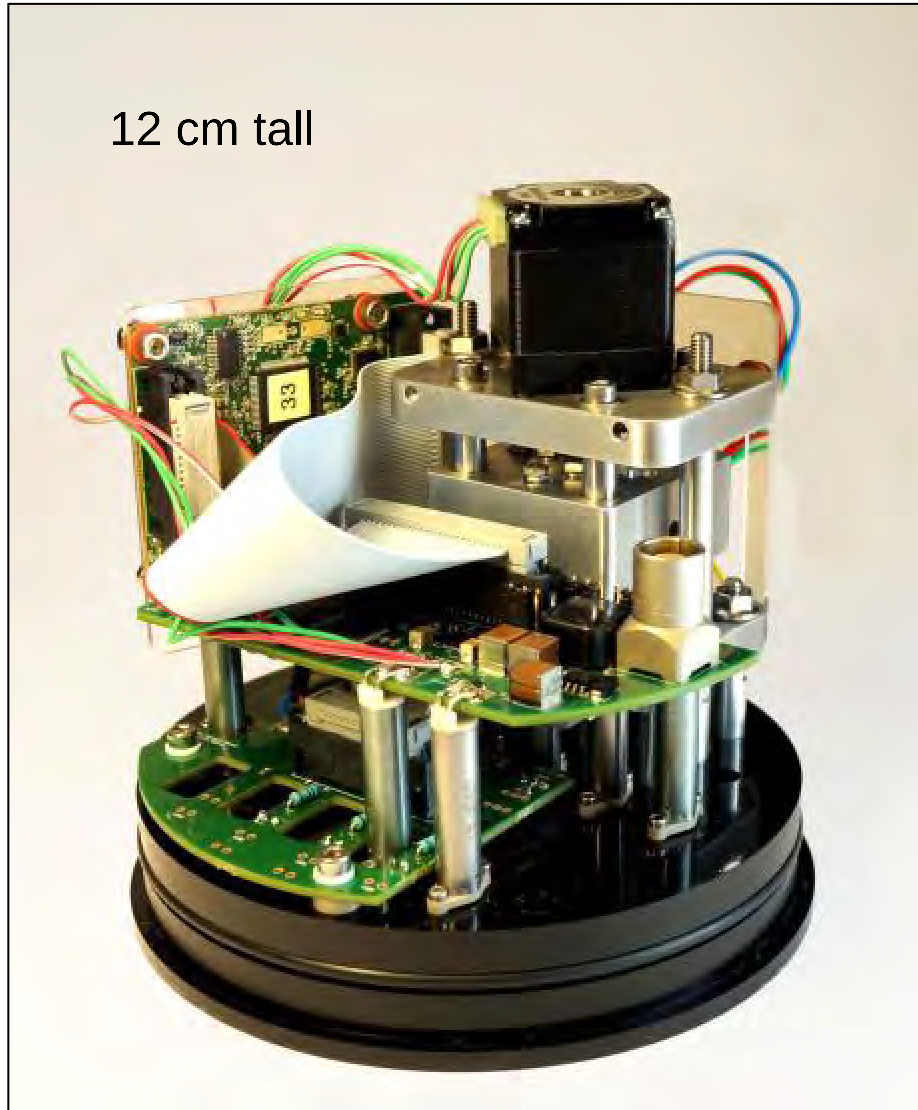
V3 nitrate sensor

Limit of detection: 0.025 µM

Range: up to 1000 µM

Power consumption: 1W, or 300 Joules per measurement

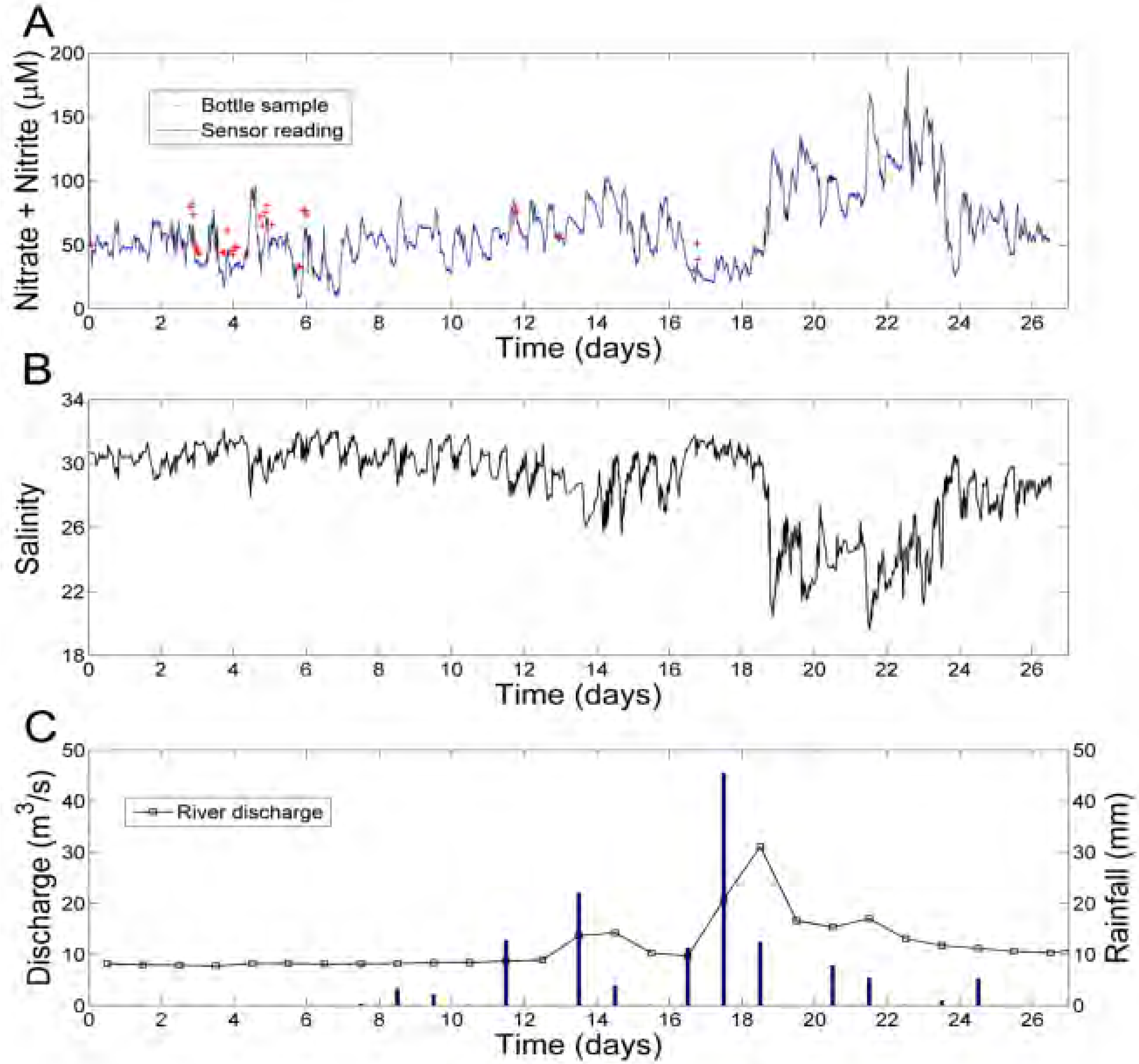
Size allows installation inside underwater glider



Nitrate + Nitrite data from 26-day deployment

Salinity

River Test discharge and local rainfall

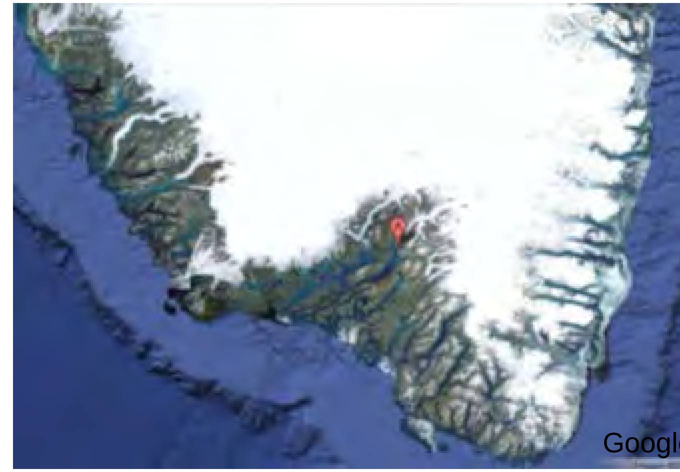


Glacial meltwater

Studying nutrient export from the Greenland ice sheet

Two week deployment in 2013 – planning to deploy again for longer in 2014

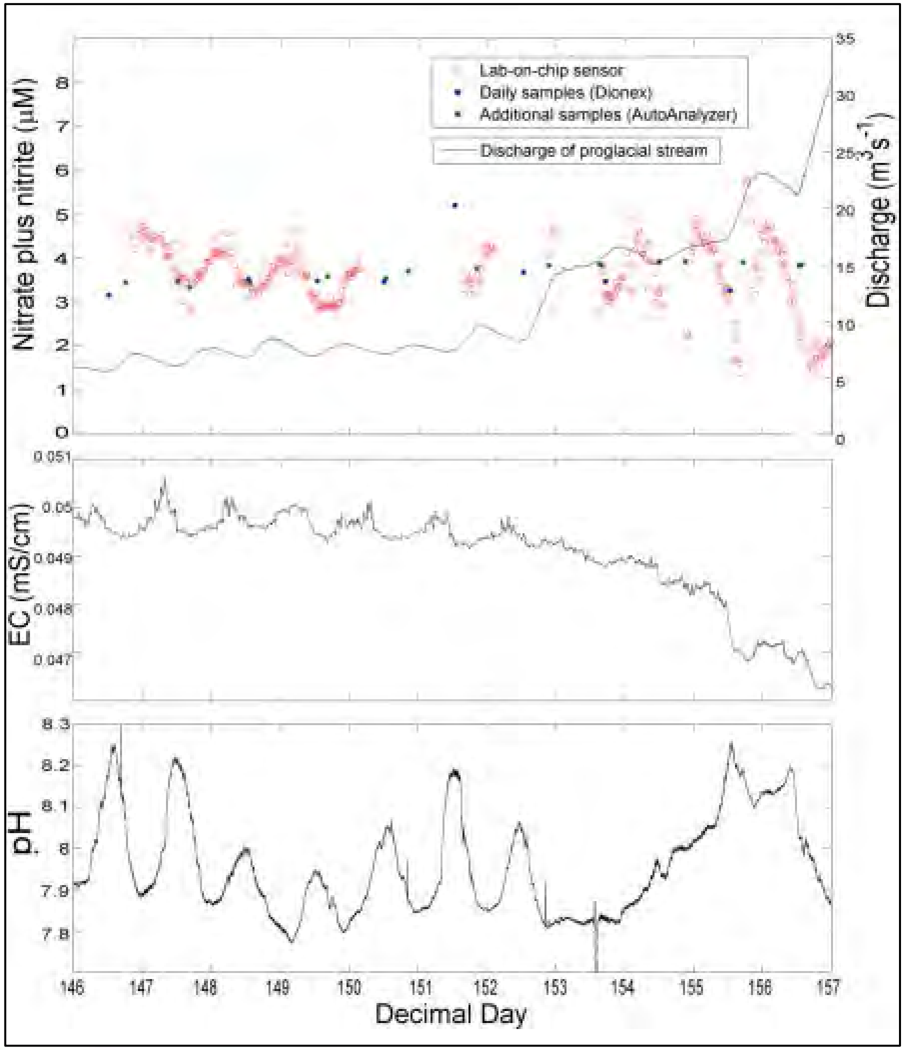
Highly turbid waters – two stage filtering system used

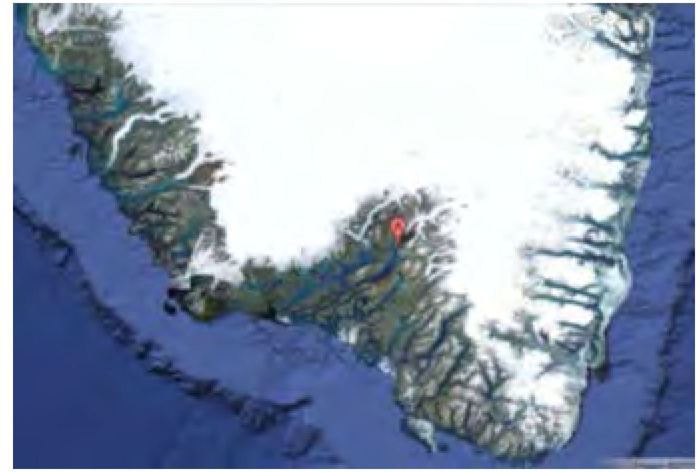


© NASA

With Jemma Wadham and Martyn Tranter, University of Bristol

Glacial meltwater





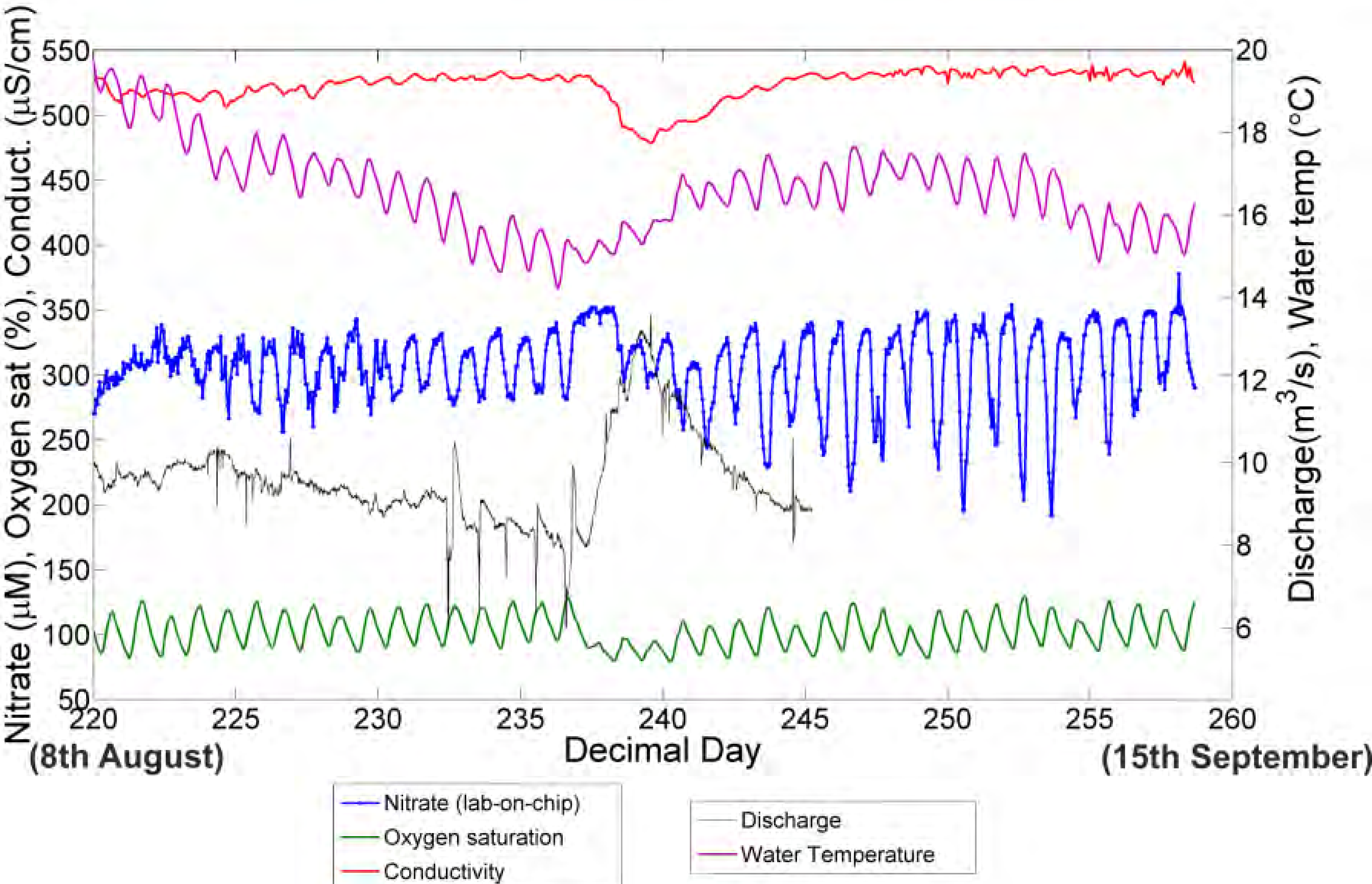
With Jemma Wadham and Martyn Tranter, University of Bristol

Macronutrient cycles

Christchurch harbour, UK

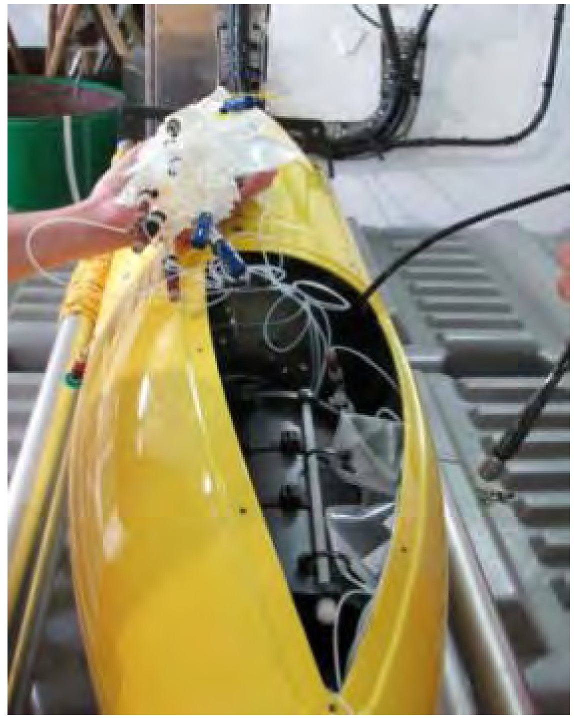
With Duncan Purdie and others as part of the Macronutrient Cycles project

Data from nitrate sensor deployed in Hampshire Avon, UK (blue line)



Nitrate deployment on gliders

Celtic Sea, April 2015

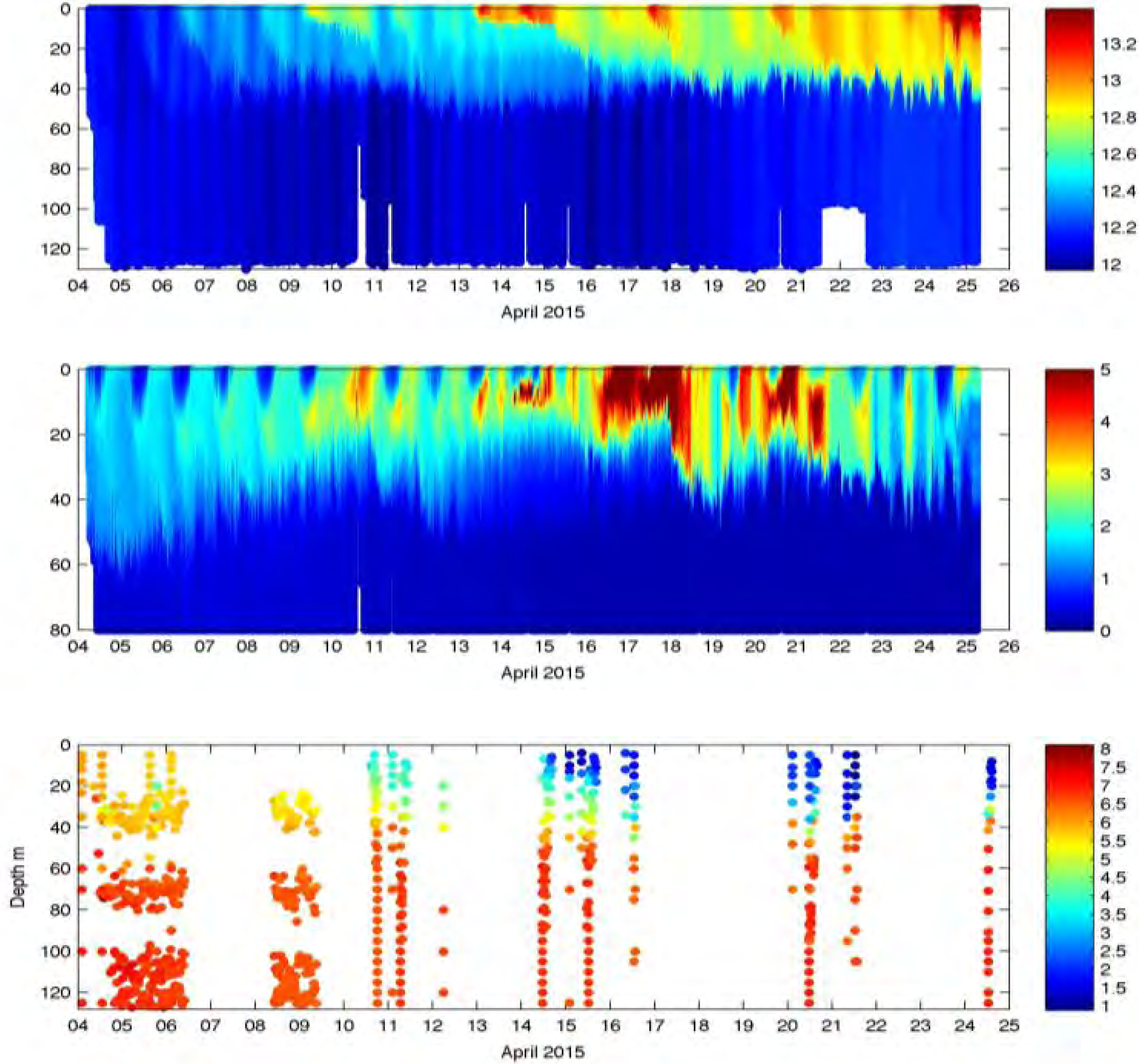


Alex Vincent & Maeve Lohan, NOC / SOES (U. Soton)

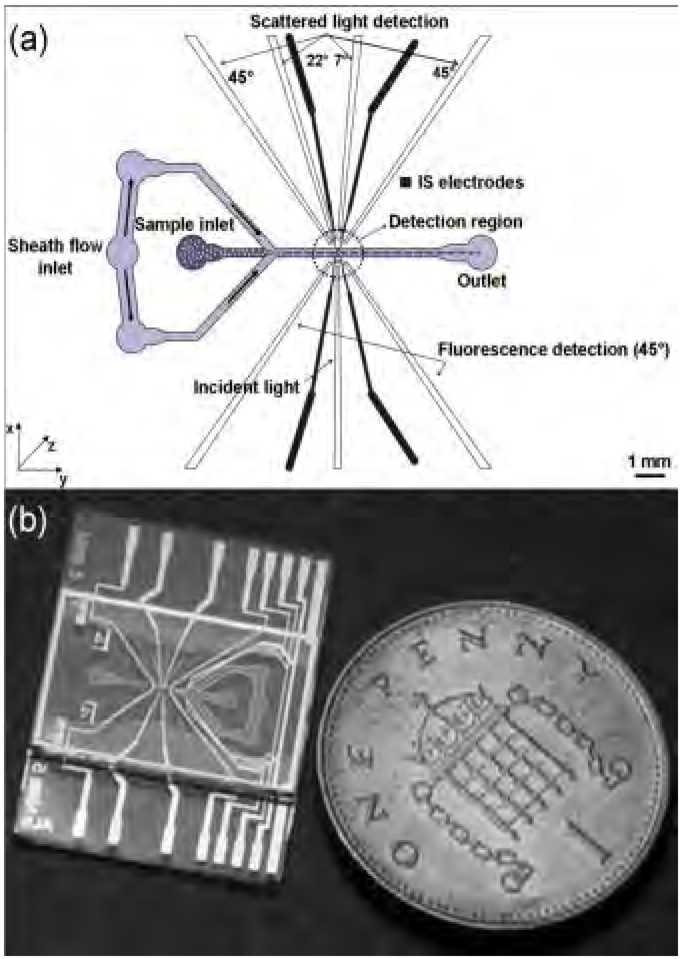
Temperature (°C)

Chlorophyll (mg/m³)

Nitrate (µM)

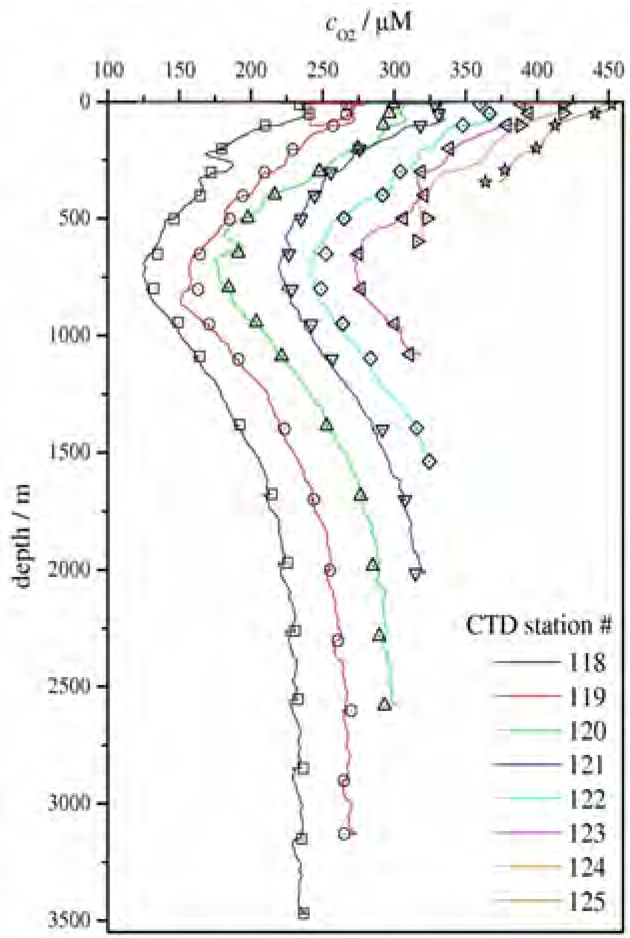


Cytometer



- Simultaneous measurement of electrical (impedance) and optical properties of individual cells
- In-lab prototype
- No air required for optics or operation (suitable for deep sea)
- Challenges include sample concentration, and optical detection limits (power in chip)

CT-DO Sensor



c_{O2} / μM
100
150
200
250
300
350
400
450
depth / m
0
500
1000
1500
2000
2500
3000
3500
CTD station #
118
119
120
121
122
123
124
125

S

Acknowledgements

Work by current and past members of OTEG & MARS

Group head: Matt Mowlem

Subgroup heads:
Robin Pascal (Multidisciplinary)
Socratis Loucaides (Analytical science)
Chris Cardwell (Electronics & Software)
Kevin Saw (Mechanical)

NERC SCIENCE OF THE ENVIRONMENT

School of Ocean & Earth Sciences (Southampton)

Plymouth Marine Laboratory

Scottish Marine Institute

Photos from Dave Owsianka, Alex Beaton, Martin Arundell and others

Some OECD Perspectives on Evaluation

Claire Jolly
Head, OECD Space Forum / Ocean Economy Group
Directorate for Science, Technology and Innovation
Organisation for Economic Co-operation and Development

OECD Ocean Economy Group / AtlantOS project
Workshop: Exploring the Economic Potential of Data from Ocean Observatories
27 - 28 June 2016, Kiel, Germany

BETTER POLICIES FOR BETTER LIVES

Background

OECD's recently published flagship report on *The Ocean Economy in 2030*

- provides an original forward-looking assessment of the ocean economy to 2030 and beyond.
- places particular emphasis on the development potential of established and emerging ocean-based industries,
- as well as on the implications for the ocean environment and ocean management.

There are growing demands on evaluation of Science & Technology in every domain

- Demand for evaluation increasing as a tool for priority setting and decision making.

- … and evolving from evaluating the quality of research (via peer review)
  - To assessing the outcomes, outputs and impacts of public R&D
  - To Increasing interest in evaluating entire research systems, research portfolios and infrastructure

Evaluation capacity remains weak and fragmented in most countries

- Evaluation functionally fragmented (basic/applied);
- Role of outside evaluators
- Importance of standards for evaluation (Handbook)
- Role of self-evaluation
- Establishing follow-up process and consequences
- Role of stakeholders outside research establishment (e.g. in peer review committees)

Evaluation can no longer be done solely in relation to the national situation…

… but must be done in the light of international comparisons

- The use of international comparisons in policy analysis is increasing
- The evaluation of public policies, especially in those areas where countries are competing, cannot be done without reference to international benchmarks.

Impact assessment is part of evaluation but the rationale for impact assessment is expanding

- Impact assessment is more than measuring success in meeting past objectives

- About determining where, who and how much to fund research and anticipate what society gets in return.

- An impact analysis should help determine both the economic effects of public investment in R&D as well as the social impacts (e.g. better health outcomes).

Measuring impacts is neither straightforward…

- …nor an easy task especially as regards demonstrating causality

- Many of the dimensions through which S&T impact upon society (e.g. societal, cultural or environmental impacts)
  - are not easily captured by existing national statistical frameworks,
  - they are less tangible and therefore difficult to measure or evaluate
  - and therefore difficult to link to policy interventions.

Evaluation of social / economic impacts requires the use of new metrics by the research community!

- But must ensure stakeholder involvement

- Also requires new communication channels (to decision makers, to agents, stakeholders)

- Balancing the tension between (scientific) relevance and social /economic impacts

Choice of methodology is not universal but context specific (1/2)

The selection of specific metrics for an economic impact study is determined by the following factors:

- objectives of the study
- the timing of the exercise (ex ante and/or ex post)
- nature of (expected, known) benefits and costs
- available assessment expertise
- resources provided for the study
- quality of primary data sources (both benefits and costs)

Choice of methodology is not universal but context specific (2/2)

- Reviews by OECD/STI found:
  - *Bottom-up approaches* may be favoured, when the subject of the assessment is a research programme and/or institution that aims at developing a specific type of technology with a clear industrial focus;
  - *Top-down approaches*, especially econometric and mathematical models (e.g. general equilibrium), better suited to assess impacts affecting the whole research system and dealing with all types of research (basic and applied) in particular to assess systemic impacts *ex ante*.

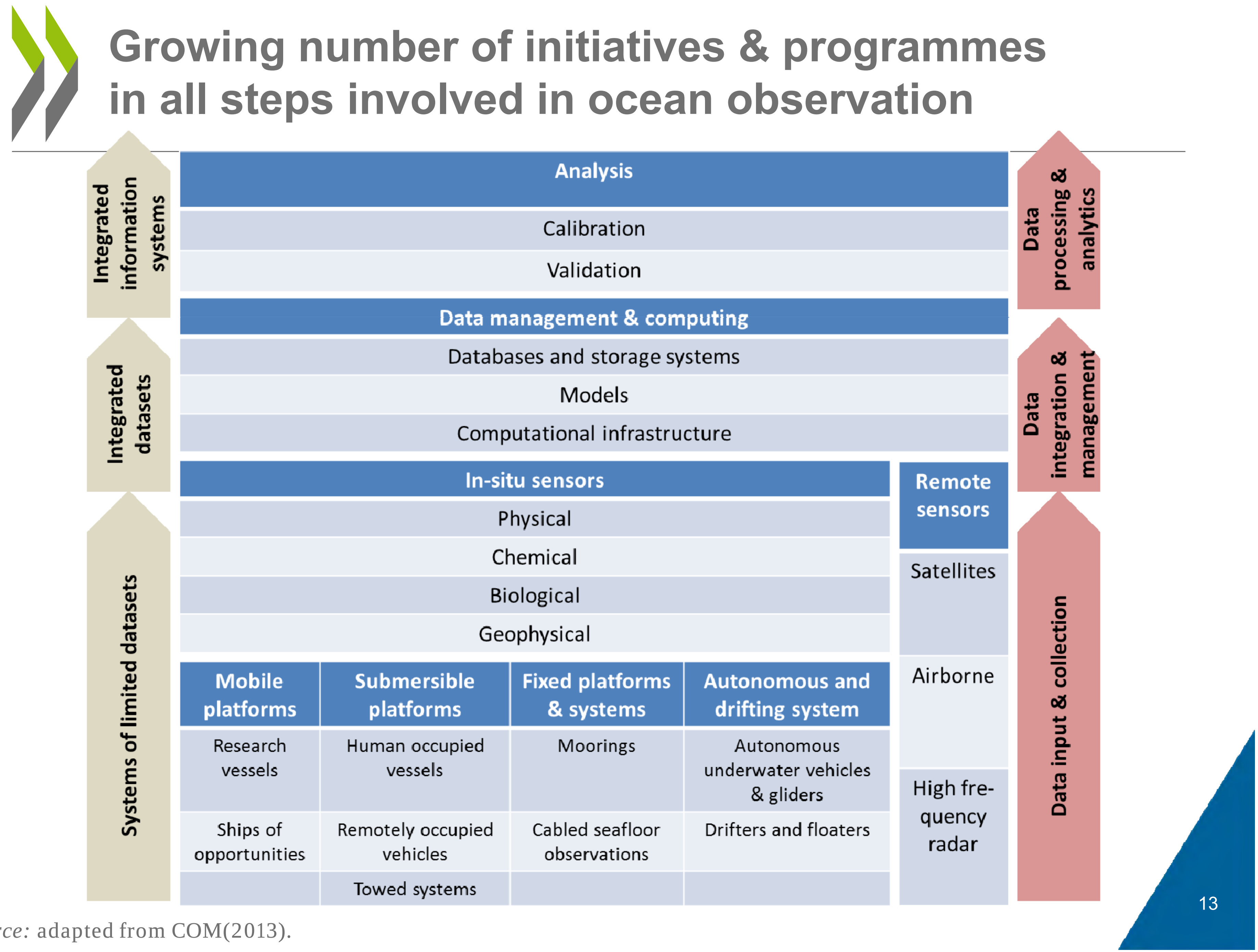
Tool-Box for evaluation of space programmes: selected methods

R&D PROGRAMMES OUTPUTS	
Scientific returns	Quantifiable measure of publications
"CLASSIC" RETURN ON INVESTMENT TECHNIQUES	
Key performance indicators	Quantifiable performance measures
Cost-benefit analysis (CBA)	Measures tangible and intangible benefits and assesses these against costs
Break-even analysis	The amount of time necessary for benefits to equal costs
Transaction costs	Segmentation methods to calculate use and benefits to different user groups
Cost-effectiveness	Marginal costs for achieving specific goals
Net present value	The difference between the present value of cash inflows and outflows at a given discount rate
Initial rate of return	The discount rate that makes net present value of all cash flows equal to zero
Value assessment	A complex method that captures and measures factors unaccounted for in traditional return on investment (ROI) calculations
Portfolio analysis	A complex method that quantifies aggregate risks relative to expected returns for a portfolio of initiatives
Real options analysis	Analysis of capital investments in terms of the options they contain, with uncertainty accounted for by risk-adjusting probabilities ("equivalent martingale approach")

New practices being developed / refined to assess impacts…

… but methodological issues remain as does the issue of the (international) comparability

- Some of the most promising and forward-looking practices include:
  - general equilibrium models, econometric analyses, data linkages and scientometrics methods, survey-based indicators combined with econometric analyses and STILL case studies.
- Various methodologies are still evolving but…
  - until now, none of the available techniques has been able to capture the full range of impacts of public R&D on society
  - although they have opened new and encouraging lines of investigation.



Source: adapted from COM(2013).

Growing number of initiatives & programs contribute to data input and data collection..

Growing number of initiatives and programmes worldwide :

Autonomous and drifting systems:

- *OceanSITES*, the *Argo Network*, *European Gliding Observatories Network*, …

Fixed platforms and systems:

- *Data Buoy Cooperation Panel*, *Global Sea Level Network*, …

Submersible platforms:

- *Autonomous Ocean Sampling Networks*, …

Mobile platforms:

- *Ship Observations Team (SOT)*, *Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP)*, *International Ocean Carbon Coordination Project (IOCCP)*, …

Remote sensors:

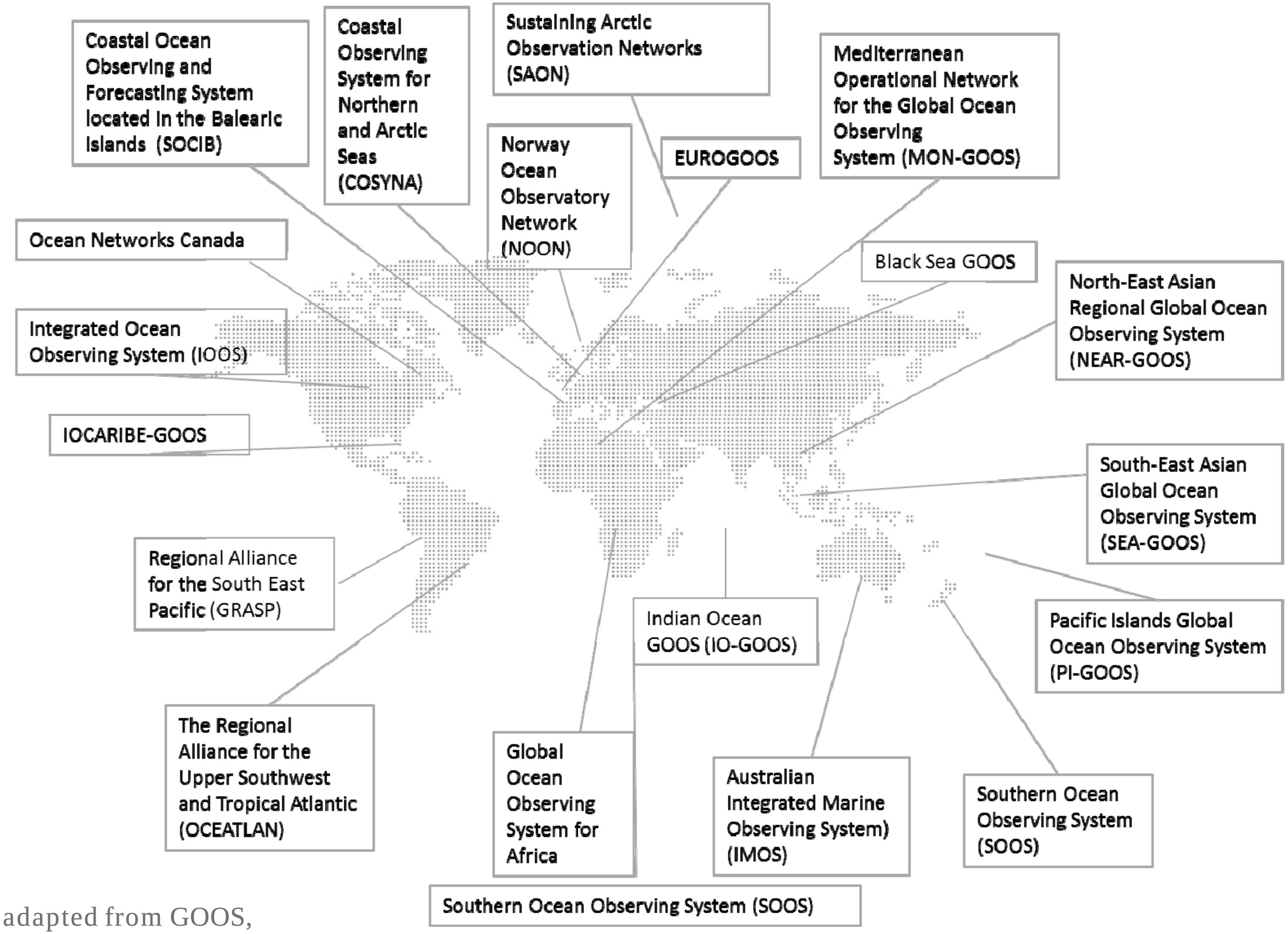
- *Group for High-Resolution Sea Surface Temperature…*

.. demand for intensified data integration and data processing,…

Patchy landscape due to collection and processing of individual datasets and in some cases limited number of indicators

Tendency towards improved coordination
(e.g. European Marine Data Observation Network (EMODnet), SeaDataNet, Water Information System for Europe, …

… for the growing network of integrated information systems worldwide



Source: adapted from GOOS, various sources.

What do we mean by ocean observation?

- Many purposes for ocean observation, e.g.:
  - Monitor environmental changes of the marine ecosystems
  - Improving marine spatial planning / ocean management
  - Generating data for applications for wider economy (weather forecast...)

- Many activities involved in ocean observation (research programmes, physical platforms, information systems...)

➢ **And what are trying to measure?**

Socio-economic impact studies on ocean observation vary widely

Wide range of more than 30 economic impact studies of ocean observation, but they are differ in:

- **Objectives** (prove expenditure, investment, find maximum level of expenditure,...)
- **Funder of study**
- **Overall approach** (sector-specific vs. wider public good, micro vs. macro analysis...)
- **Geographical** scope
- **Methods** (Cash-flow NPV, Cost-Benefit Analysis, One-sided analysis (only benefits or only costs)...)
- **Time-scale** of return (5 years, 30 years...)

-> Results can hardly be compared

-> Benefits of different studies can’t be aggregated

Classifying impact studies by socio-economic beneficiaries / end-users?

Separating studies by different socio-economic beneficiaries (Flemming 2012, EuroGOOS scoping report):

1. Most of studies focus on market-driven efficiency information (benefits to user),
2. Few studies focus on improved environmental management,
3. Few studies focus on environmental and welfare issues, improved regulations, non-market values and public good benefits
4. Few studies that focuses on planetary public goods, improving the management, mitigation, and adaptation of environmental change and climate; global environmental policy on the grand scale

Classifying impact studies by socio-economic beneficiaries / end-users?

- Different beneficiaries require different types of evaluation, or mixtures of techniques.

- May be useful to create categories of users / beneficiaries? But it requires mapping in details…

The need to move forward…

- More pressure to come with demands for more evaluation / impact assessment
- It remains key to maintain the effort in building **internationally** the **knowledge base** to provide:
  - Know-how and valid experiences to practitioners (avoiding reinventing the wheel)
  - **Evidence-based** information to **decision-makers and citizens** on benefits (and limitations) of ocean observations

An overview of the expected economic benefits of ocean observations

Ralph Rayner

LSE
THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

My background

- London School of Economics
- US Integrated Ocean Observing System
- Association of Marine Scientific Industries
- IMarEST Operational Oceanography Special Interest Group
- Journal of Operational Oceanography, SUT/MTS/Underwater Systems Design
- GOOS and GOOS advocacy
- Various ocean science and technology businesses

Benefits

‘Benefit’

A helpful or good effect

Cambridge Dictionary

Economic benefit

Economic benefit has a narrower definition:

- Economic benefits are benefits that can be quantified in terms of money generated, such as net income, revenues etc. Can also be money saved when considering a policy to reduce costs.
- Can be expressed numerically as an amount of money that will be saved or generated as a result of an action.

Some other useful concepts

	Cost	Price	Value
Meaning	Cost is the amount spent in producing and/or maintaining something	Price is the amount paid for acquiring any product or service	Value is a measure of the benefit provided by a good or service
Ascertainment	Cost is ascertained from the producer's perspective	Price is ascertained from the consumer's perspective	Value is ascertained from the user's perspective
Estimation	Through Fact	Through Policy and what a user actually pays for a good or service	Through Opinion

‘Nowadays people know the price of everything and the value of nothing’

Oscar Wilde, The picture of Dorian Gray

Benefits of ocean observations

Benefit category	Benefits
PUBLIC GOOD BENEFITS	• Improved scientific understanding • Better understanding of the natural capital and ecosystem benefits of the oceans • Better understanding of the role of the oceans in the overall earth system and especially their role in weather and climate • Supporting the formulation of policy, monitoring of policy compliance and effectiveness associated with measures to protect the environment or regulate ocean uses • Educational benefits
PUBLIC GOOD AND COMMERCIAL BENEFITS	• Supporting safety and emergency response
COMMERCIAL BENEFITS	• Supporting protection of coastal communities • Underpinning the metocean information needs of commercial maritime activities and operations

The challenges of quantifying economic benefits

- Largest benefit areas are related to supply of public goods
- Many of the benefits are indirect (eg improved weather forecasts)
- Data and information are often used in multiple applications making assignment of value or cost benefit difficult (collect once use many times)
- Ocean data and information is rarely used in isolation - difficult to separate benefits of ocean data from benefits of other data (eg many insurance applications)

The challenges of quantifying economic benefits

Historically, sustained ocean observations have developed as a patchwork of research initiatives, policy/regulation driven monitoring and observations for specific operational/commercial needs

Only since 1990 and the establishment of the Global Ocean Observing System that the need for a sustained and integrated operational capacity supporting research and multiple socio-economic benefits has been formally recognized

Only much more recently that national components of GOOS have reached significant levels of maturity as integrated systems delivering sustained data and information services eg US IOOS, IMOS, Copernicus

Specific Use Benefit Studies

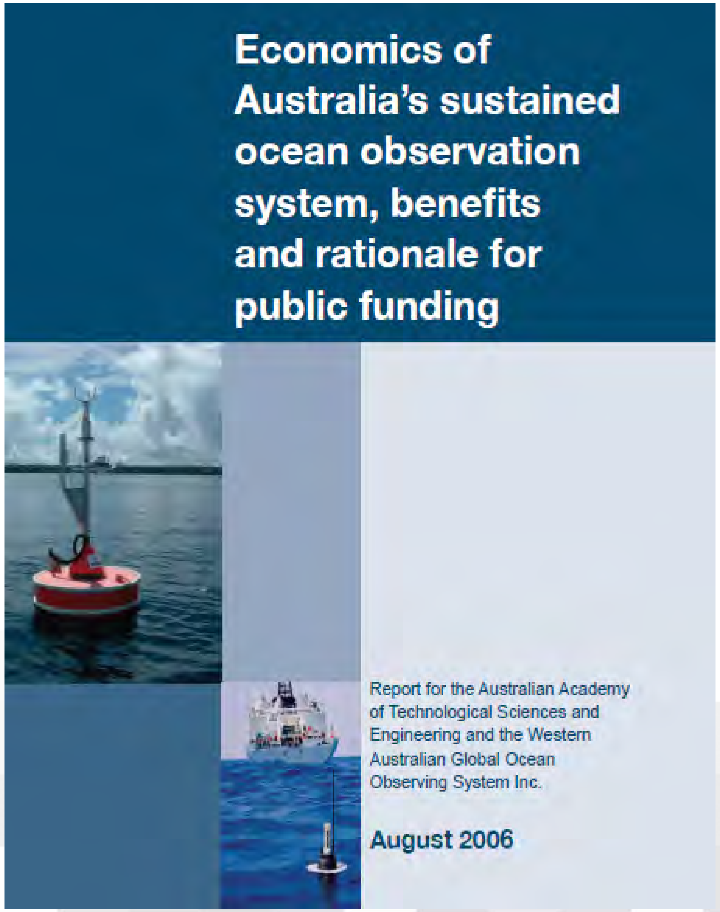
Most benefit analyses have been confined to case studies of specific benefits for direct applications (eg HABs and beach closures, Port observations and port operations)

Derived with widely differing methodologies and sometimes inconsistent results

Often locally specific

Difficult to aggregate and compare

National Benefit



There have been a small number of attempts to estimate the benefits of ocean observations at a national level and across a variety of end-uses (especially in agriculture through improved weather and seasonal forecasts)

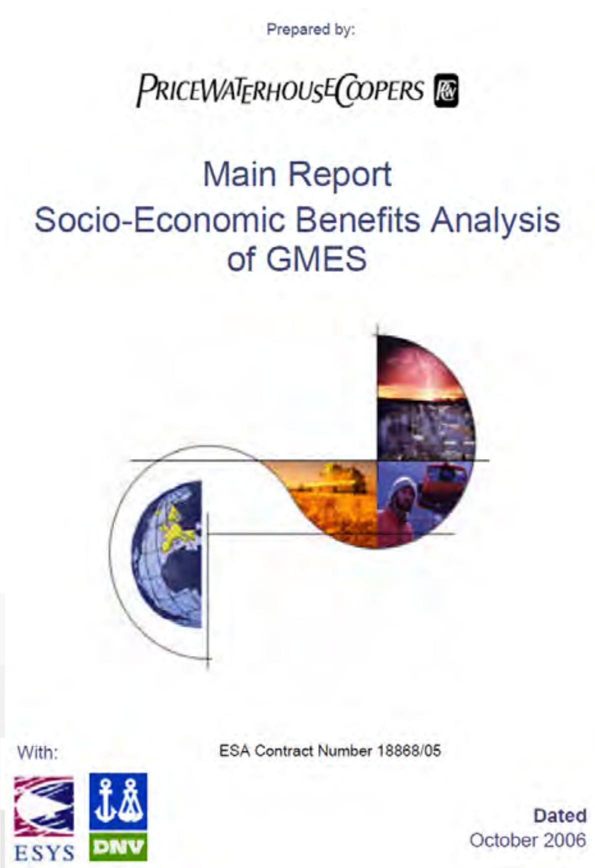
National Benefit

Agricultural productivity	$241 million
Flow-on benefits in the rest of the economy	$318 million
Oil production	$11 million
Iron ore production	$7 million
Fishing industry	$39 million
TOTAL ANNUAL BENEFIT	$616.9 million

Annual benefit	$616.9 million
Annual cost	$27.3 million
BENEFIT COST RATIO	22.6

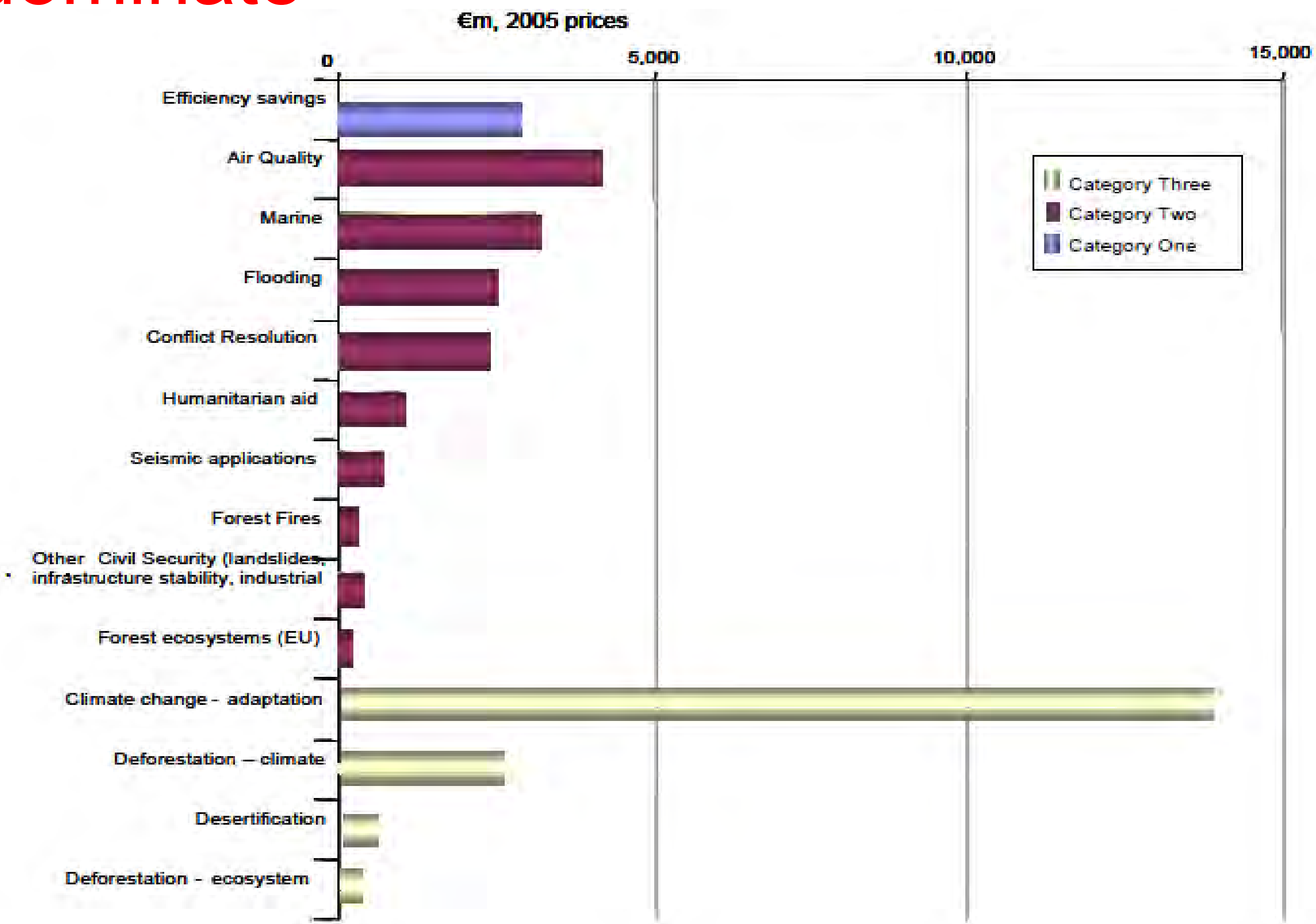
- These have been used to derive a benefit cost ratio that supports national investment in sustained observations
- Such studies make the assumption that the rest of the world is playing its part in delivering the overall global system within which the national system is embedded

Overall benefits of sustained environmental observations

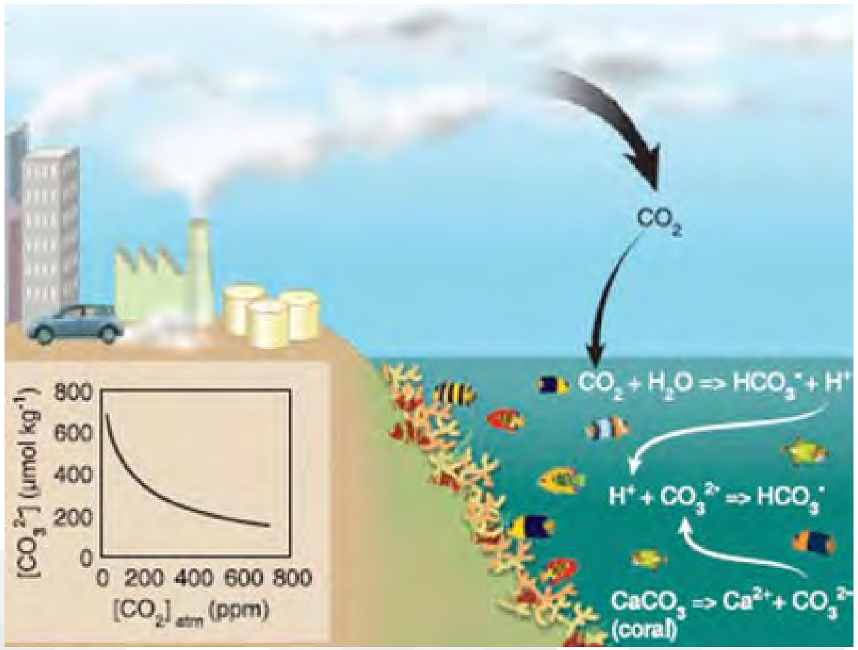


- Benefits of full GMES (now Copernicus) implementation estimated at up to €28B/annum
- Based on expert opinion
- Does not attempt to separate contributions from thematic areas
- So does not estimate contribution of ocean observations as distinct from all environmental observations

Climate change related benefits dominate



Oceans and Atmospheric Emissions



This becomes an even more important area given the outcomes of COP 21with regard to carbon neutrality:

Goal of emissions neutrality necessitates sustained monitoring of the oceans as a carbon sink and

Better understanding of consequences of carbon uptake, eg, for coral reefs (estimated benefit of $30B/year and feed feed about 1B people)

Systematic review of benefits of ocean observations

Proposal/Contract no.: 009876

SEPRISE

Sustained, Efficient Production of Required Information and Services within Europe

SIXTH FRAMEWORK PROGRAMME
PRIORITY 1.1.6.3
Global Change and Ecosystems

SEPRISE SOCIO-ECONOMIC ANALYSIS: SCOPING REPORT

SEPRISE WP4 Deliverables D4 & D5

N.C. Flemming

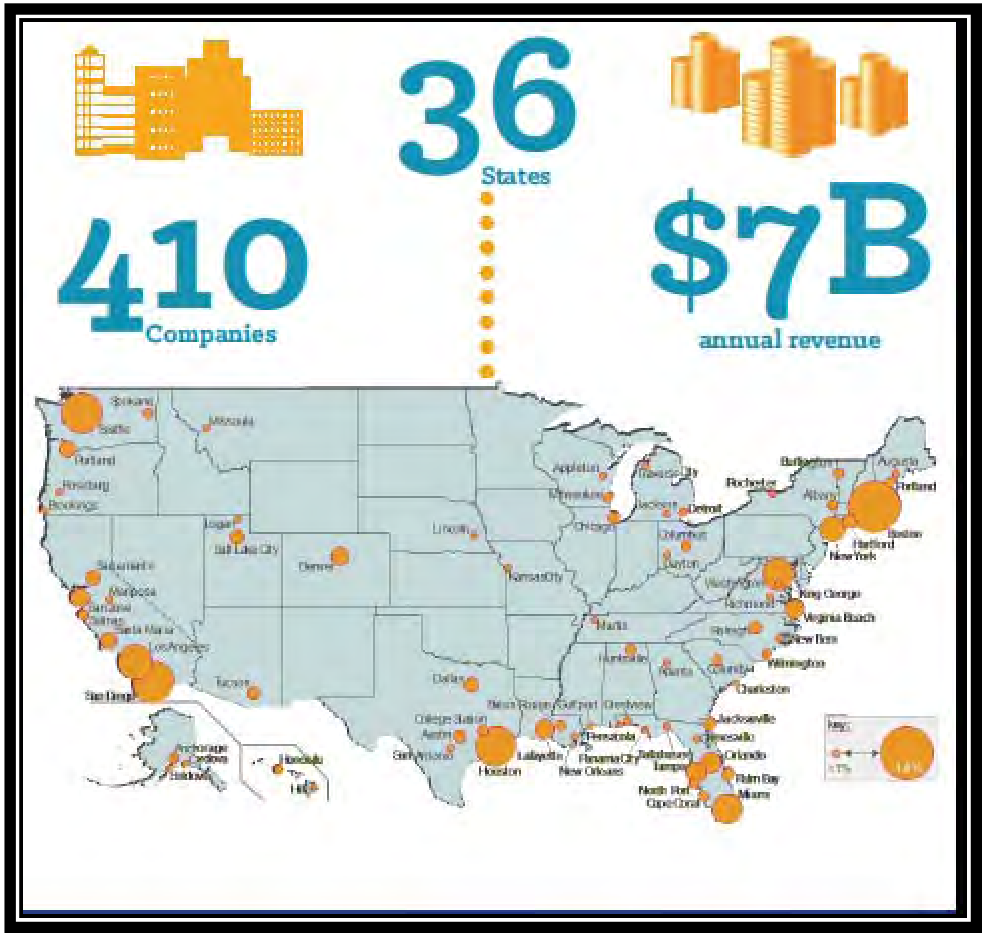
In 2012 a EuroGOOS scoping report identified the steps needed to produce a comprehensive and systematic high level socio-economic analysis for benefits of ocean observations to Europe

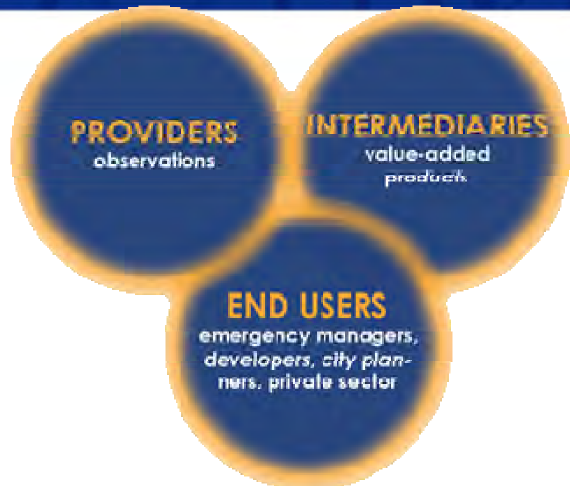
Recent studies – OECD Ocean Economy in 2030

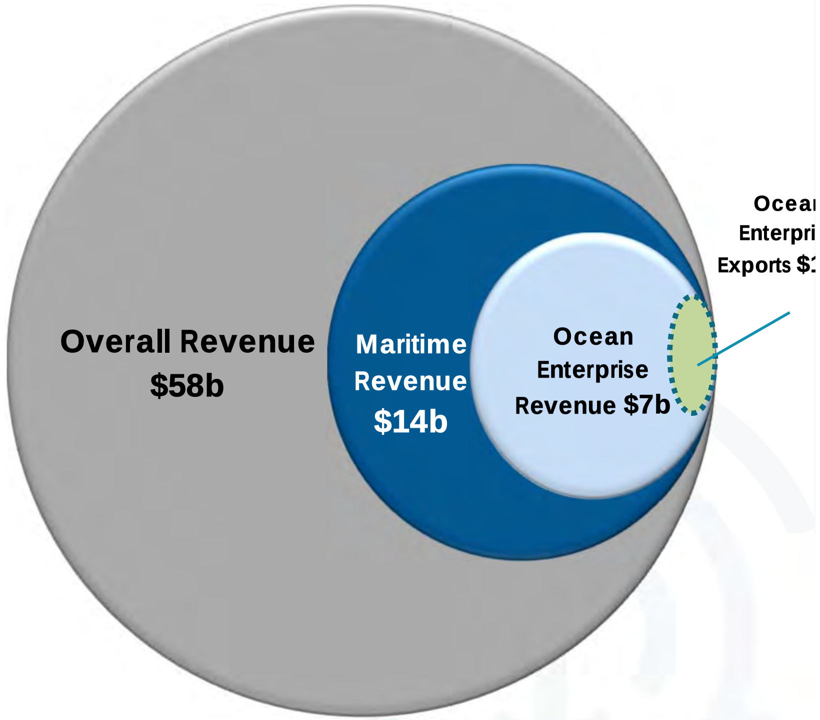
Ocean-based industries

Established		Emerging	
Capture fisheries	★	Marine aquaculture	★
Seafood processing		Deep- and ultra-deep water oil and gas	★★★
Shipping	★★	Offshore wind energy	★
Ports	★★	Ocean renewable energy	★
Shipbuilding and repair		Marine and seabed mining	★
Offshore oil and gas (shallow water)	★★	Maritime safety and surveillance	★
Marine manufacturing and construction		Marine biotechnology	
Maritime and coastal tourism	★	High-tech marine products and services	
Marine business services		Others	
Marine R&D and education	★		
Dredging	★		

US IOOS/NOAA Ocean Enterprise Study







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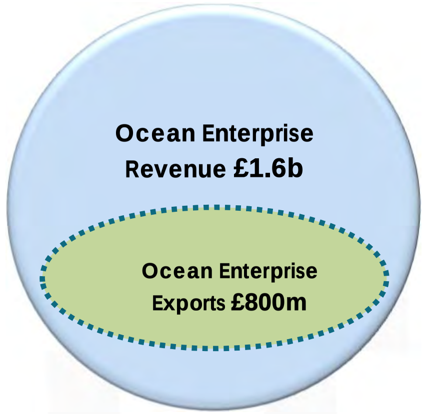
AMSI annual review of UK marine scientific industry, 2016

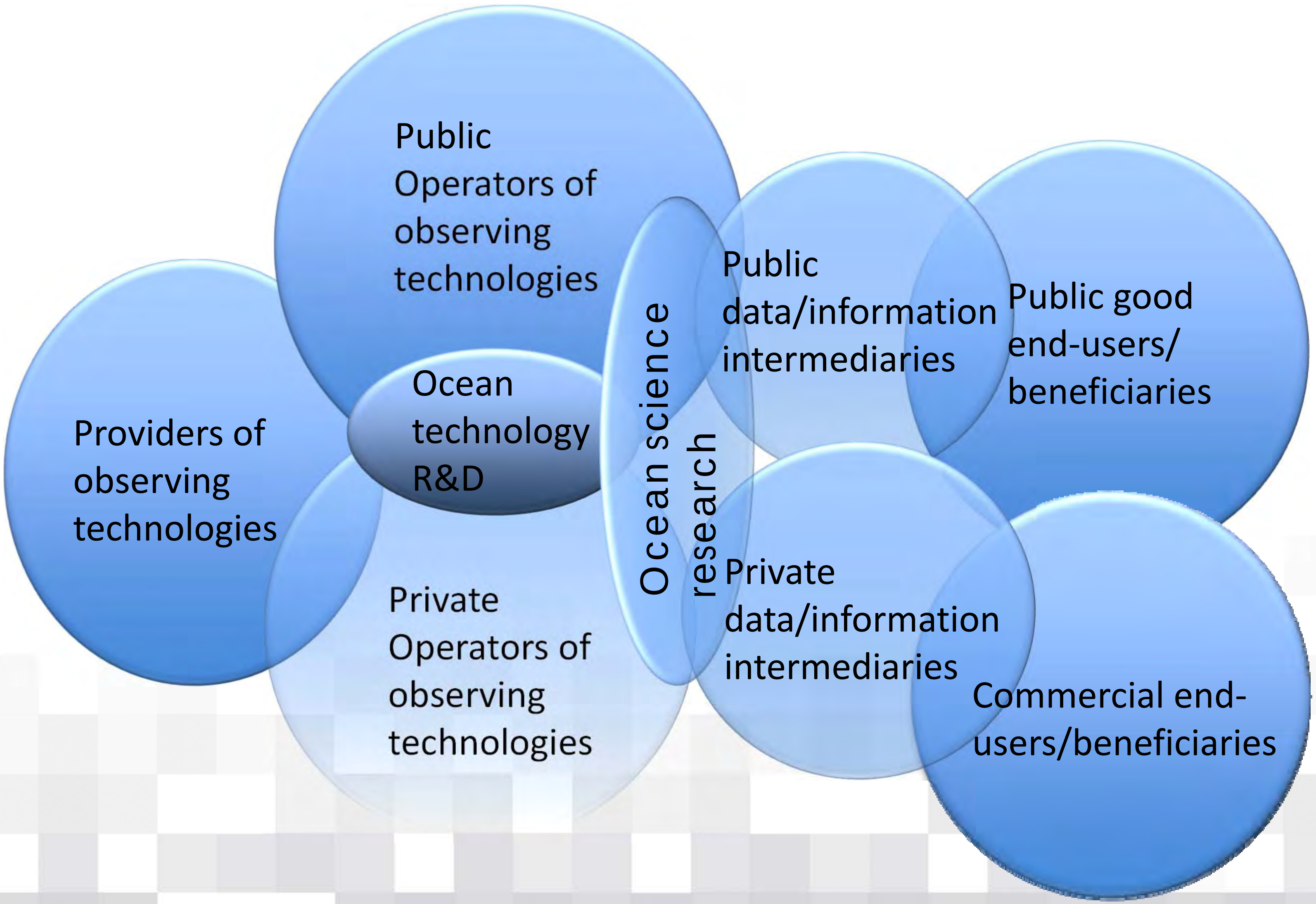
90
Companies

$2.4B
Annual revenue



Society of Maritime Industries

Joining the dots



Ocean Economics - NOAA & IOOS
The Ocean Enterprise and the NFL alike?!

Zdenka Willis
Director, US IOOS

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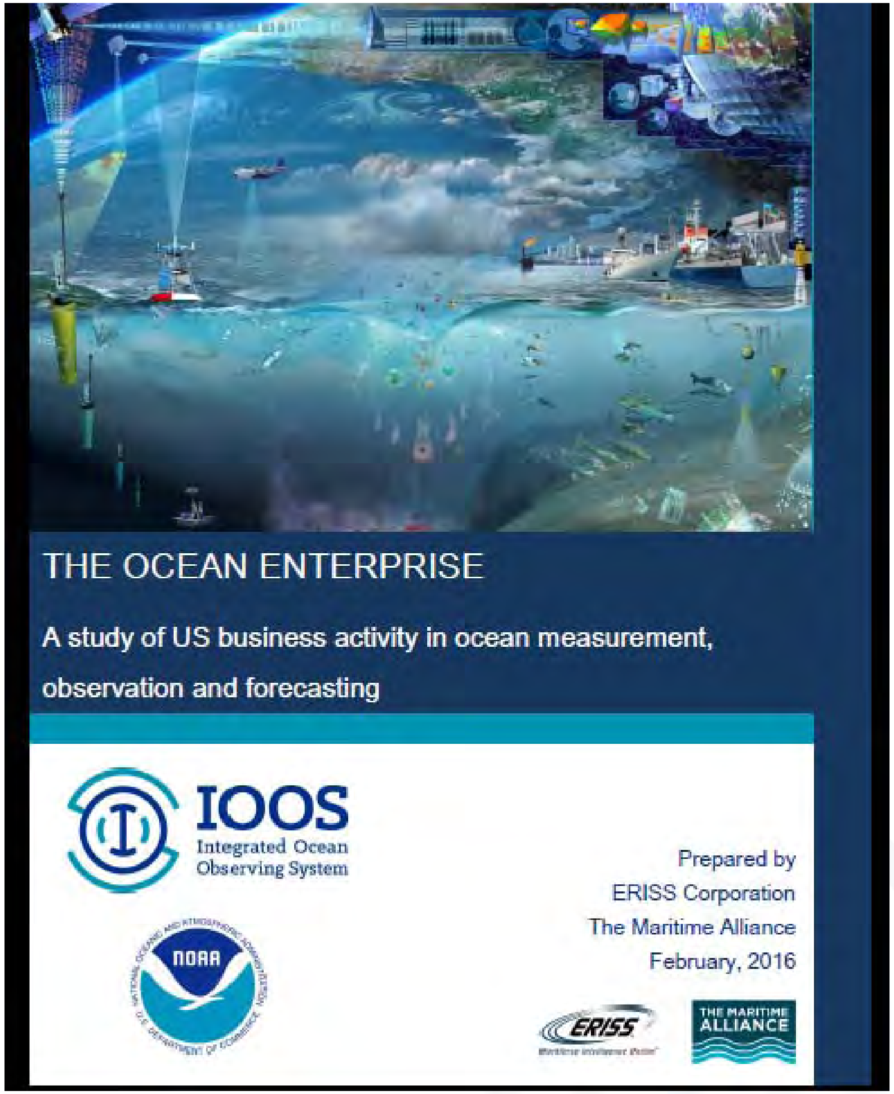
Background

Objective - Determine breadth & value of the US Ocean Observation Enterprise.

- Understand the scale and scope of business activity in ocean measurement, observation and forecasting.
- Studies have looked at “weather enterprise,” but no equal nationally for marine enterprise
- Raise visibility and awareness of the sector’s economic importance



Sponsored by NOAA’s National Ocean Service and US IOOS®.
Conducted by ERISS Corp and The Maritime Alliance

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The Ocean Enterprise

Study focus

Public, Private, Non-Profit, Research, Academia

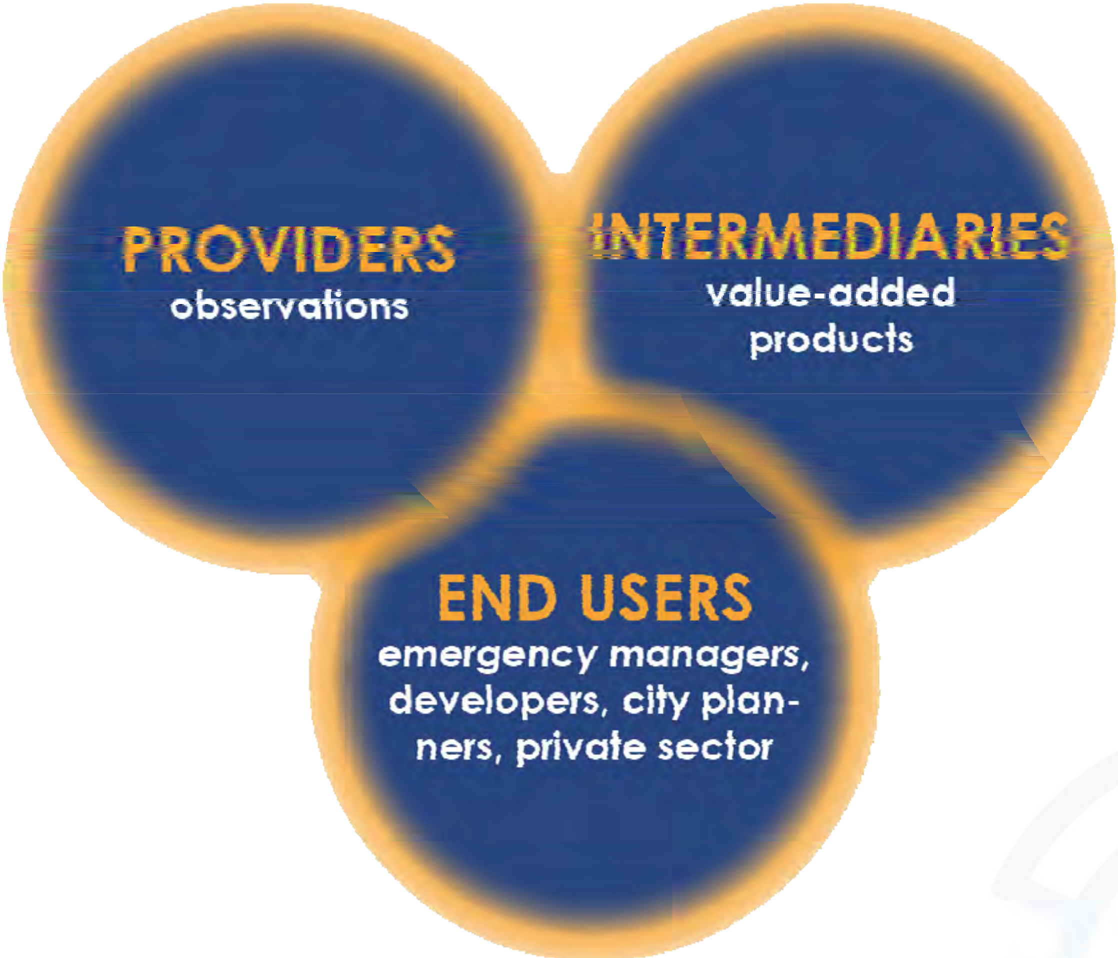
↓

Information, Services, Infrastructure

↓

ISSUES: Oceans – Ecosystems – Climate

Stakeholders



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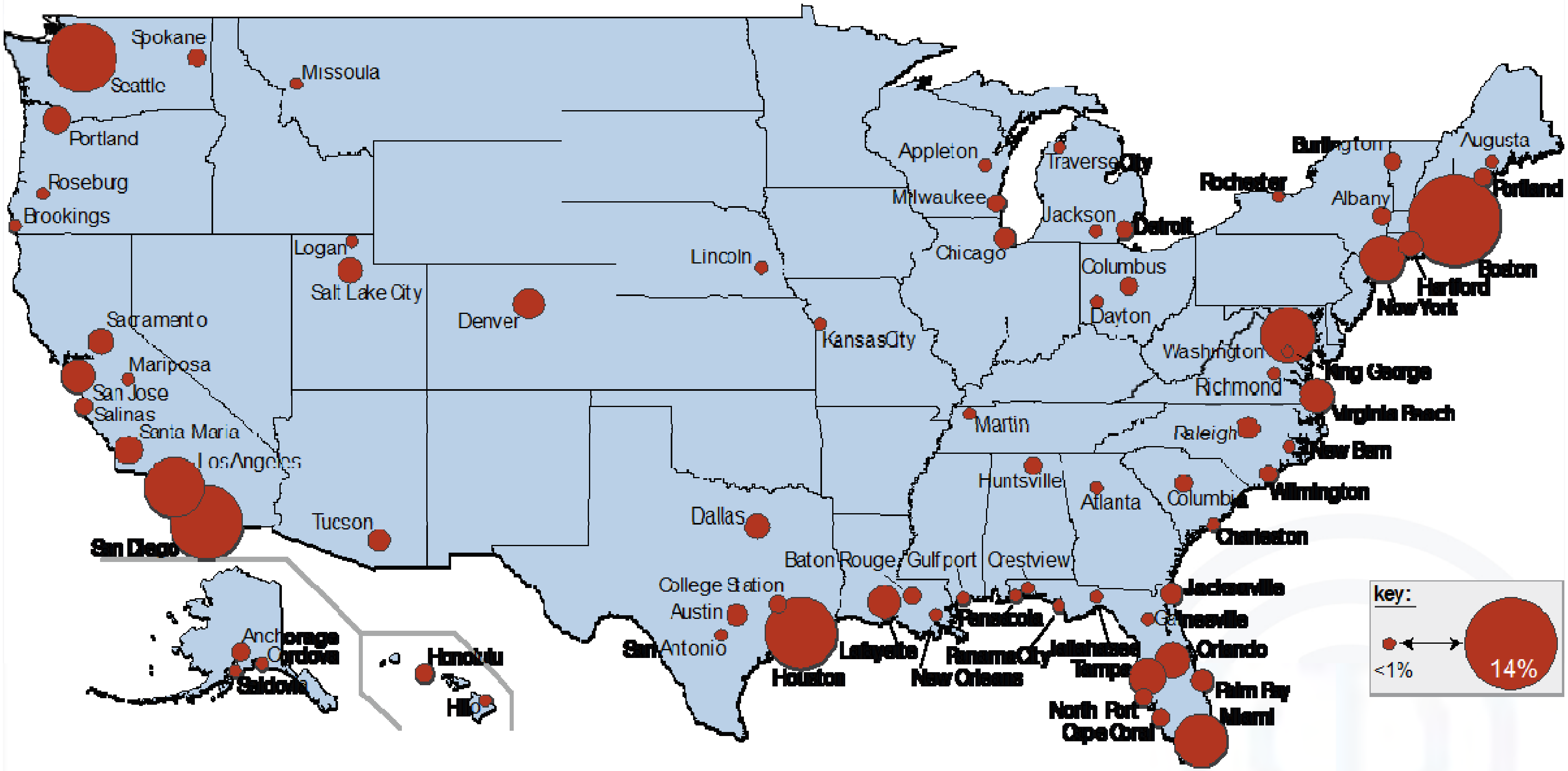
Ocean Enterprise Study: U.S. locations of companies

Total: 410 companies



Size of circles is relative to # of companies in a location. 14% = 14% of the companies in the survey are in *X* local area

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Ocean Enterprise Study 2015: Revenue

- Overall: Maritime & Ocean Enterprise
- $7B represents both providers and intermediaries
- $1.4B in exports from Ocean Enterprise

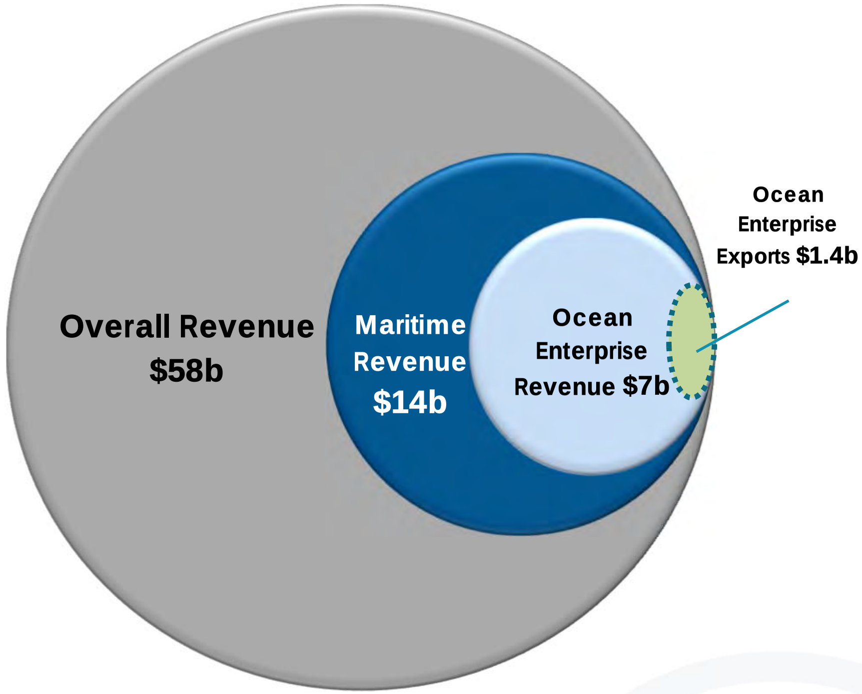
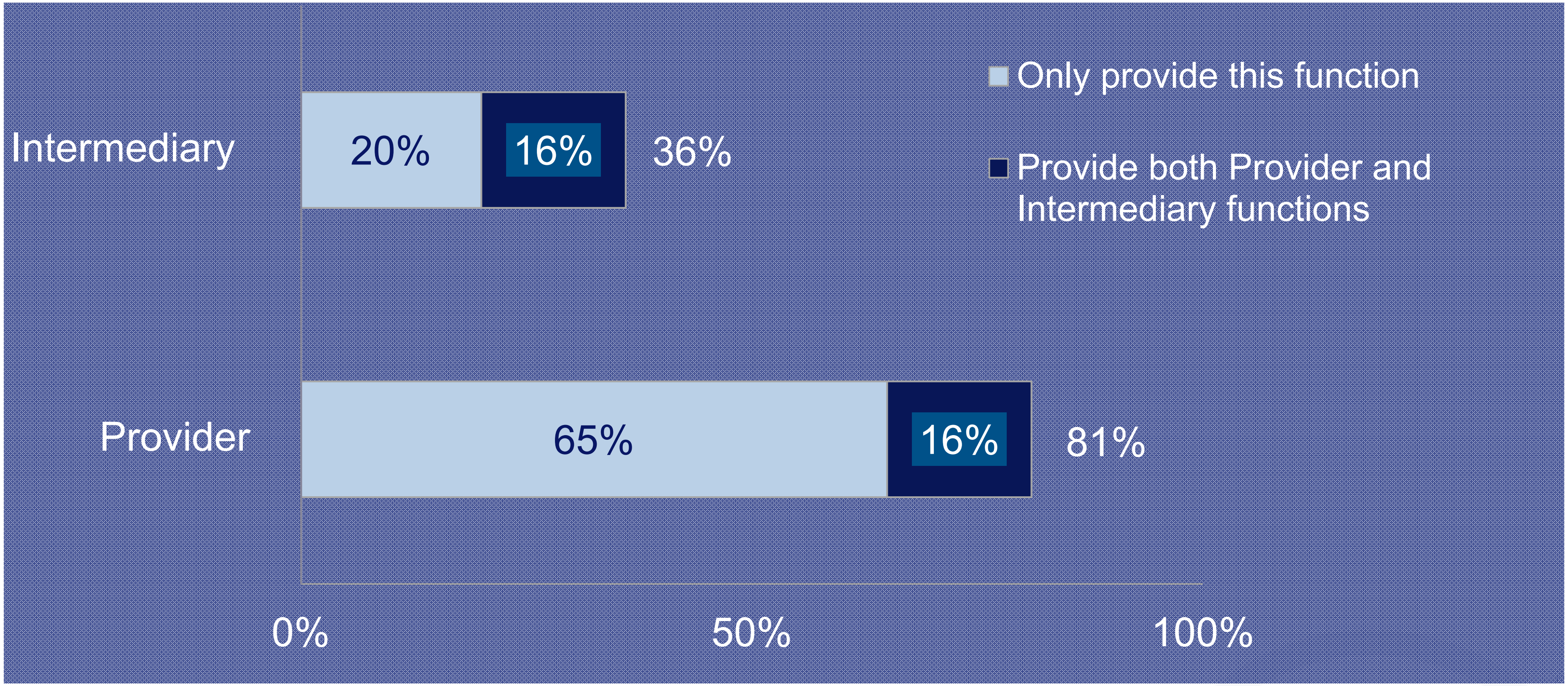


Figure ES- 3. Revenue projections

'overall' – is the total revenue of companies within study and "maritime' and 'ocean enterprise' are estimated components within that overall revenue.

Ocean Enterprise Study 2015: Functions



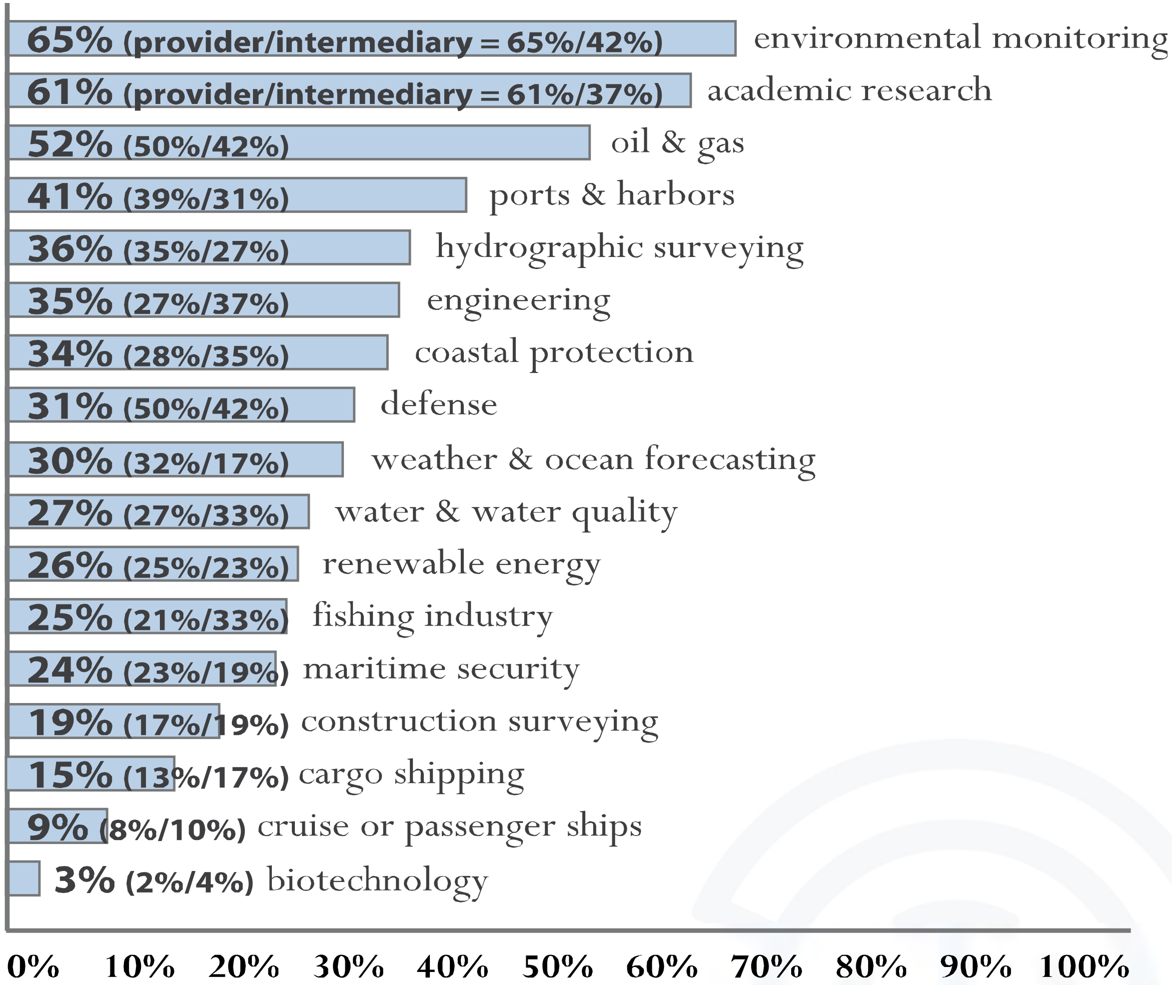
81 % of the companies we surveyed were providers

36% were Intermediaries

Market Sectors

Represents 'overall' activities of firms

Shows provider, intermediary split



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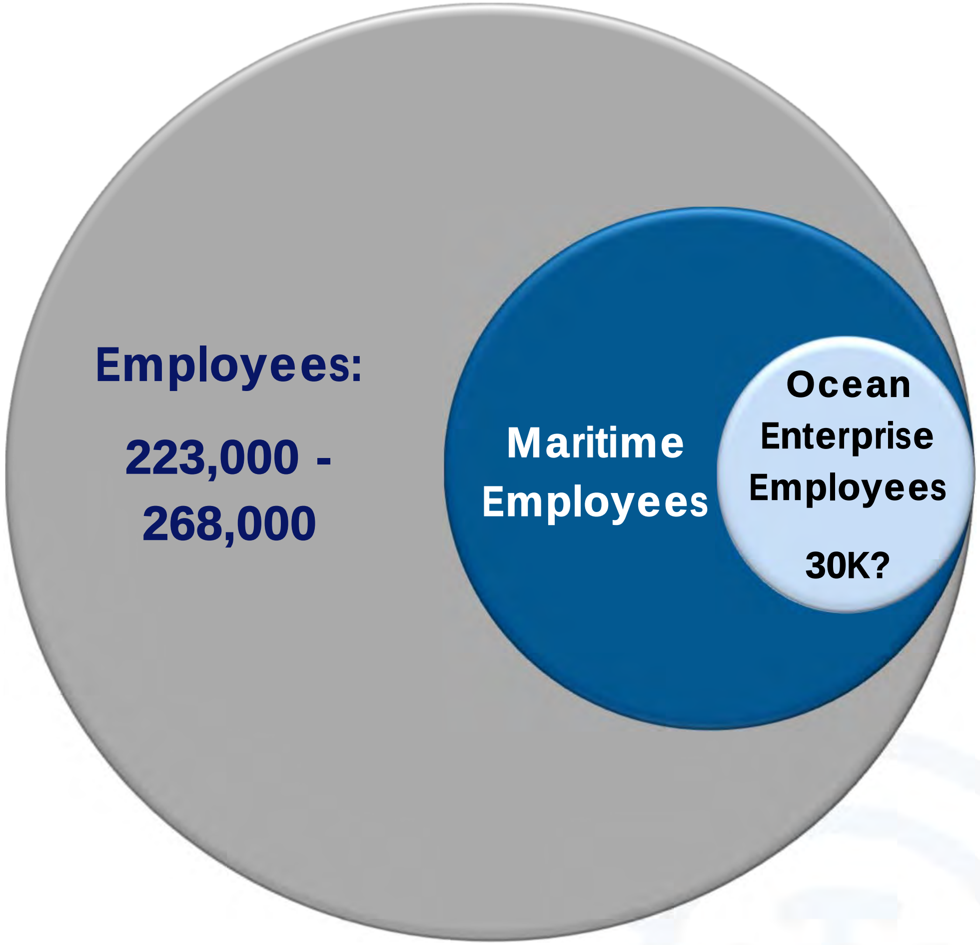
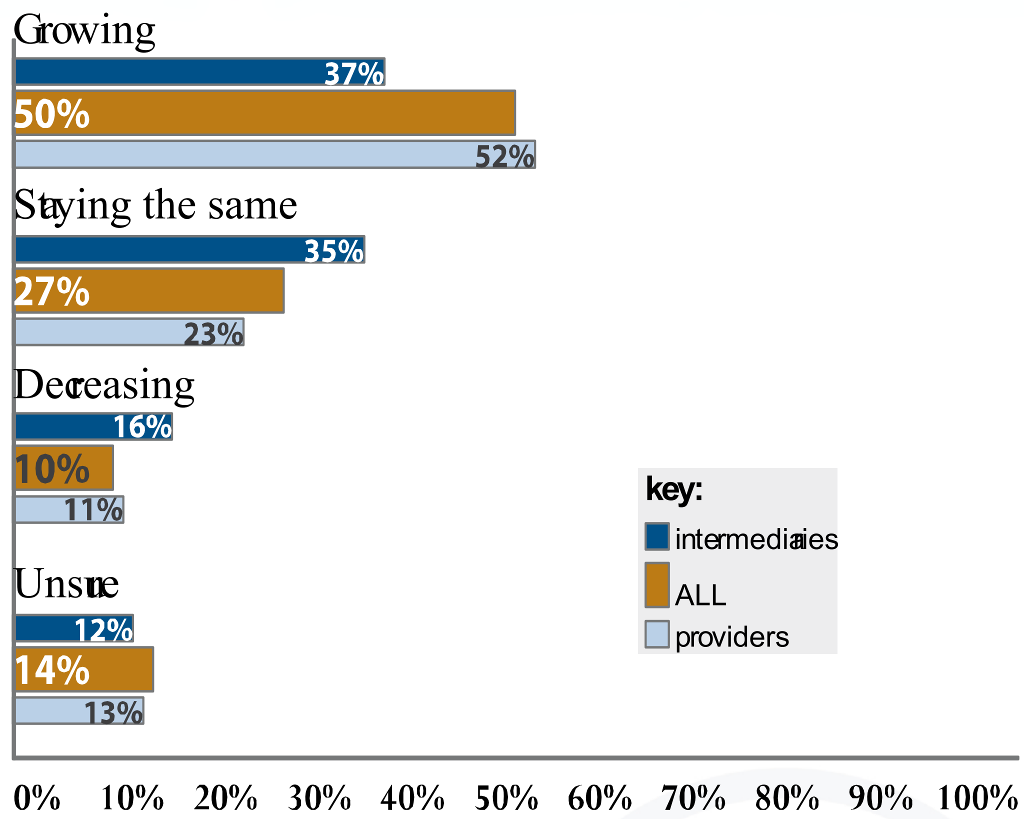
Ocean Enterprise Study 2015: Employment

- Overall Employment 223,000 – 268,000
- Don't have precise information for Maritime and Ocean Enterprise subsets.
- Ratios same as revenue: ~30,000 employees in Ocean Enterprise with ~$233K per employee



Business Outlook

- Generally optimistic
- Majority expect to grow
- Providers: anticipate growth
- Intermediaries: staying the same or uncertainty



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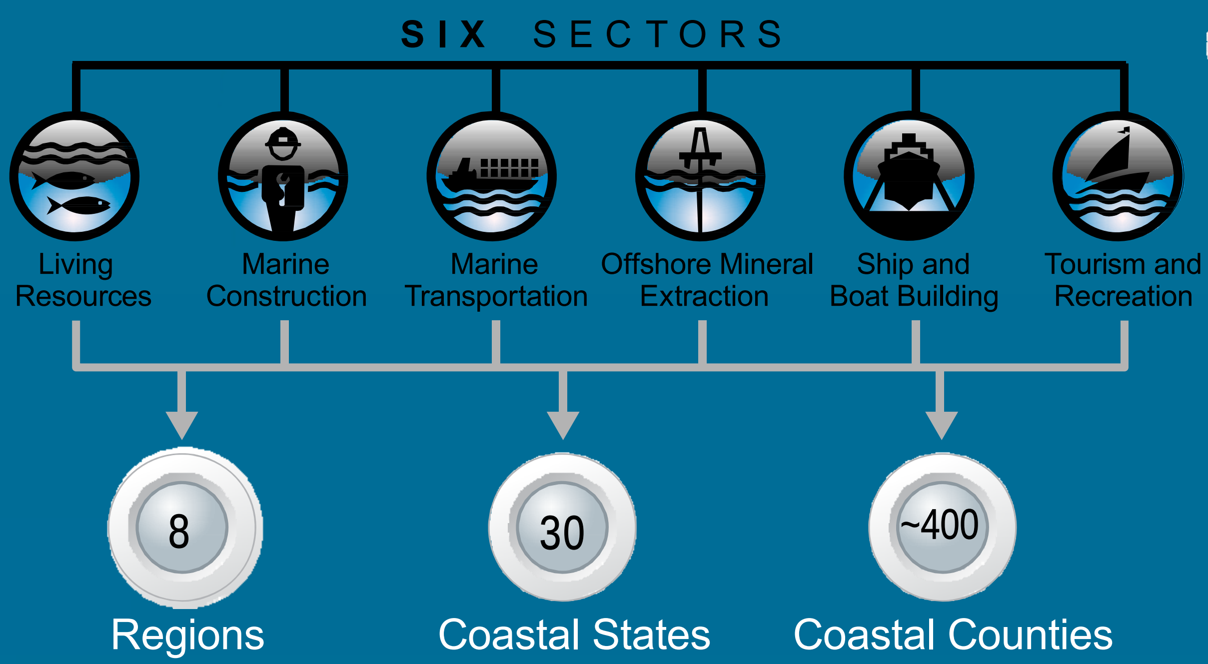
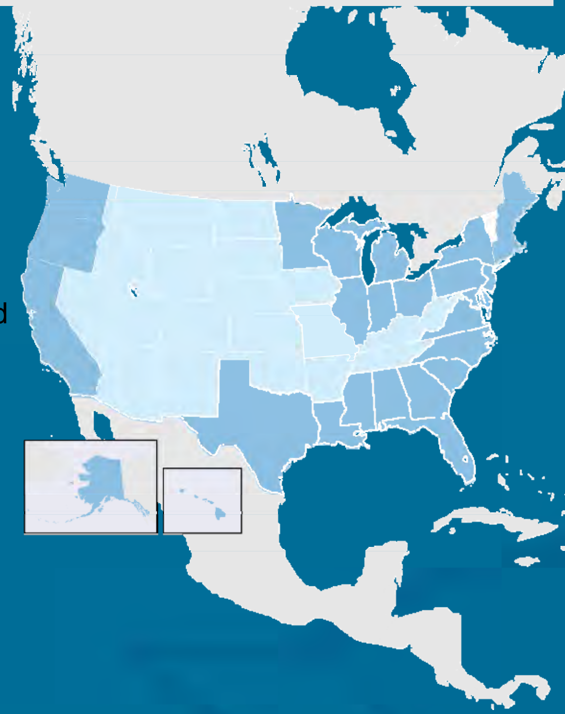
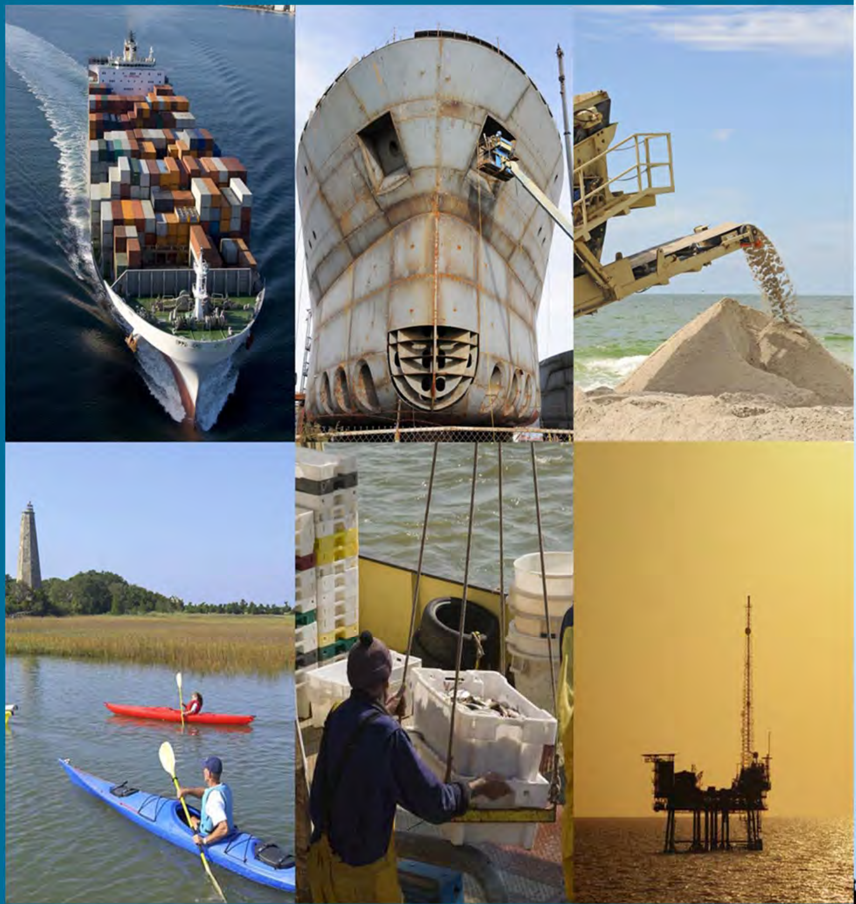
What is the Ocean Economy?

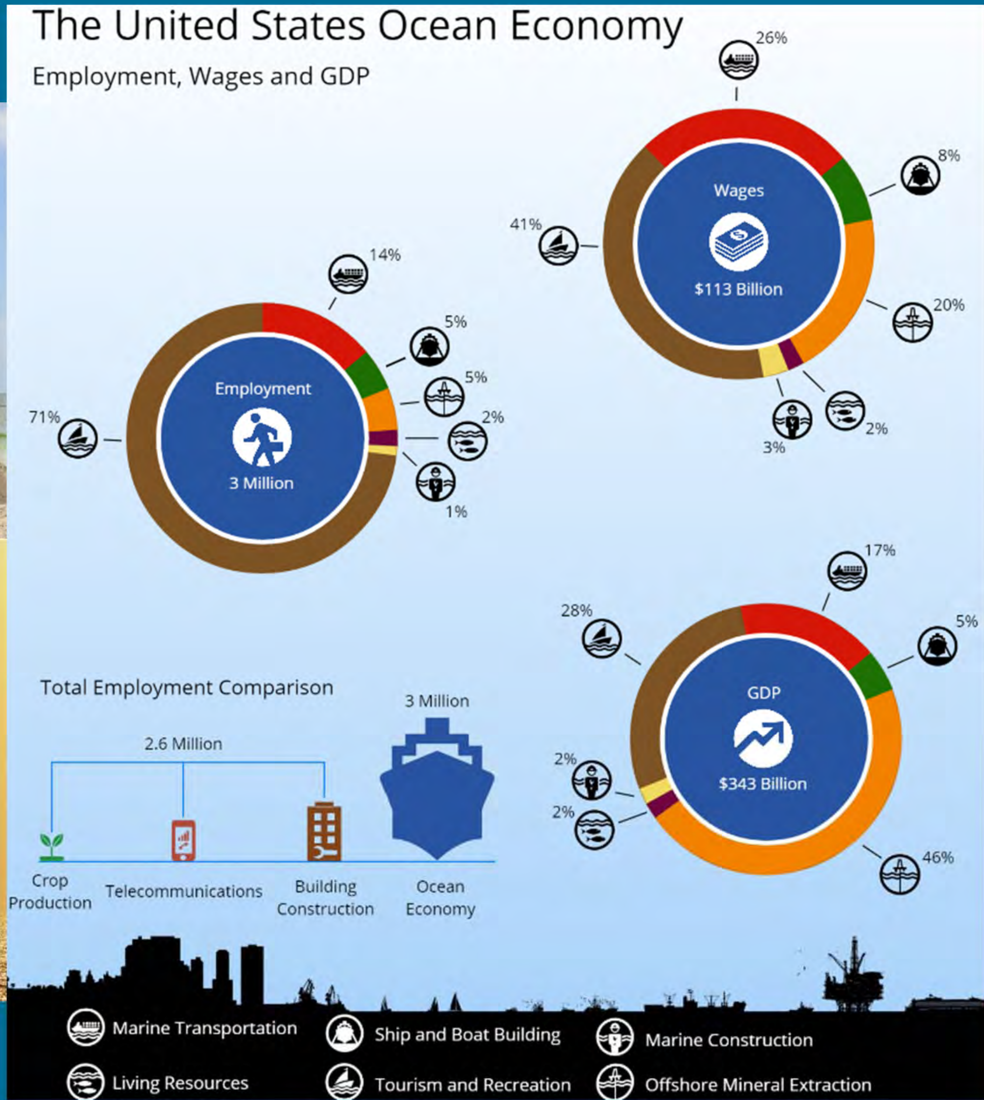




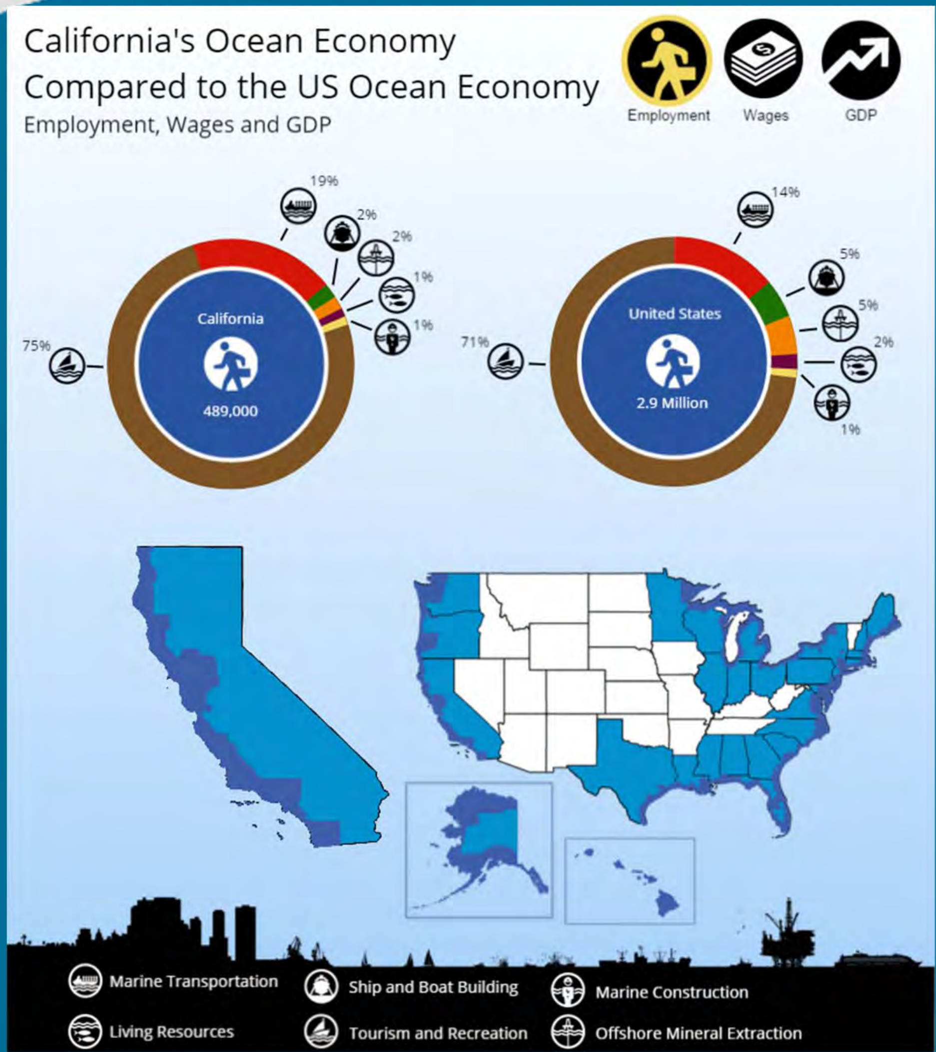
www.coast.noaa.gov/digitalcoast/data/enow

Measuring the Ocean Economy: ENOW





Connecting the Ocean and Natl Economy: Ocean Satellite Account



- Partnership between NOAA and BEA
- Makes the connection between ocean and inland economies
- Pilot focuses on 2 sectors in the State of California

- Econ 120 Video available: https://www.youtube.com/watch?v=ntglteLKjJ4

Questions

Enables decision making

Fosters Advances in Science and Technology

https://ioos.noaa.gov

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The Global Ocean Observing System
www.ioc-goos.org

The value of the Global Ocean Observing System

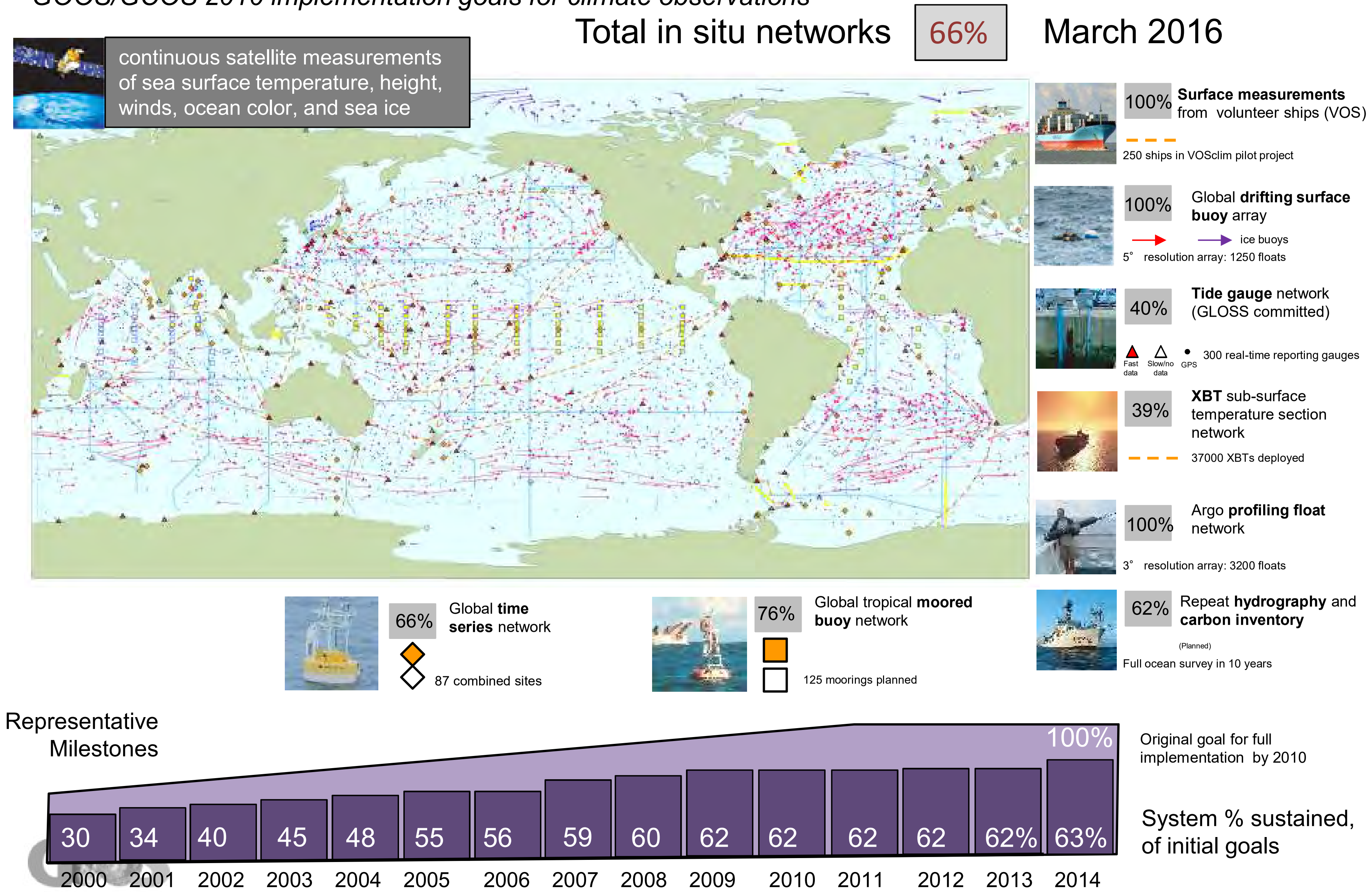
Albert Fischer
GOOS Office Director, IOC/UNESCO
a.fischer@unesco.org

OECD / AtlantOS workshop, 27 June 2016, Kiel, Germany

UNESCO IOC WMO UNEP ICSU

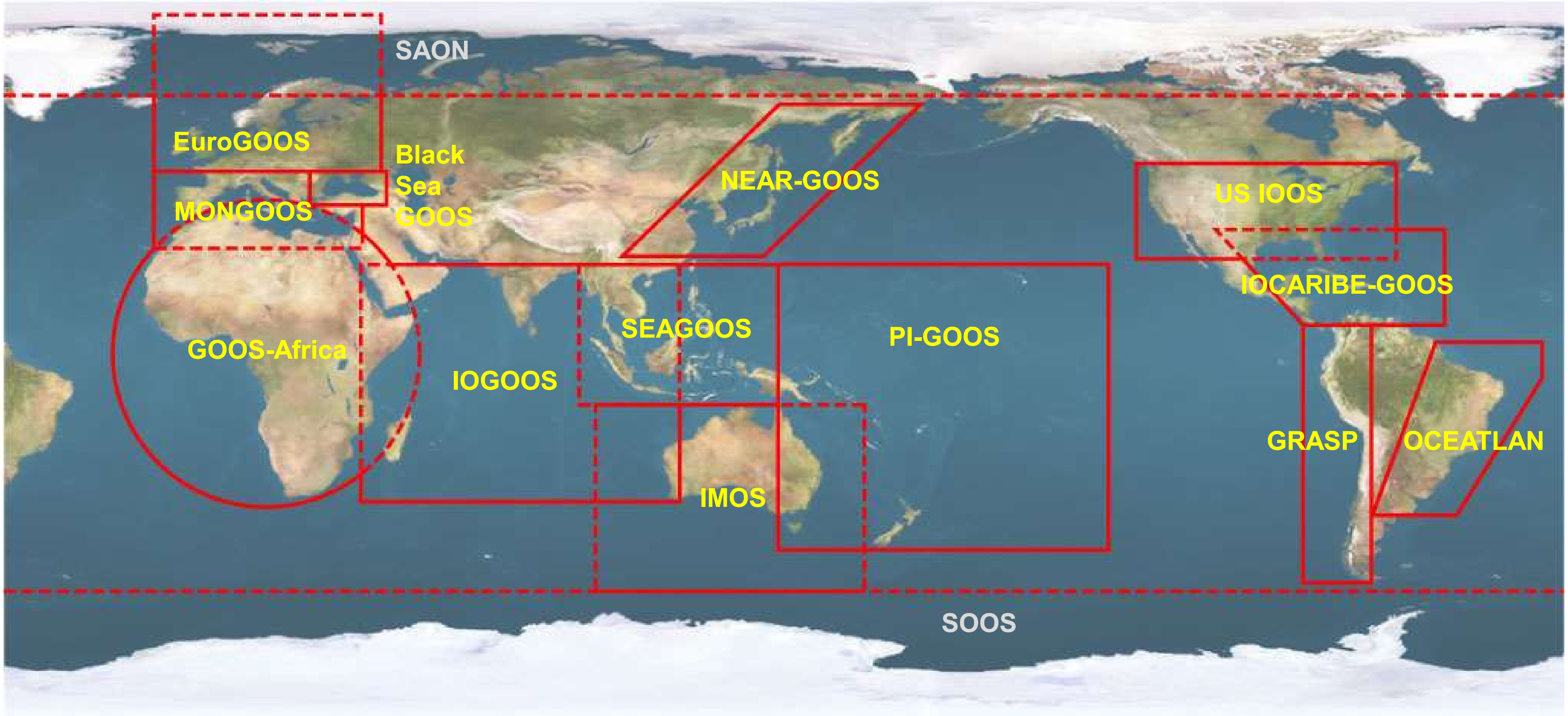
Global networks

GOOS/GCOS 2010 implementation goals for climate observations



Global approaches

GOOS Regional Alliances and collaborating regional observing systems



A global view

Data available from Regional Alliances and global-scale networks

EMODNET physics portal: GRA + GOOS view

Ocean observations for societal benefit

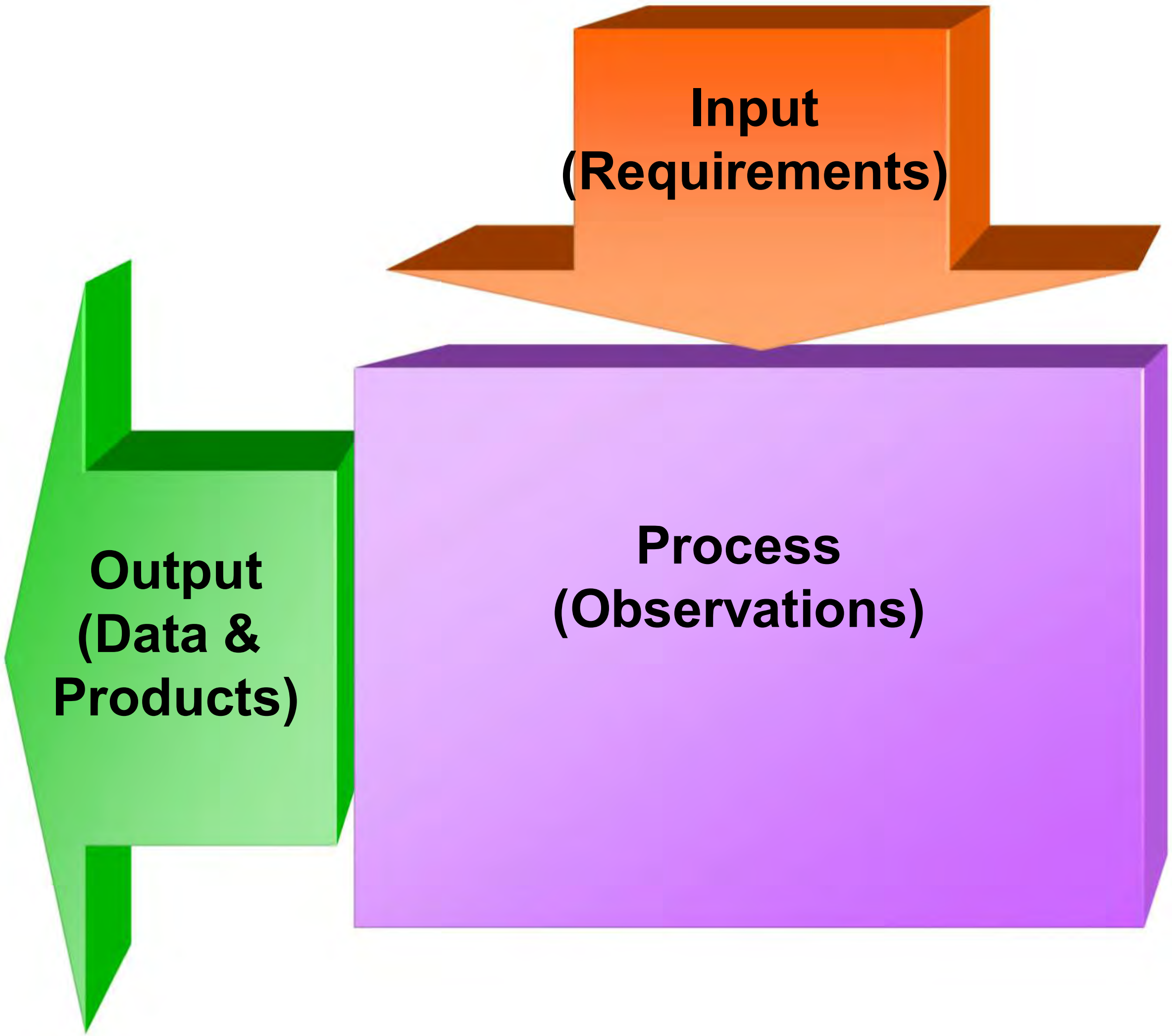
Climate,

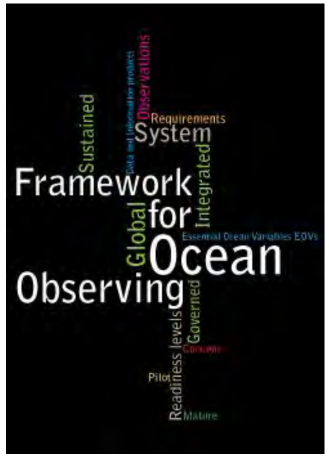
Operational ocean services,

Ocean health

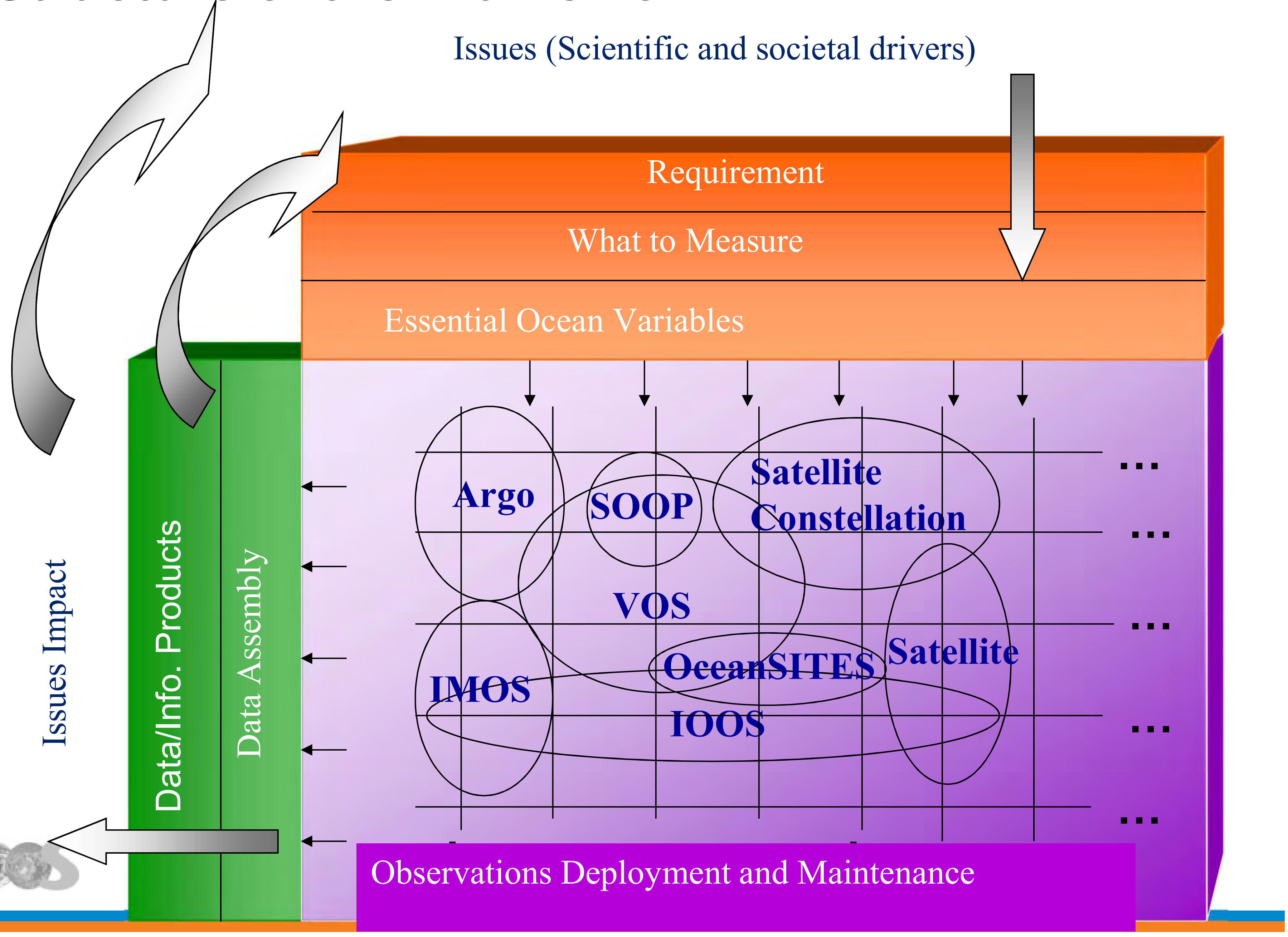
Framework for Ocean Observing

A simple system



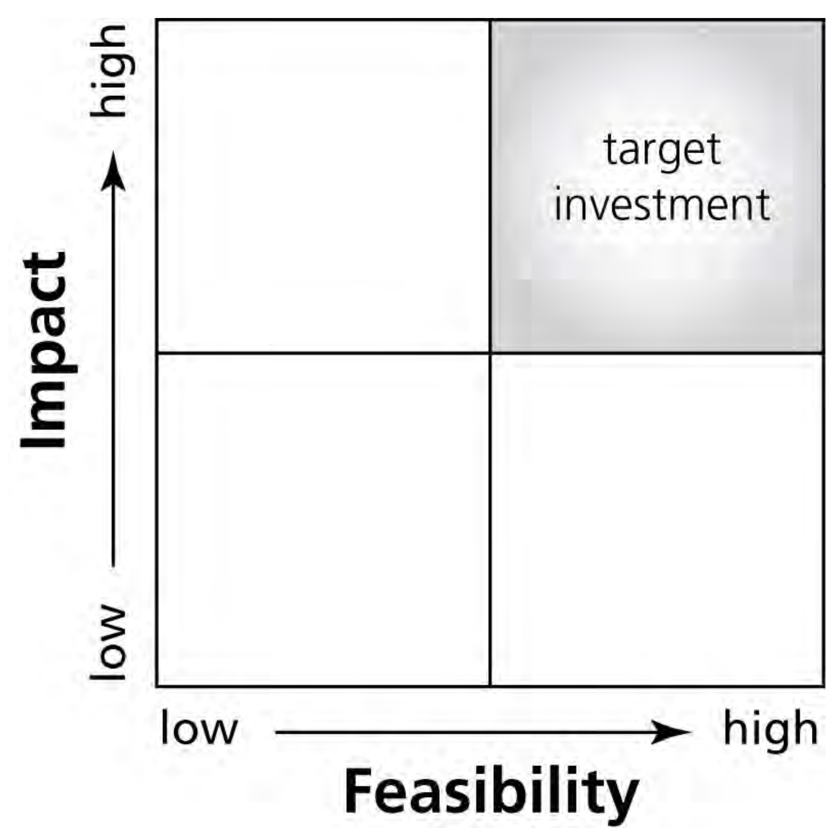


Structure of the Framework



Driven by requirements, negotiated with feasibility

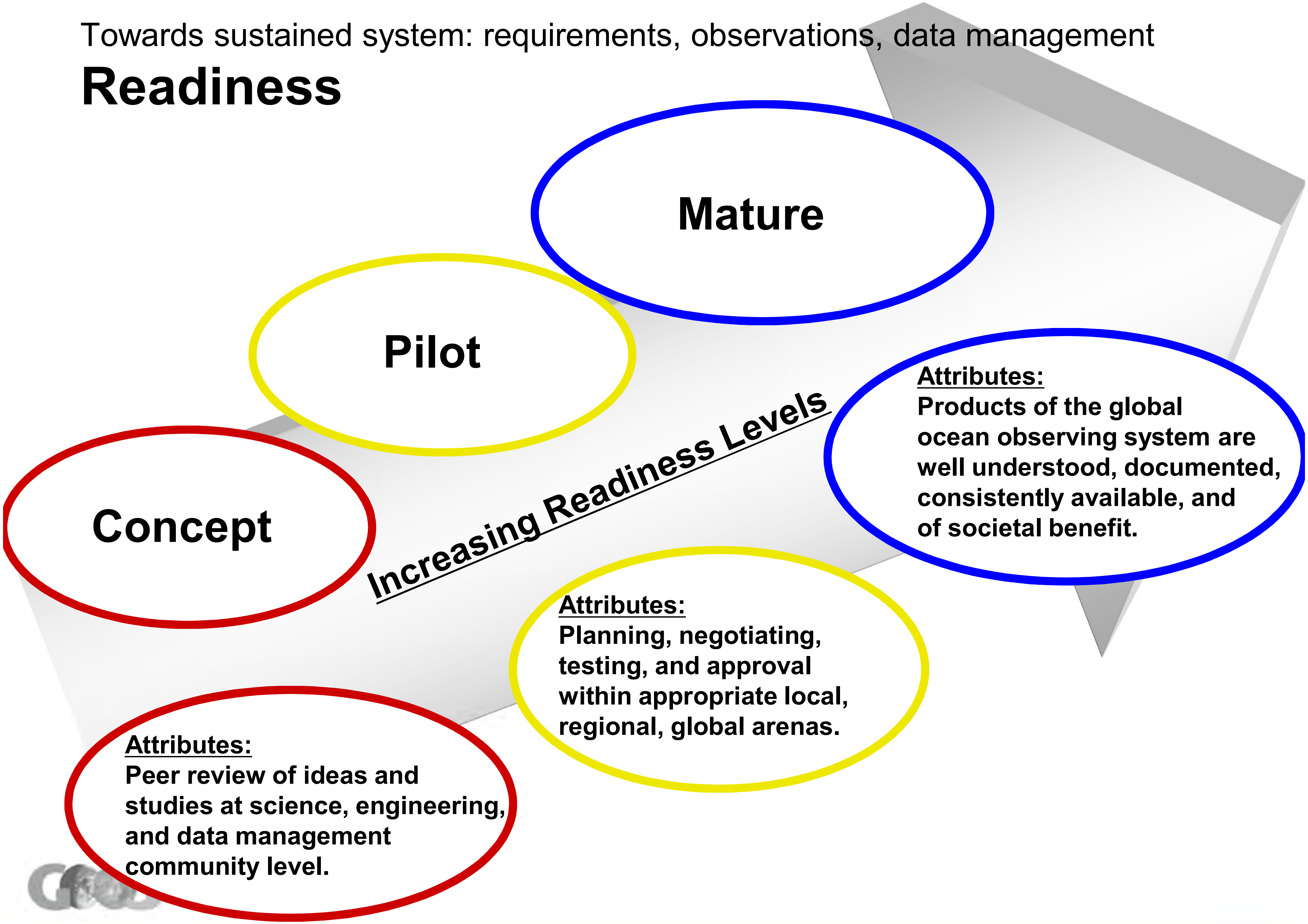
Essential Ocean Variables



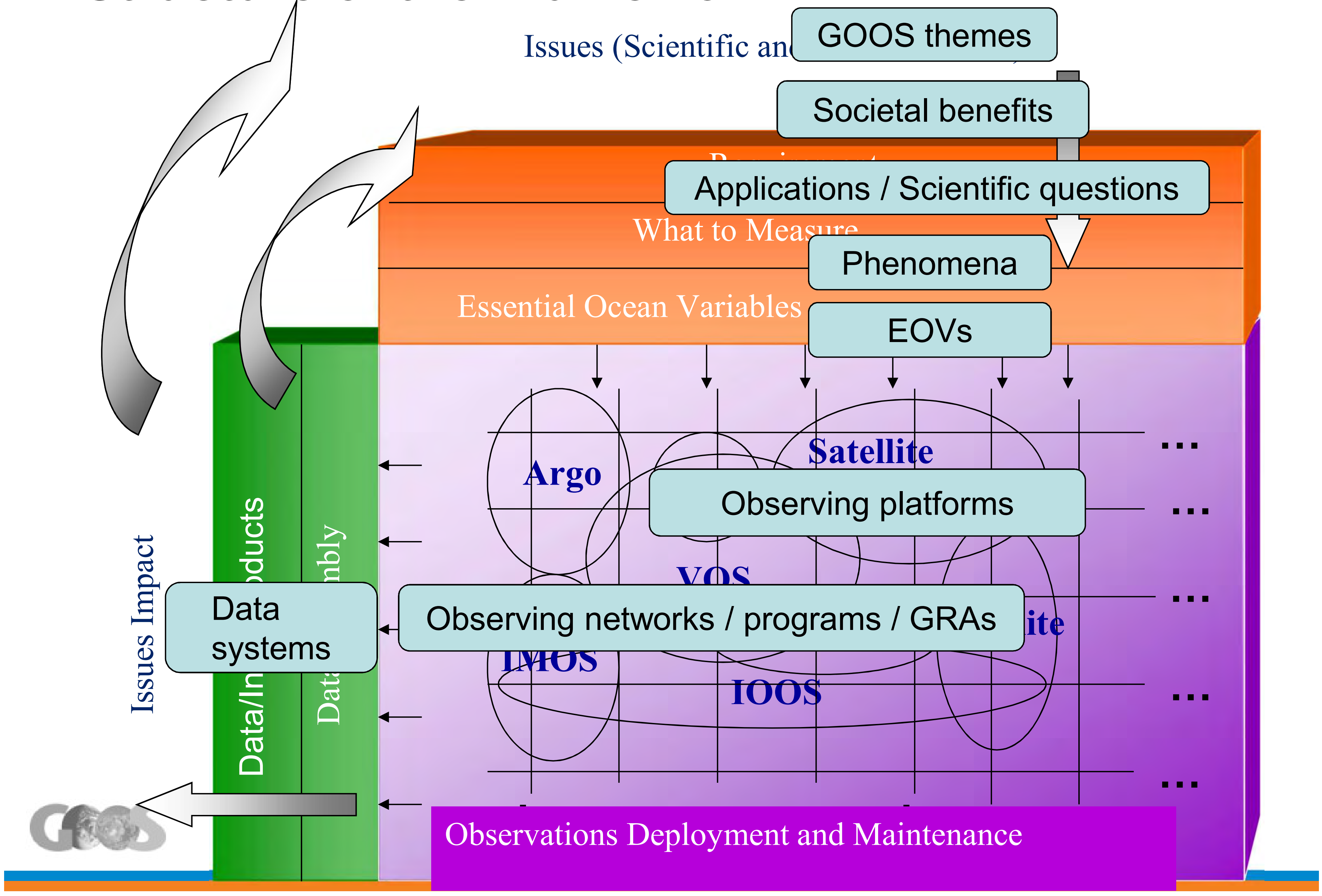
- **We cannot measure everything, nor do we need to**
- basis for including new elements of the system, for expressing requirements at a high level
- Driven by requirements, negotiated with feasibility
- Allows for innovation in the observing system over time

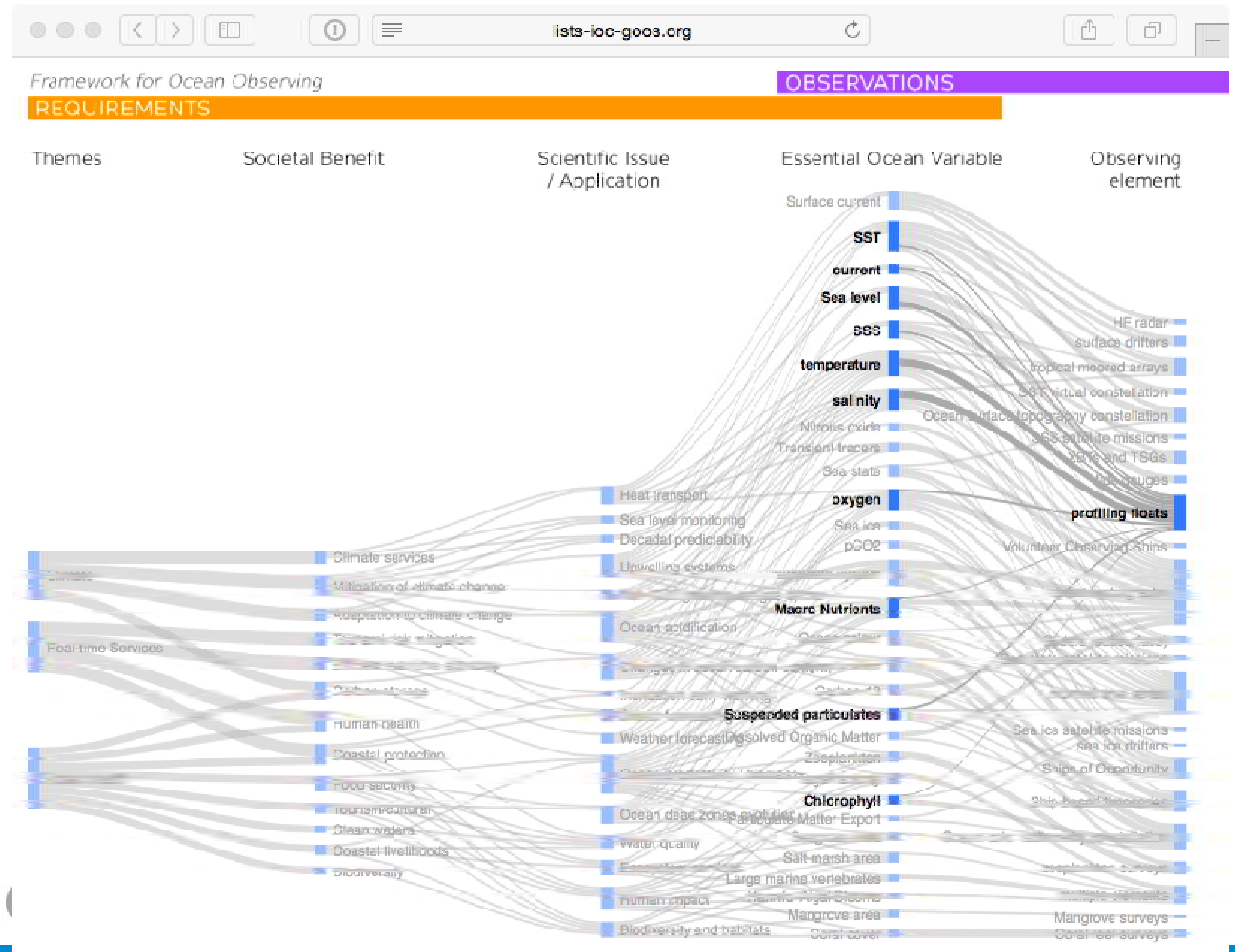
Towards sustained system: requirements, observations, data management

Readiness



Structure of the Framework



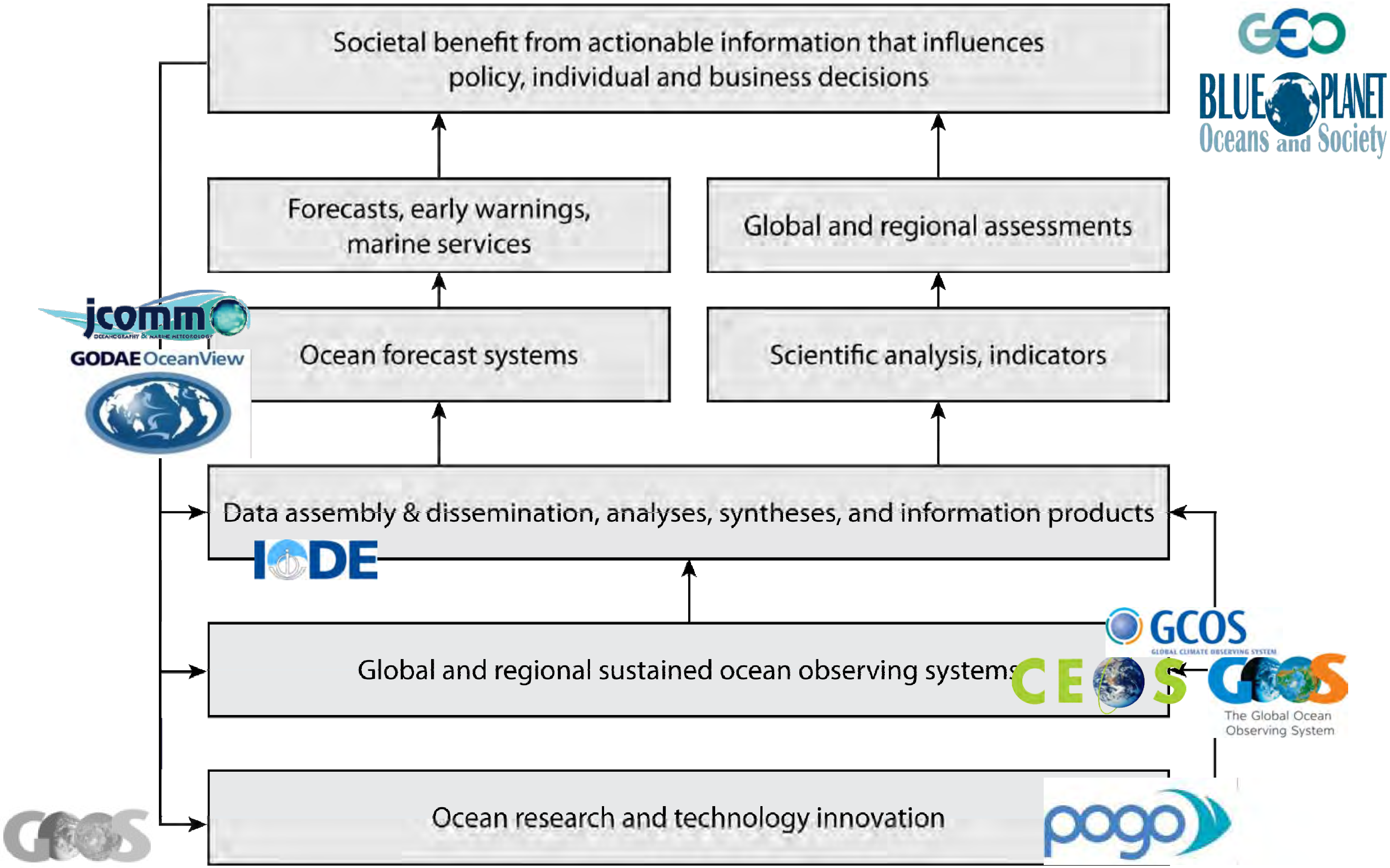


ists-ioc-goos.org
Framework for Ocean Observing
OBSERVATIONS
REQUIREMENTS
Themes
Societal Benefit
Scientific Issue / Application
Essential Ocean Variable
Observing element
Surface current
SST
current
Sea level
SSS
temperature
salinity
Nitrous oxide
Transient tracers
Sea state
oxygen
Sea ice
pCO2
Macro Nutrients
Suspended particulates
Dissolved Organic Matter
Zooplankton
Chlorophyll
Particulate Matter Export
Salt marsh area
Large marine vertebrates
Mangrove area
Coral cover
HF radar
surface drifters
tropical moored arrays
SST virtual constellation
Ocean surface topography constellation
SSS satellite missions
XBTs and TSGs
tide gauges
profiling floats
Volunteer Observing Ships
Sea ice satellite missions
Sea ice drifters
Ships of Opportunity
Mangrove surveys
Coral reef surveys
Heat transport
Sea level monitoring
Decadal predictability
Upwelling systems
Ocean acidification
Weather forecasting
Ocean dead zones
Water quality
Human impact
Biodiversity and habitats
Climate services
Mitigation of climate change
Adaptation to climate change
Human health
Coastal protection
Food security
Tourism/cultural
Clean waters
Coastal livelihoods
Biodiversity
Real-time Services

A value chain

Innovation, observations, data management, forecasts / science & assessment, societal benefit

Adapted from G7 Think Piece on Ocean Observations



Ocean observations as a **public good**

- GOOS principle: timely, free and unrestricted access to all data
- Often focused on large transboundary issues
- Cover areas under and beyond national jurisdiction
- Implemented on basis of international collaboration and open exchange

- **Non-excludable**: difficult to set up barriers to access to the outputs
- **Non-rivalrous**: can be consumed by an increasing number of users with no devaluation

Challenges to valuation of ocean observations

- The **length of the value chain**
  - value is added at each intermediate step after the measurement and availability of data – hard to identify the full value generated
- The **multiplicity of the value chain**
  - A diverse and growing set of users
- The **public good** nature of observations contributing to GOOS

Examples - climate

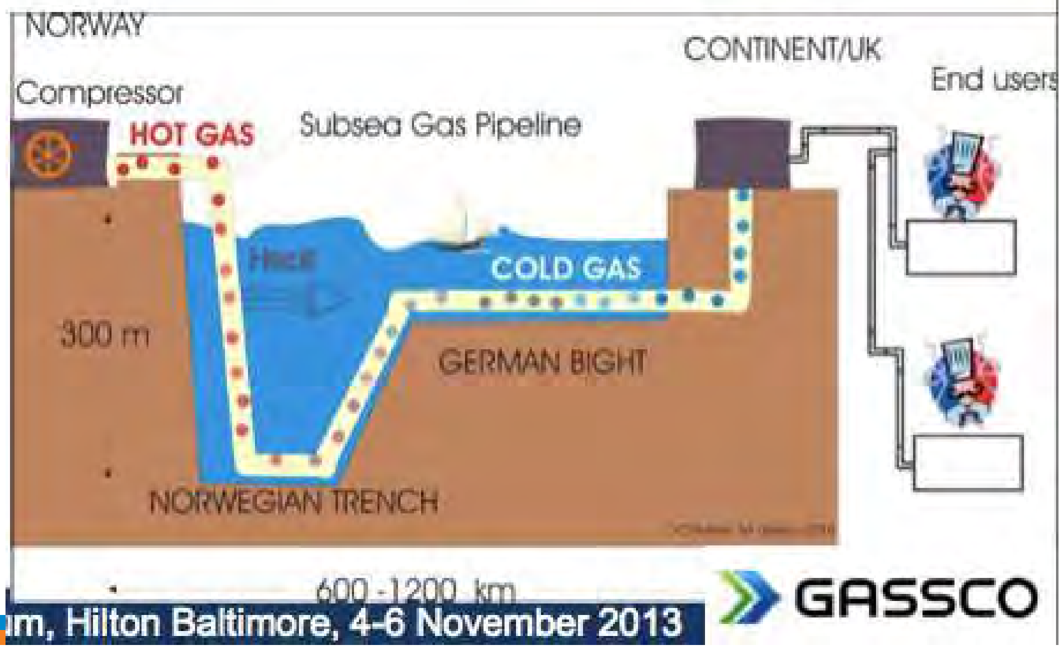
- ENSO prediction depends on observations of the Tropical Pacific Ocean
- **Climate sensitivity by economic sector**
  - US economic activity *Lazo et al. 2011*
  - Sensitivity: low of **2.2%** for wholesale trade sector
  - Sensitivity: high of **14.4%** of mining sector
  - Sensitivity: **12%** for agriculture
  - Practical value of forecasts is much lower than sensitivity, but provides a suggestion of value
  - **Value for Australia estimated at A$1-2 billion / year** *Centre for International Economics (2014a,b)*

- Centre for International Economics. 2014a: Analysis of the benefits of improved seasonal climate forecasting for agriculture, Prepared for the Managing Climate Variability Program, March 2014, available from http://www.managingclimate.gov.au/publications/benefits-of-improved-forecasts/, 41 pp.
- Centre for International Economics. 2014b: Analysis of the benefits of improved seasonal climate forecasting for sectors outside agriculture, Prepared for the Managing Climate Variability Program, March 2014, available from http://www.managingclimate.gov.au/publications/benefits-of-improved-forecasts/, 84 pp.
- Lazo, J.K., M. Lawson, P.H. Larsen, and D.M. Waldman. 2011. United States economic sensitivity to weather variability. Bull. Am. Meteor. Soc., 35 pp, DOI: 10.1175/2011BAMS2928.1

Examples – operational ocean services

Ocean information for the **marine economy**

- Norwegian gas operations: GASSCO 20% of European consumption
  - gas temperature volume, pressure dependent on sea bed temperature
  - ocean prediction systems support economic and safety decisions



Examples – ocean health

- Valuation of ocean ecosystem services can be in **$ trillions / year**

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Changes in the global value of ecosystem services

Robert Costanza[a,*], Rudolf de Groot[b], Paul Sutton[c,d], Sander van der Ploeg[b], Sharolyn J. Anderson[d], Ida Kubiszewski[a], Stephen Farber[e], R. Kerry Turner[f]

[a] Crawford School of Public Policy, Australian National University, Canberra, Australia
[b] Environmental Systems Analysis Group, Wageningen University, Wageningen, The Netherlands
[c] Department of Geography, University of Denver, United States
[d] Barbara Hardy Institute and School of the Natural and Built Environments, University of South Australia, Australia
[e] University of Pittsburgh, United States
[f] University of East Anglia, Norwich, UK

ARTICLE INFO

ABSTRACT

Learn more

The Global Ocean Observing System UPDATE WEBINAR

Outreach, sign up: **ioc-goos.org/join**

Twitter: **@GOOSocean**


Thank you

EuroGOOS

HOW HAVE SELECTED OCEAN OBSERVATORIES BEEN EVALUATED SO FAR?

EOOS – European Ocean Observing System

OECD Workshop
27th June 2016, Kiel

Glenn Nolan
Glenn.nolan@EuroGOOS.eu

Talk structure

Costs: well understood

Benefits: demonstrated but not quantified

SEPRISE Project outcomes

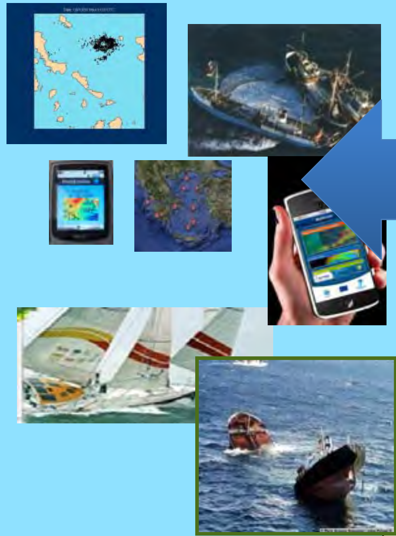
EEA GMES In-situ component (GISC) project

What we know so far

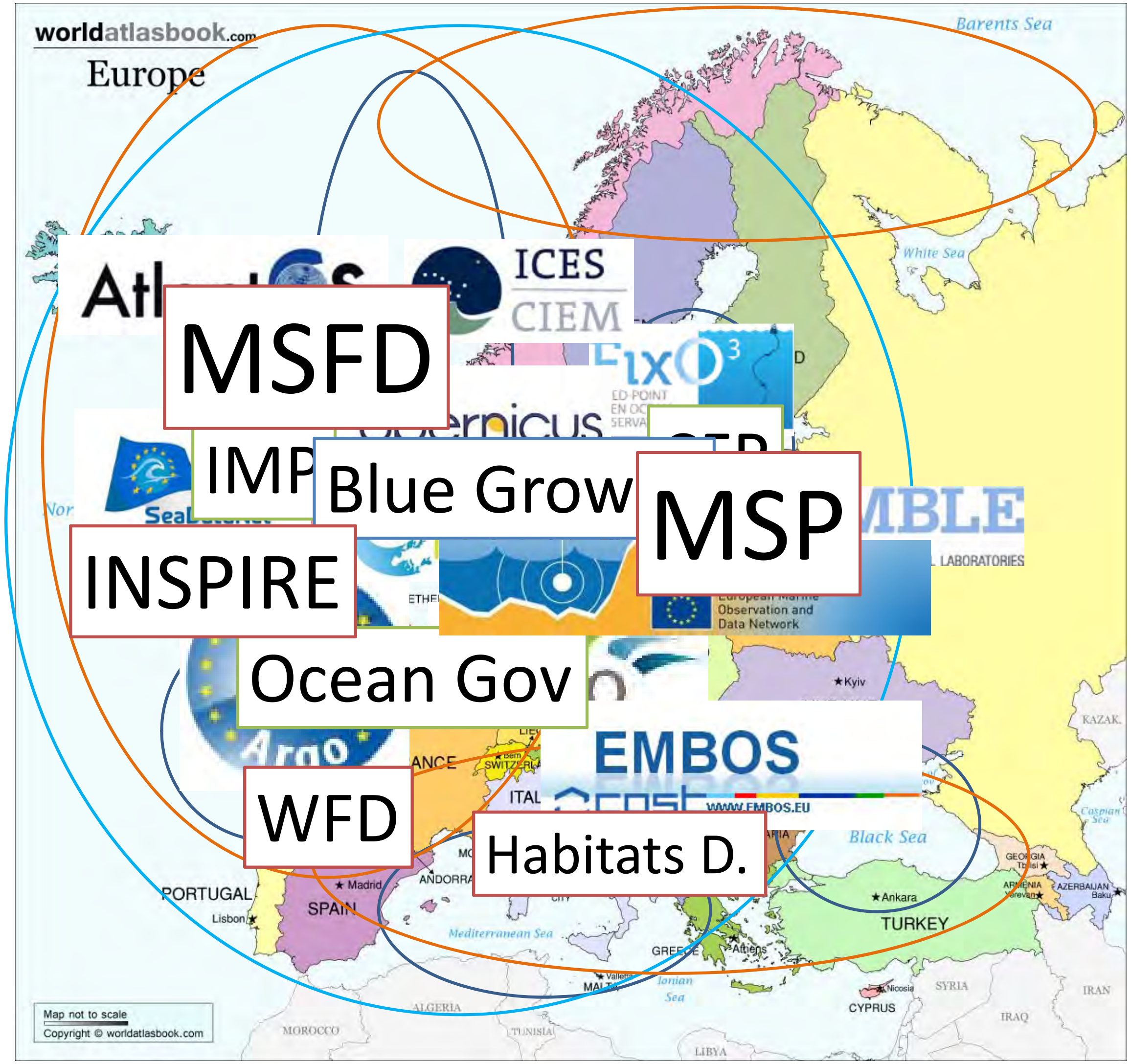
Cost of system

Full cost benefit analysis has not been conducted with economic expertise

Services

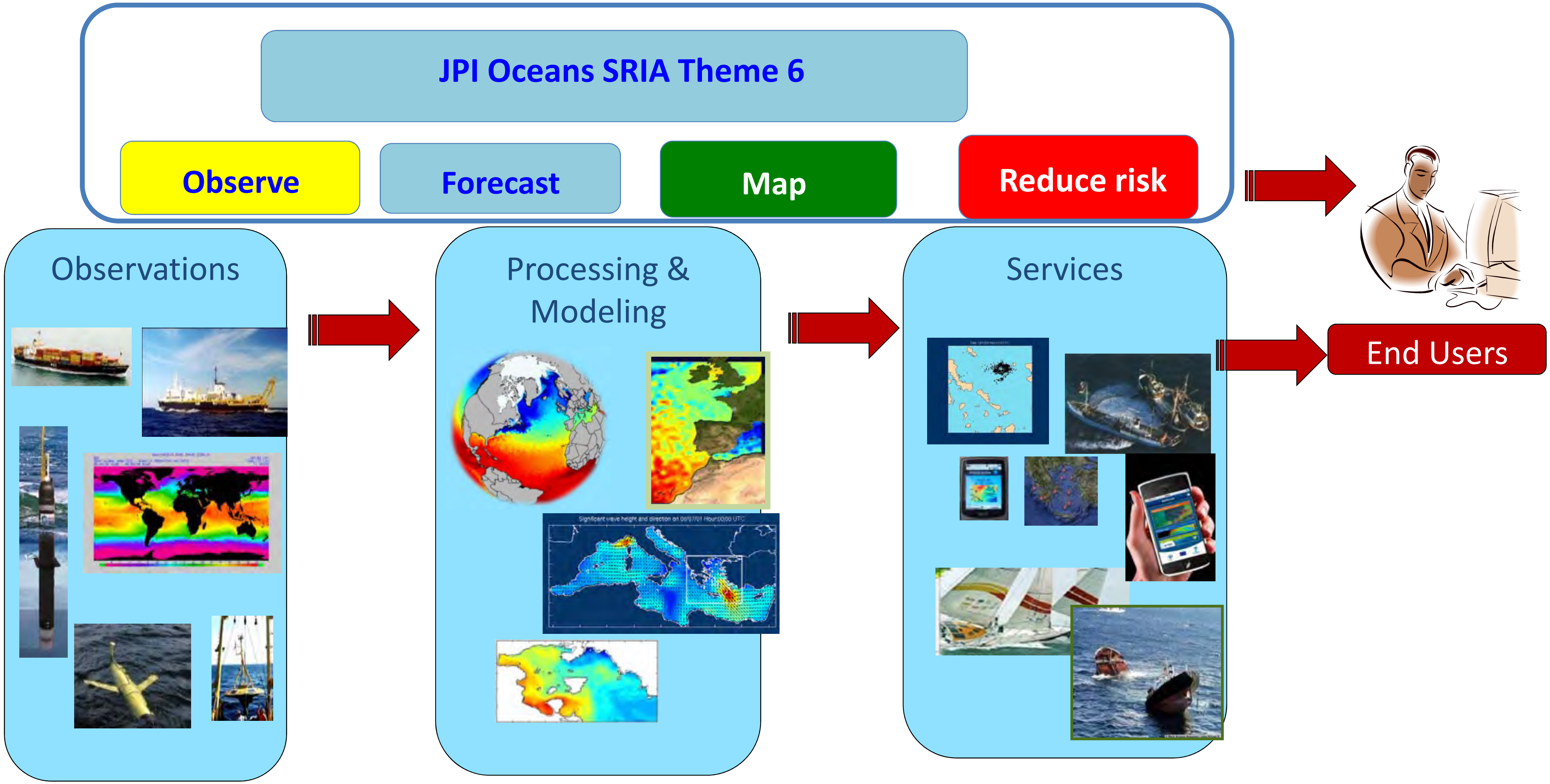


End Users



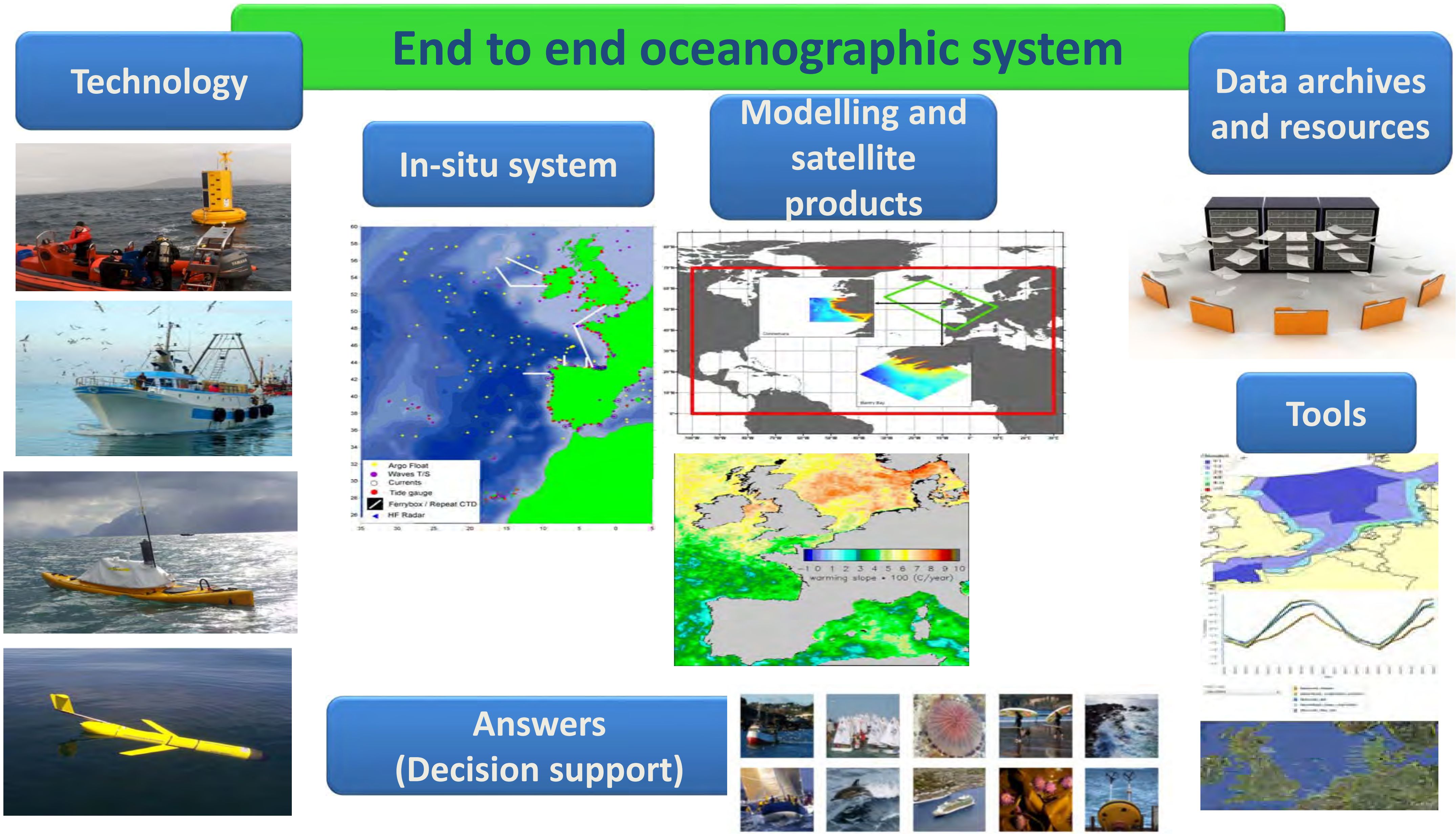
- End-to-End
- Inclusive
- Common
- Focal point

Operational Oceanography



A Diversity of Marine Resources

Courtesy Jenny O'Leary, IMI



End to end oceanographic system
Technology
In-situ system
Modelling and satellite products
Data archives and resources
Tools
Answers (Decision support)
Argo Float
Waves T/S
Currents
Tide gauge
Ferrybox / Repeat CTD
HF Radar
-1 0 1 2 3 4 5 6 7 8 9 10
warming slope • 100 (C/year)

Norwegian Sea
ICELAND
Reykjavik
SWEDEN
FINLAND
NORWAY
Oslo
Stockholm
Helsinki
Saint Petersburg
ESTONIA
Baltic Sea
URAL MOUNTAINS
Yekaterinburg
Moscow
North Sea
UNITED KINGDOM
Dublin
IRELAND
London
Brussels
Copenhagen
Vilnius
Minsk
BELARUS
Berlin
POLAND
Warsaw
GERMANY
Cologne
Kiev
UKRAINE
CZECH REPUBLIC
Vienna
Budapest
AUSTRIA
HUNGARY
Paris
FRANCE
Milan
ROMANIA
Bucharest
Volgograd
KAZAKH
Caspian Sea
UZBEKISTAN
TURKMENISTAN
Baku
GEORGIA
BULGARIA
ITALY
Rome
Barcelona
Madrid
PORTUGAL
SPAIN
Lisbon
Istanbul
Ankara
TURKEY
GREECE
Athens
Tehran
Algiers
Tunis
ATLAS MOUNTAINS
TUNISIA
Tripoli
Mediterranean Sea
Damascus
SYRIA
Baghdad
IRAQ
IRAN
ZAGROS MOUNTAINS
AFGHANISTAN
Amman
Cairo
Kuwait City
MOROCCO
ALGERIA
LIBYA
LIBYAN DESERT
EGYPT
SAUDI ARABIA
Dubai
Karachi

COSTS AS OF TODAY	Equipment Cost/year	Personnel Costs*	Total costs
IBIROOS	6525	5460	11985
NOOS	5400	4300	9700
BOOS	3186	1910	5096
MOON	4757	1366	6123
Black Sea	412	2960	3372
Arctic	2630	1315	3945
TOTAL EuroGOOS Regions	22909	17311	40221
Euro-Argo	2300	2500	4800
Euro-Sites	1632	2013	3645
EGO	1500	1100	2600
E-SURFMAR	6712	1132	7844
CPR	500	2700	3200
FerryBox	470	1500	1970
Central data management (in-situ TAC)		2000	2000
TOTAL Components	13114	10945	24059

REQUIREMENTS	Equipment Cost/year	Personnel Costs*	Total Cost
IBIROOS	9321	7800	17121
NOOS	5940	4730	10670
BOOS	4253	2540	6793
MOON	6795	1952	8747
Black Sea	1022	3750	4772
Arctic	3250	1625	4875
TOTAL EuroGOOS Regions	30581	22397	52978
Euro-Argo	4700	3500	8200
Euro-Sites	2331	2876	5207
EGO	3000	2200	5200
E-SURFMAR	6800	1200	8000
CPR	500	2700	3200
FerryBox	940	3000	3940
Central data management (in-situ TAC)		5350	5350
TOTAL Components	18271	20826	39097

Applications sectors

115 applications (1999)

00. Transport (excluding military)
01. Shipping operations
02. Hovercraft operations
03. Hydrofoil operations
04. Submersible/submarine operations/ROVs
05. Tunnel subsea operations
06. Barrage roads
07. Causeway
08. Bridges, sea channels
09. Navigational safety, lights etc. Electronic charts
10. Safety services, rescue, life preserving, fire
11. Port operations
12. Energy production
13. Oil and gas production (Oil companies only)
14. Oil and gas exploration and prospecting, and drilling services
15. OTEC
16. Wave energy
17. Tidal energy
18. Wind energy, offshore installation

19. Environmental protection/ preservation
20. Clean beaches
21. Oil pollution control
22. Non-oil pollution control
23. Estuarine pollution
24. Health hazards
25. Marine reserves
26. Species protection
27. Environmental forecasts
28. Flood protection
29. Safe waste disposal
30. Amenity evaluation
31. Environmental quality control
32. Environmental data services

33. Mineral extraction
34. Aggregate, sand, gravel
35. Deep ocean, Mn, hydrothermal muds, crusts
36. Placer minerals, diamonds, tin, etc.
37. Salts extraction, magnesia, bromine
38. Desalination
39. Phosphate
40. Coal, subsea

41. Food from the sea
42. Fisheries, catching
43. Fish farming
44. Shellfisheries
45. Shellfish, crustacea, farming
46. Fishing gear
47. Defence
48. Military vessels, surface and submarine
49. ASW, oceanographic applications
50. Underwater weapons
51. Navigation, position fixing, etc.
52. Defence sales, equipment, components
53. Operations and efficiency, logistics, controls, computing

54. Building, construction, and engineering
55. Coastal defences
56. Port construction
57. Dredging
58. Land reclamation
59. Barrage construction
60. Tunnel construction
61. Outfalls/intakes
62. Consulting engineering
63. Components, hydraulics, motors, pumps, batteries, etc.
64. Cables, manufacture and operations, laying
65. Corrosion prevention, paint, antifouling, etc.
66. Heavy lifting, cranes, winches
67. Marine propulsion, efficient ship, automatic ships, DP, props
68. Offshore construction, platforms, etc.
69. Pipelaying, trenching, burial
70. Ship-building, non-defence, all kinds

71. Services
72. Certification
73. Climate forecasting
74. Data consultancy
75. Data services
76. Data transmission, telecommunications
77. Diving, including suppliers
78. Inspection, maintenance, repair
79. Insurance
80. Metocean survey, mapping, hydrographic surveys
81. Project management, non-defence, consultancy
82. Remote sensing
83. Salvage, towing
84. Ship routing
85. Weather forecasting

86. Equipment sales
87. Marine electronics, instruments, radar, opto-electronics, etc.
88. Sonar
89. Buoys

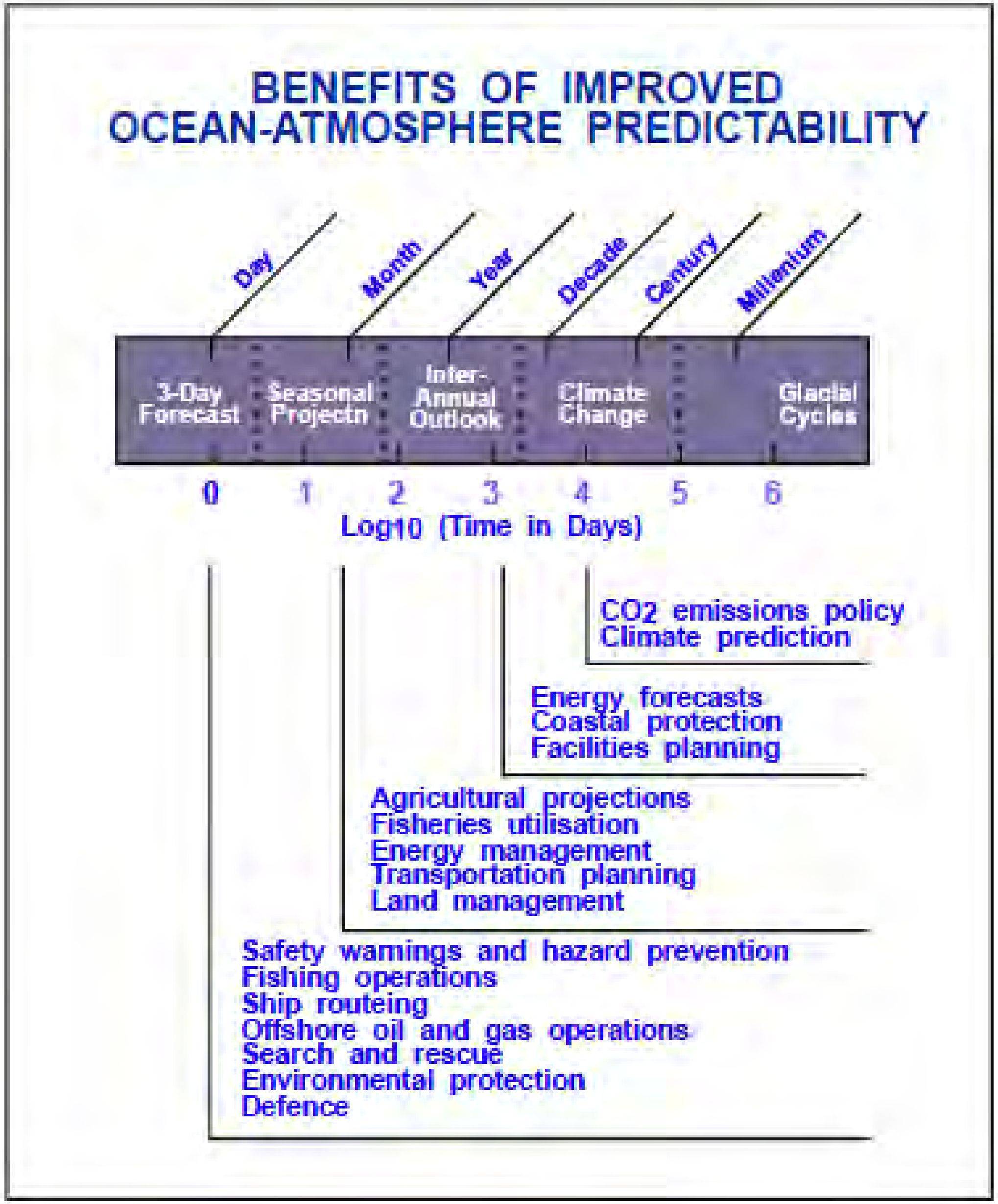
90. Tourism and recreation

91. Applied research, and operational services
92. Acoustics, electronics
93. Civil engineering
94. Climate change
95. Climate forecasting
96. Coastal modelling
97. Data centre
98. Environmental sciences
99. Estuarine modelling
100. Fisheries
101. Marine biology
102. Marine weather forecasting
103. Ocean modelling
104. Oceanography
105. Polar research
106. Remote sensing
107. Shelf seas modelling
108. Shipping/naval architecture

109. Hinterland
110. Agriculture
111. Land use planning or zoning
112. Urban management
113. Local government
114. Wetlands management
115. Public health

Common Variables	Group	No	Common Variables	Group	No
Current Velocity	Surface Fields	94	Tidal constants	Coastal & Shelf	35
Current Direction	Surface Fields	93	Upper ocean salinity	Upper Layer Fields	35
Waves Hs	Surface Fields	85	Precipitation	Surface Fields	35
Wave Period	Surface Fields	81	Meteorological forcing	Sea Surface topogr.	34
Sea surface temperature	Surface Fields	79	Monthly mean sea level	Sea Surface topogr.	34
Wave direction spectrum	Surface Fields	75	River runoff	Coastal & Shelf	34
Sea surface Wind stress	Surface Fields	71	Phytoplankton	Biogeochemical	34
Wave spectrum	Surface Fields	68	Suspended sediments	Biogeochemical	34
Wave swell	Surface Fields	67	Sea level anomaly	Sea Surface topogr.	33
Coastal bathymetry	Coastal & Shelf	60	Chlorophyll	Biogeochemical	33
Sea surface salinity	Surface Fields	60	Gridded bathymetry	Sea Bed	32
Coastline map	Coastal & Shelf	58	Nitrate	Biogeochemical	31
Bathymetry	Sea Bed	56	Oxygen	Biogeochemical	31
Surface currents	Upper Layer Fields	55	CTD sections	Deep Ocean	30
Hourly mean sea level	Sea Surface topogr.	48	Stratification	Coastal & Shelf	30
Sediment transport	Coastal & Shelf	44	Eddies, jets, fronts	Upper Layer Fields	30
Shelf bathymetry	Coastal & Shelf	41	Sound velocity profiles	Acoustics	29
Surface sediments	Sea Bed	39	Velocity fields	Upper Layer Fields	29
Oceanic tides	Sea Surface topogr.	38	Phosphate	Biogeochemical	29
Geostrophic currents	Sea Surface topogr.	35	Surface outcrops	Sea Bed	26

Table 3. The 40 most frequently chosen variables (ranked). No = no of respondents requesting variable (From Fischer and Flemming 1999, Annexe 5). (See Annexe 1 for complete table). Total number of respondents N= 155.


BENEFITS OF IMPROVED
OCEAN-ATMOSPHERE PREDICTABILITY
Day
Month
Year
Decade
Century
Millenium
3-Day Forecast
Seasonal Projectn
Inter-Annual Outlook
Climate Change
Glacial Cycles
0 1 2 3 4 5 6
Log10 (Time in Days)
CO2 emissions policy
Climate prediction
Energy forecasts
Coastal protection
Facilities planning
Agricultural projections
Fisheries utilisation
Energy management
Transportation planning
Land management
Safety warnings and hazard prevention
Fishing operations
Ship routeing
Offshore oil and gas operations
Search and rescue
Environmental protection
Defence

SEPRISE: key findings

Many previous political and scientific decisions at the European and international levels have been based on the assumption that the socio-economic benefit justifies the expenditure on marine scientific research and operational oceanography. We have been lucky, and these assumptions are probably about right, but we cannot prove it.

It is possible that the real benefits of an ocean observing system are much higher than we expected, but we cannot prove that either.

As further investment is considered on large scale global operational observing systems and models the socio-economic justification must be much more robust.

SEPRISE: key findings

Operational oceanography was probably in this immature pioneer state during the 1990's and early 2000's. In that stage, at the national level, an attractive quick measurement of probable benefit might be called the "Zero-th Order Calculation".

In this method you sum the turnover, revenue, or value added by all marine industries and related activities to arrive at a percentage of GNP, and then assume that operational oceanography could add 1%, say, to this figure through improved efficiency and avoidance of losses and accidents. A great many studies start by alluding to the complexity of CBA, and then resort to the 1% rule as a pragmatic expedient

SEPRISE: key findings

This requires a combination of experience in operational oceanography and economic skills, in the design stage.

Rushing this stage will be counter-productive.

The future funding and management of operational oceanography requires both broad total figures, plus accurate technological and economic models of sub-sectors so that we can understand the system as it evolves.

SEPRISE: key findings

The project design must develop methods for aggregating benefits and costs from separate sub-sectors in a way which avoids double counting or gaps.

The final outcome should be a “headline” figure for the best estimate of the NPV for operational oceanography over the next 20-50 years, plus a series of different net benefits based on different assumptions and models, also broken down into sectors with different characteristics and time-frames.

Future of the Ocean economy (OECD)

Foster greater international cooperation in maritime science and technology as a means to stimulate innovation and strengthen the sustainable development of the ocean economy.

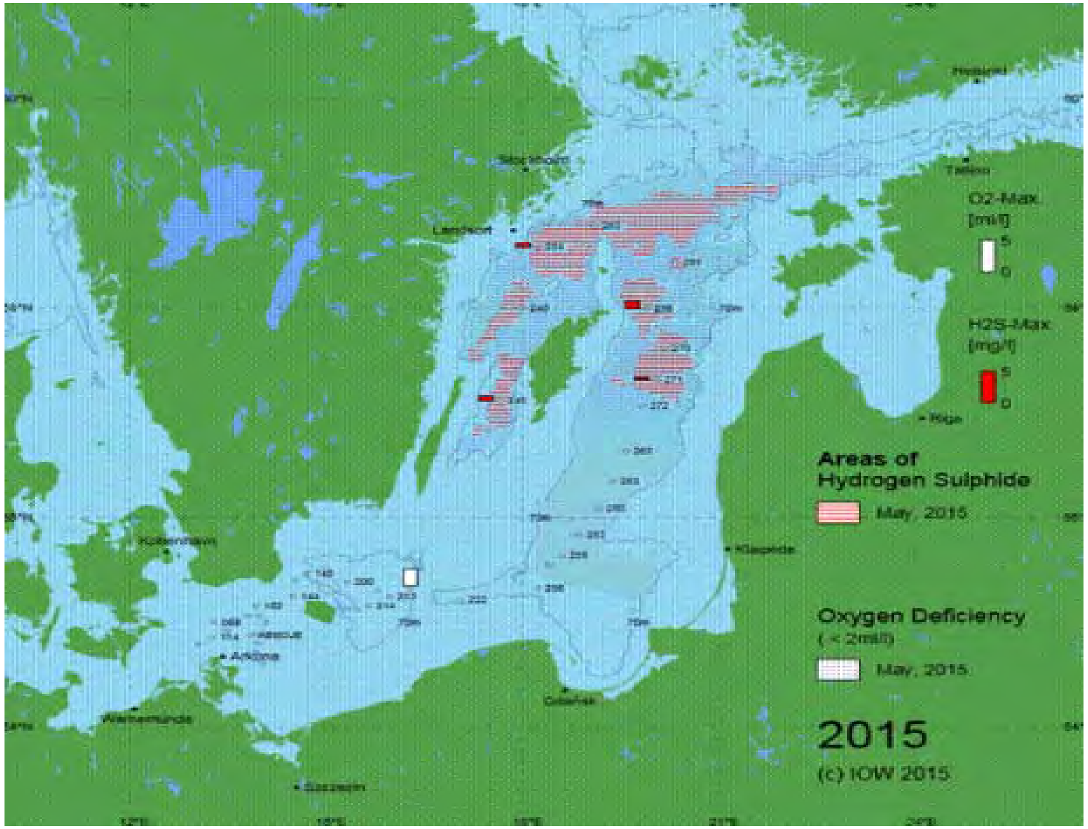
Strengthen integrated ocean management (greater use of economic analysis, platforms for exchange of knowledge)

Improve the statistical and methodological base at national and international level for monitoring … ocean-based industries and their contribution to the overall economy

Build more capacity for ocean industry foresight (future changes and trends)

Products and services

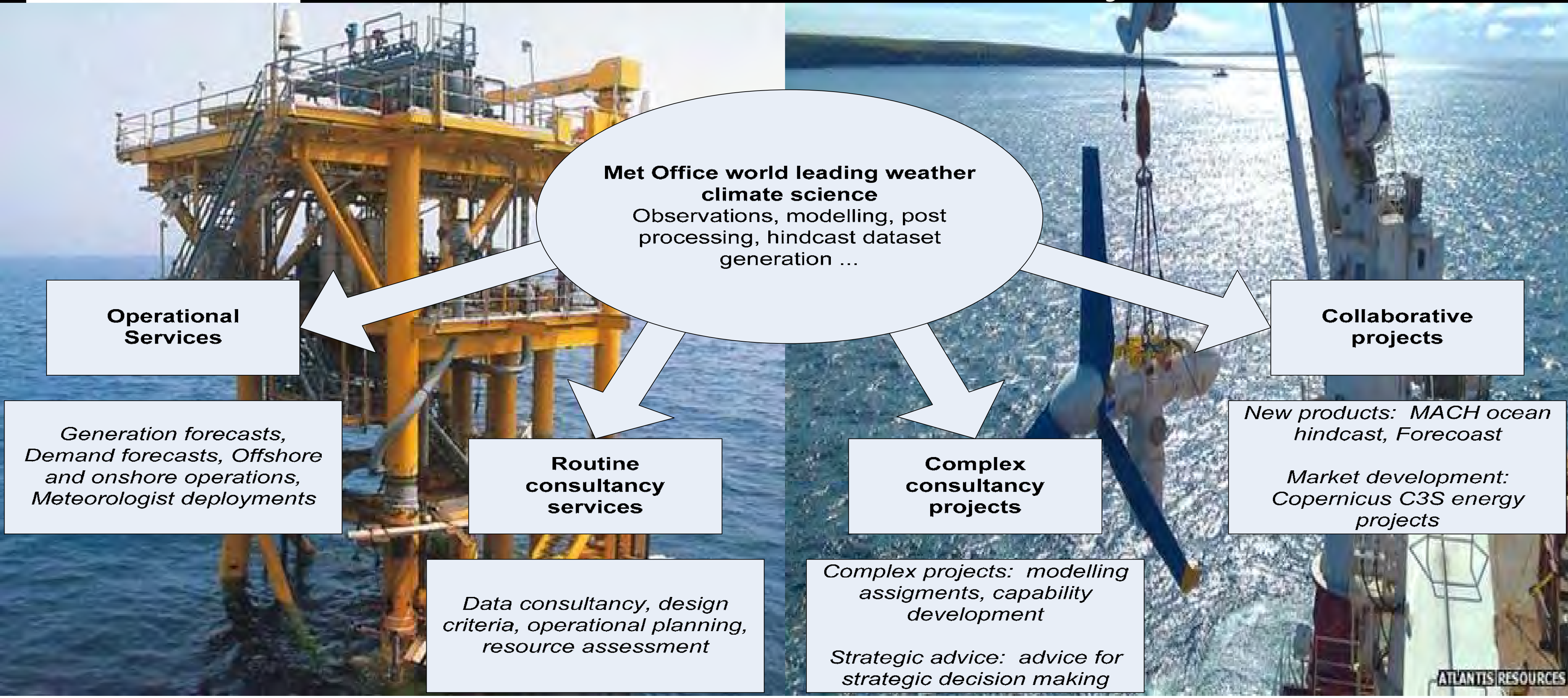
HELCOM environment fact sheets



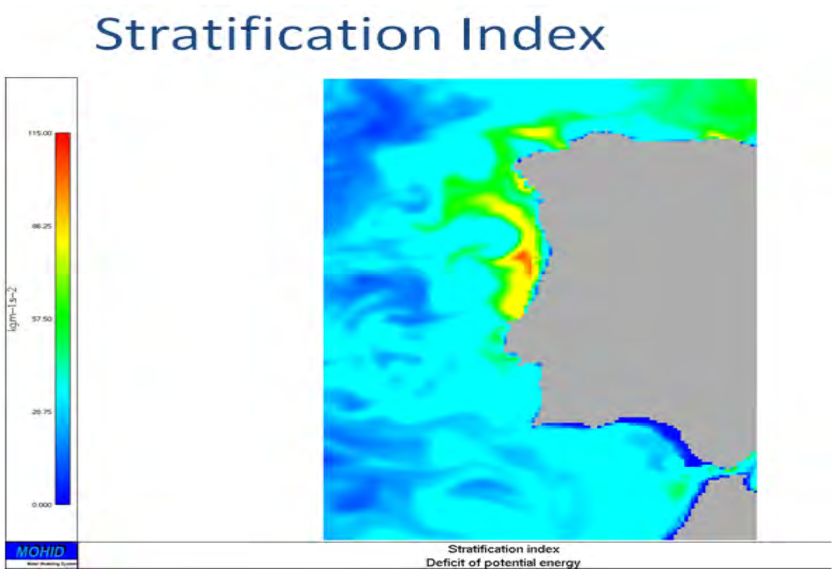
Nausch, G., Feistel, R., Naumann, M., Mohrholz, V. (IOW), 2016. WATER EXCHANGE BETWEEN THE BALTIC SEA AND THE NORTH SEA, AND CONDITIONS IN THE DEEP BASINS. HELCOM Baltic Sea Environment Fact Sheets 2015. Online. [25.05.2016], http://www.helcom.fi/baltic-sea-trends/environment-fact-sheets/.

Met Office

Marine services for industry



ICES WGOOFE Product requests 2016-2017



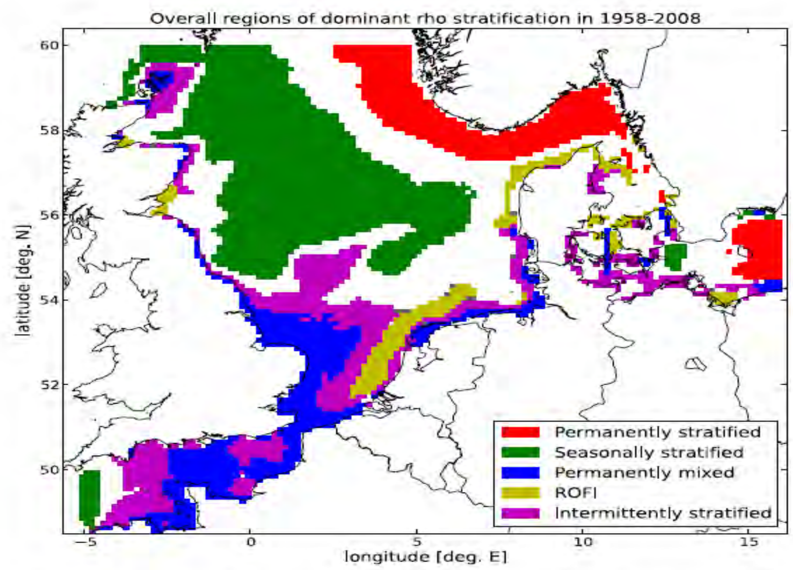


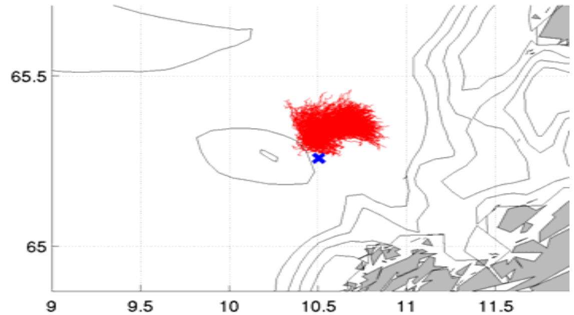
Figure 5. Time median results of the modelled, annual regions in the North Sea based on density stratification. Transparent areas indicate areas where the dominant regime occurs for less than 50% of the time (less visible due to minimal occurrence).

European seas stratification index

Gross primary production ensemble product

Applications

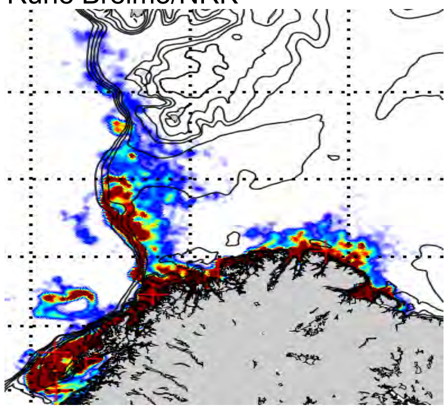
Model drift through 24 hours from sampling location

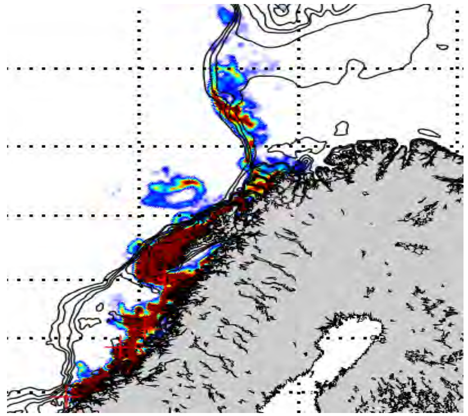


Karsten Hansen

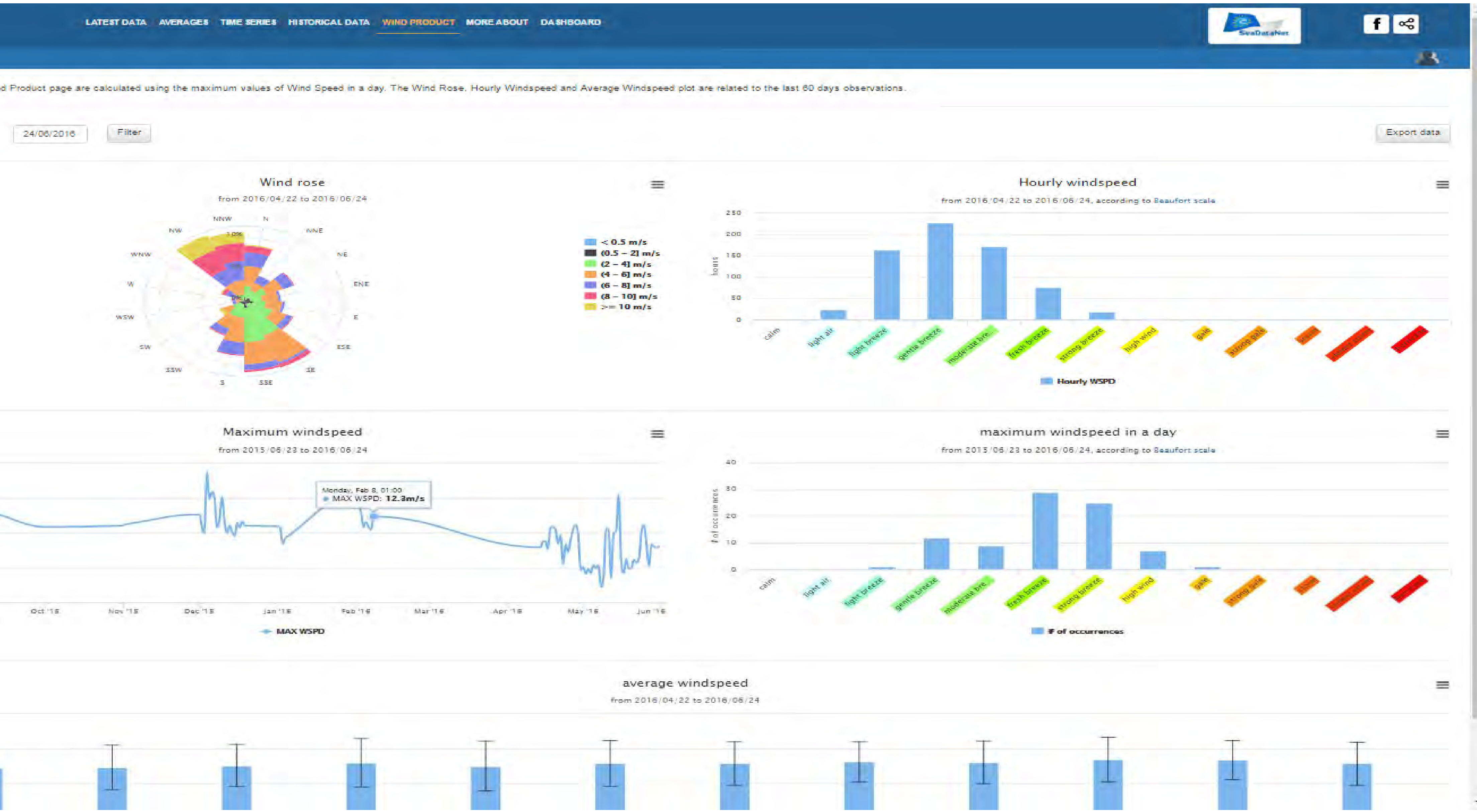
Distribution of ichthyoplankton in relation to spill from ship wreck

Rune Breimo/NRK

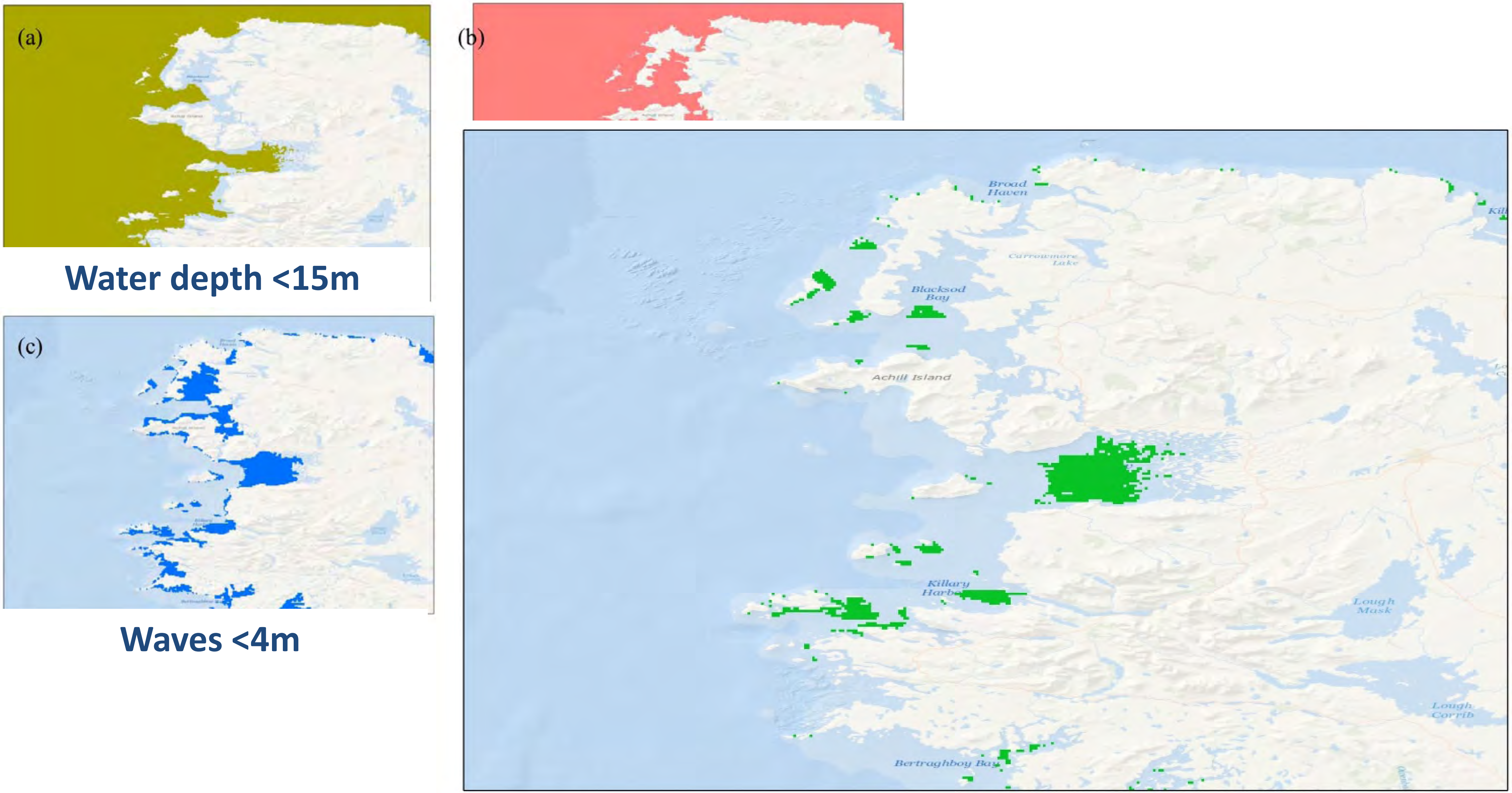




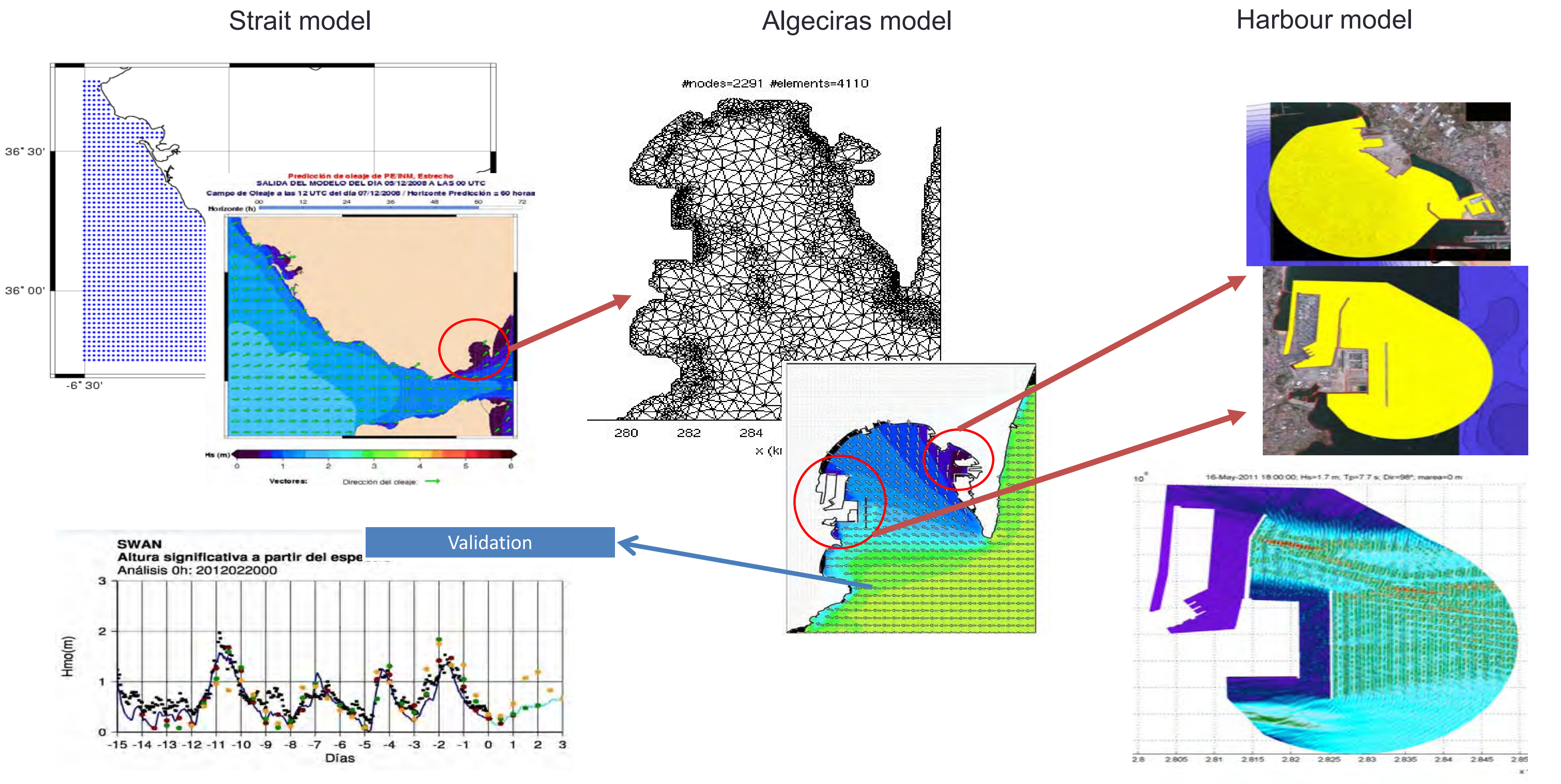
Frode Vikebø, IMR, Bergen, Norway



LATEST DATA
AVERAGES
TIME SERIES
HISTORICAL DATA
WIND PRODUCT
MORE ABOUT
DASHBOARD
d Product page are calculated using the maximum values of Wind Speed in a day. The Wind Rose, Hourly Windspeed and Average Windspeed plot are related to the last 60 days observations.
24/06/2016
Filter
Export data
Wind rose
from 2016/04/22 to 2016/06/24
< 0.5 m/s
(0.5 – 2] m/s
(2 – 4] m/s
(4 – 6] m/s
(6 – 8] m/s
(8 – 10] m/s
>= 10 m/s
Hourly windspeed
from 2016/04/22 to 2016/06/24, according to Beaufort scale
hours
Hourly WSPD
Maximum windspeed
from 2015/06/23 to 2016/06/24
Monday, Feb 8, 01:00
MAX WSPD: 12.3m/s
MAX WSPD
maximum windspeed in a day
from 2015/06/23 to 2016/06/24, according to Beaufort scale
# of occurrences
average windspeed
from 2016/04/22 to 2016/06/24


(a)
Water depth <15m
(b)
(c)
Waves <4m
Broad Haven
Carrowmore Lake
Blacksod Bay
Achill Island
Killary Harb
Lough Mask
Lough Corrib
Bertraghboy Bay

Agitation forecast



THANK YOU

ANY QUESTIONS?

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Dina.Eparkhina@EuroGOOS.eu

231 Avenue Louise, Brussels

We thank the EMB for the contribution to this presentation through our common work developing the EOOS concept

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European Commission

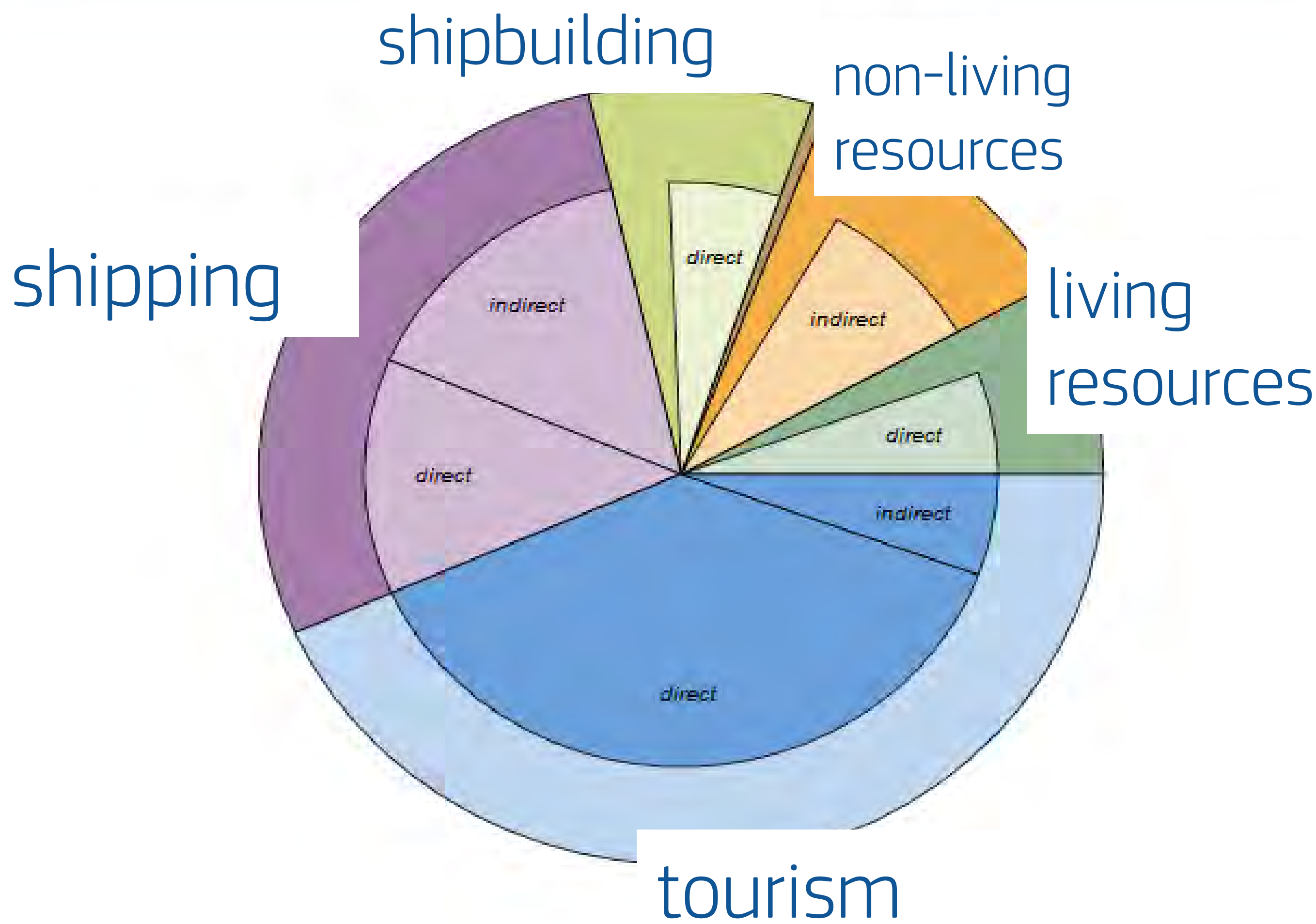
marine knowledge 2020

Joint OECD AtlantOS Project Workshop

Exploring the Economic Potential of Data from Ocean Observatories

27-28 June 2016

blue economy



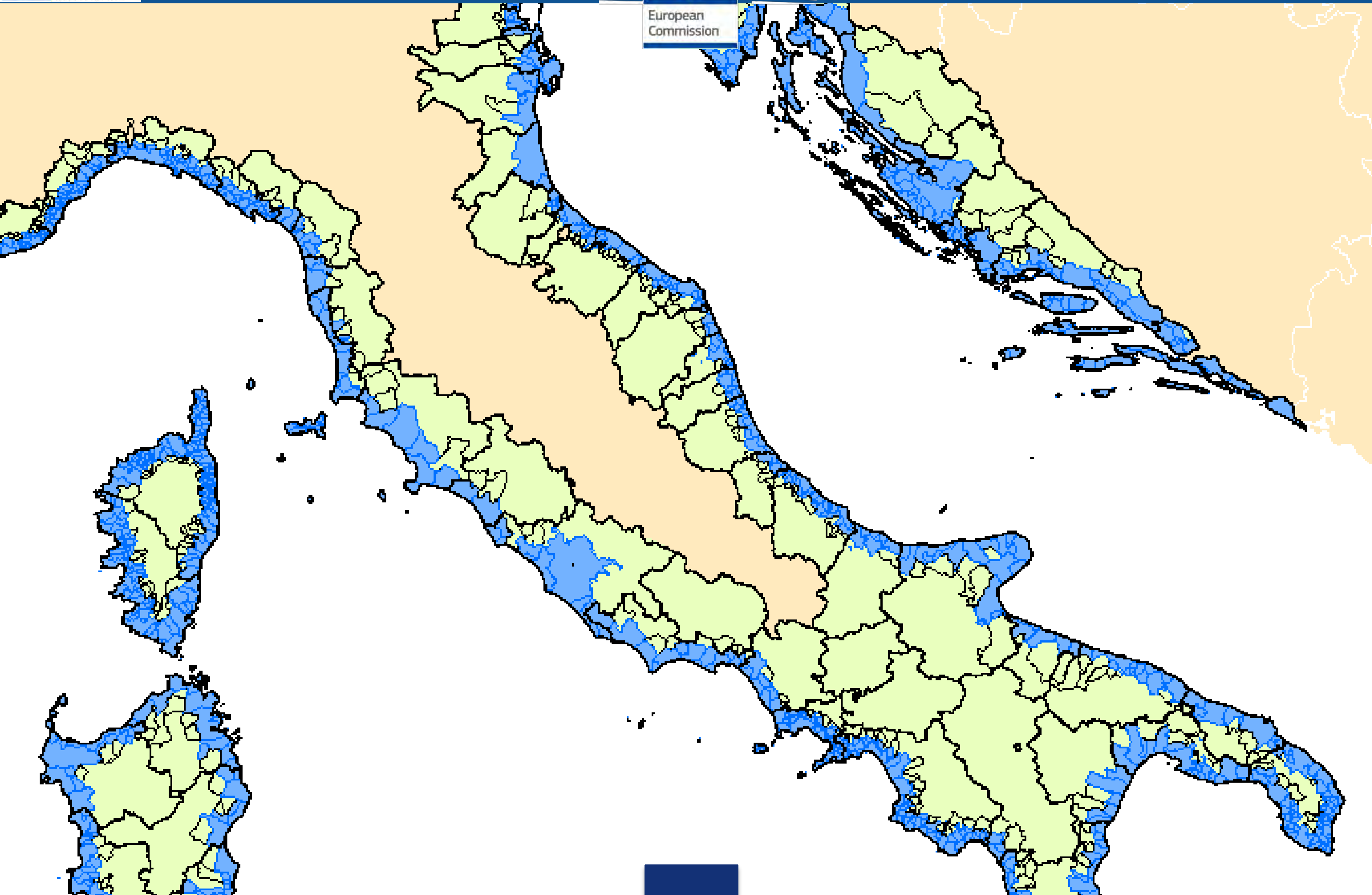
comparison with US

United States	European Union
living resources	living resources
ship and boat building	shipbuilding
offshore mineral resources	non-living resources
marine transportation	transport
marine construction	(included under transport)
tourism and recreation	coastal tourism
	renewable energy

coastal tourism

EMODnet
European Marine Observation and Data Network

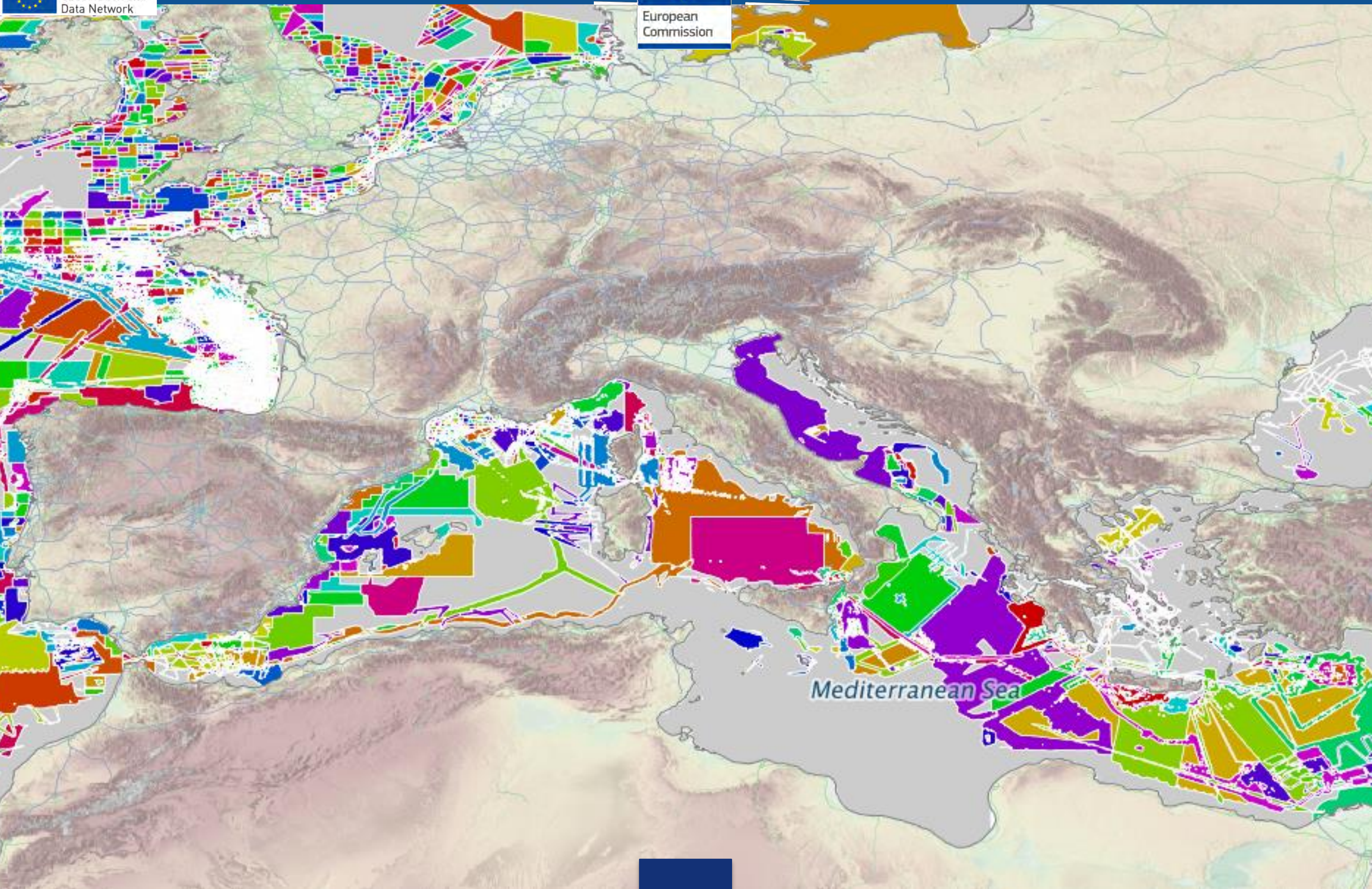
European Commission



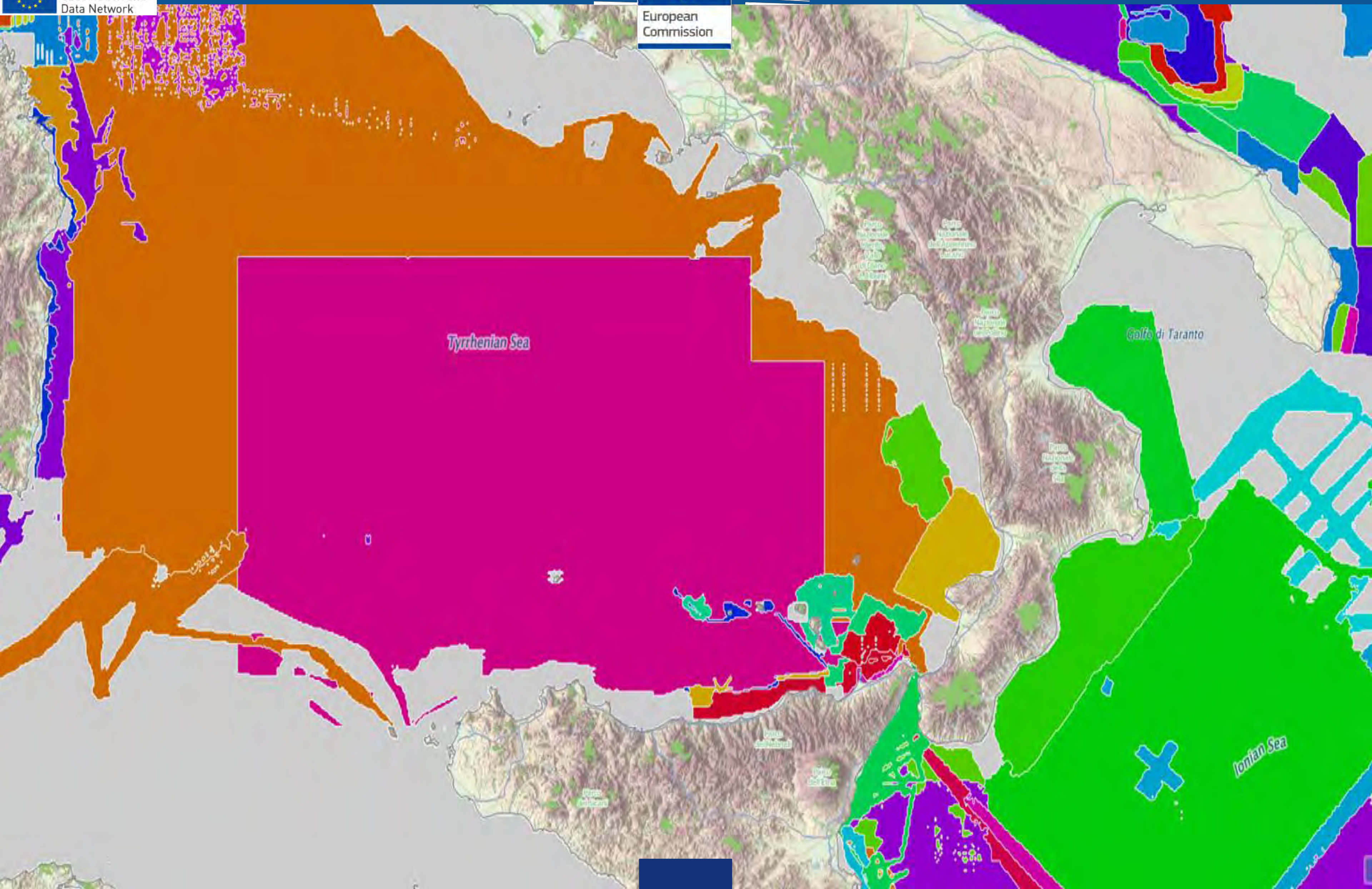
focus on availability and interoperability

- save costs
- promote innovation
- reduce uncertainty

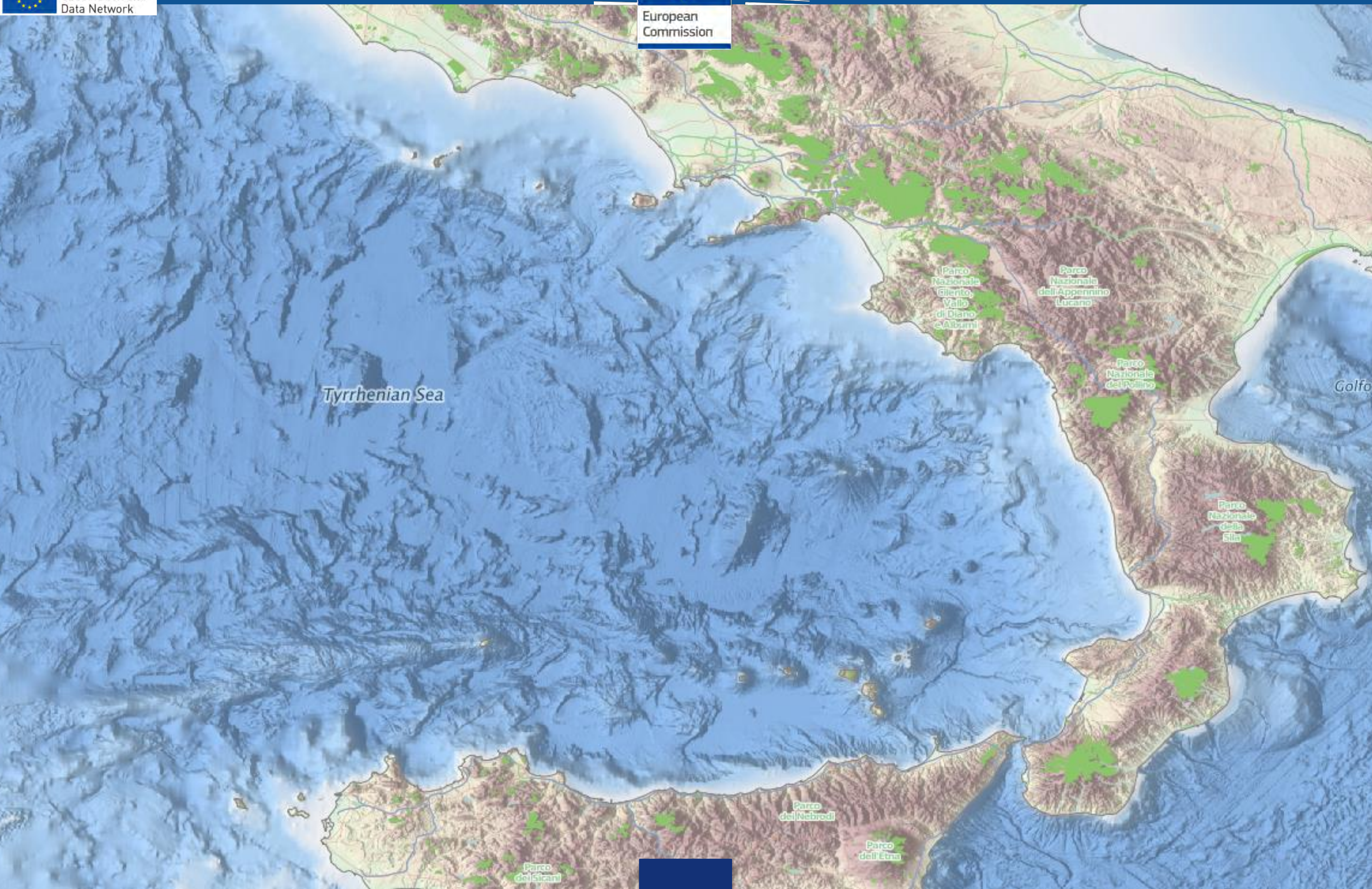
data from many sources



data from many sources



processed


Tyrrhenian Sea
Parco Nazionale Cilento, Vallo di Diano e Alburni
Parco Nazionale dell'Appennino Lucano
Parco Nazionale del Pollino
Parco Nazionale della Sila
Parco dei Nebrodi
Parco dell'Etna
Parco dei Sicani
Golfo

cost of fragmented data

$$S^s = \sum_{i=1,N} (\alpha_i^s \beta_i^s + (1 - \alpha_i^s)\gamma_i) \emptyset_i^s C^s$$

data can't be found and need to resurvey

assembling data with different formats, nomenclature, baselines, standards

EU annual savings

	private		*public*		*hydrography*		*research*		*total*
Total cost	€3,000,000,000		€225,000,000		€150,000,000		€2,000,000,000		€5,375,000,000
	geology	rest	geology	rest	geology	rest	geology	rest	
a	*0.75*	0.25	0.75	0.25	0.67	0.67	0.50	0.50	data that needs to be collected
β	*0.50*	0.50	0.15	0.50	0.1	0.2	0.15	0.15	already collected but not available
γ	*0.25*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	overhead in assembling data
φ	*0.75*	0.25	0.50	0.50	0.9	0.1	0.20	0.25	proportion of data of this type
Saving	**€1,200,000,000**		**€54,000,000**		**€23,000,000**		**€200,000,000**		**€ 1,500,000,000**

why we are doing it

- save costs
- promote innovation
- reduce uncertainty

new products and services

NAVIONICS+

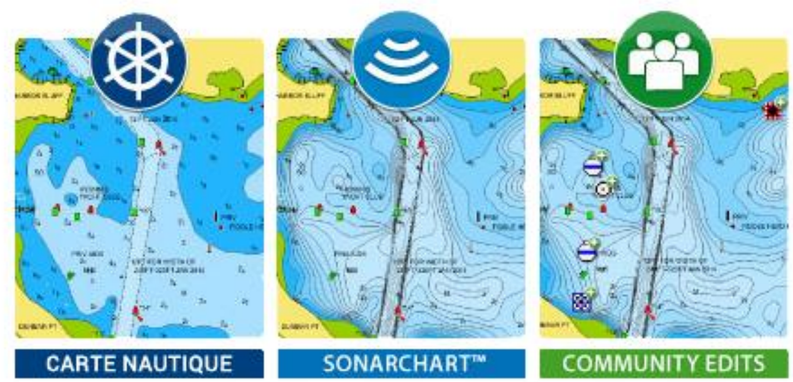
Navionics+ offre plus de contenus des mers et des lacs et le meilleur rapport qualité/prix !

Acheter

Comment bien choisir sa carte ? Couverture Compatibilité

Cartographie

Tout sur une carte mémoire ! Carte Nautique, SonarChart™ et Community Edits. Consultez la liste des lacs des Etats Unis et Canada.



Freshest Data

why we are doing it

- save costs
- promote innovation
- reduce uncertainty

reducing uncertainty

- coastal protection
- offshore construction
- safe navigation
- extraction of mineral resources
- aquaculture
- tourism
- cable laying
- Etc.

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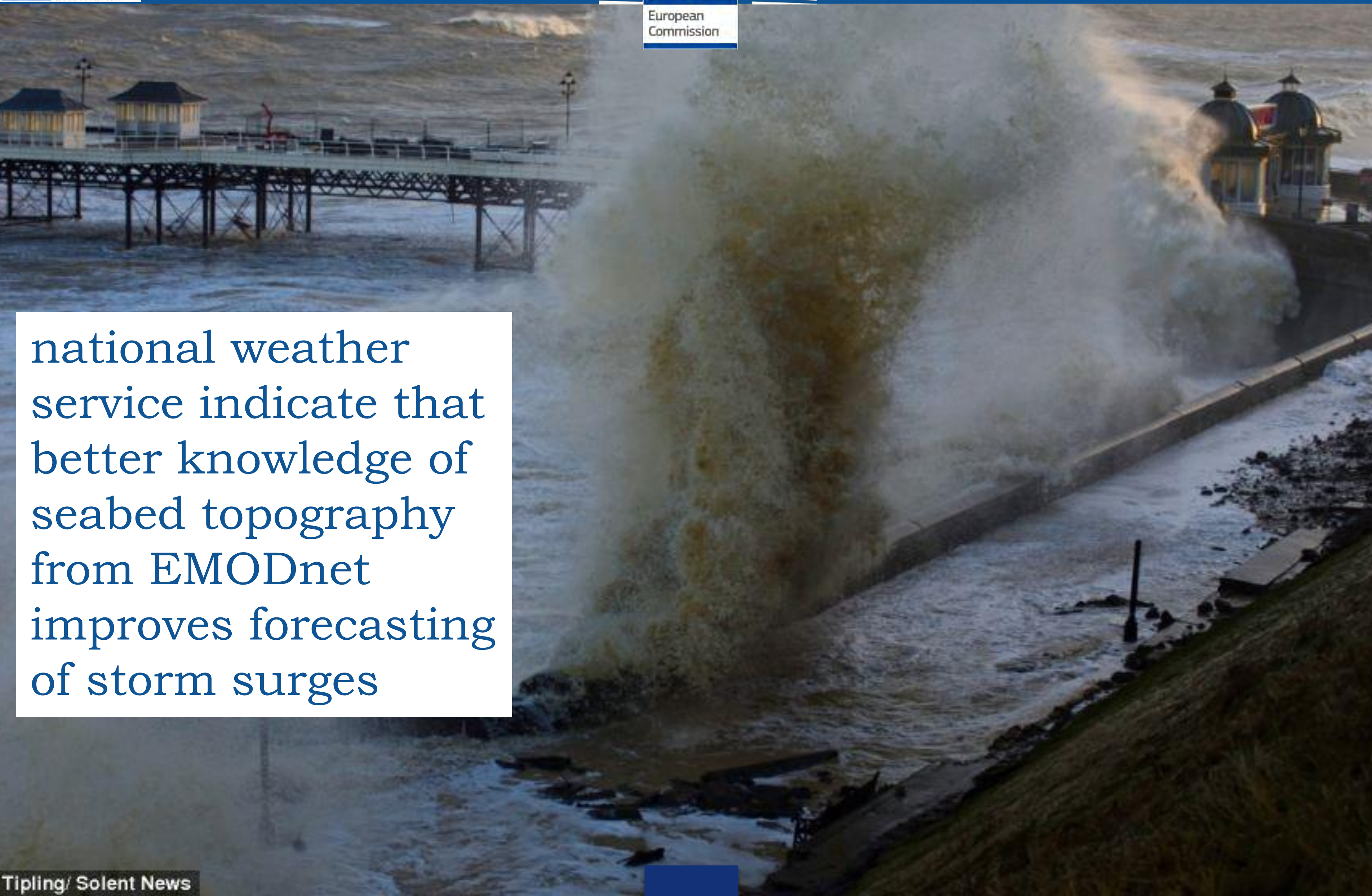
European Commission

reduce uncertainty

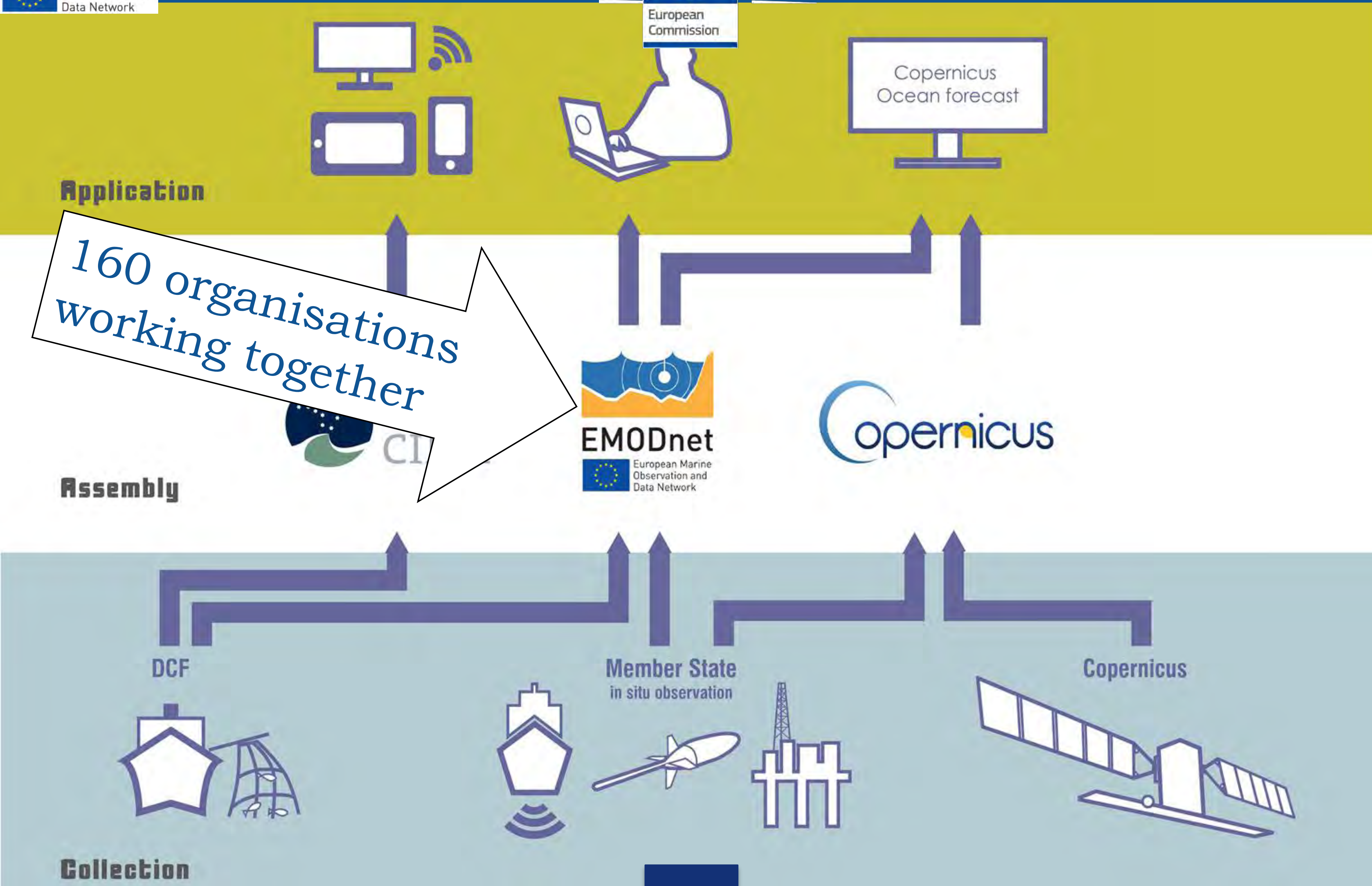


national weather service indicate that better knowledge of seabed topography from EMODnet improves forecasting of storm surges

Tipling/ Solent News

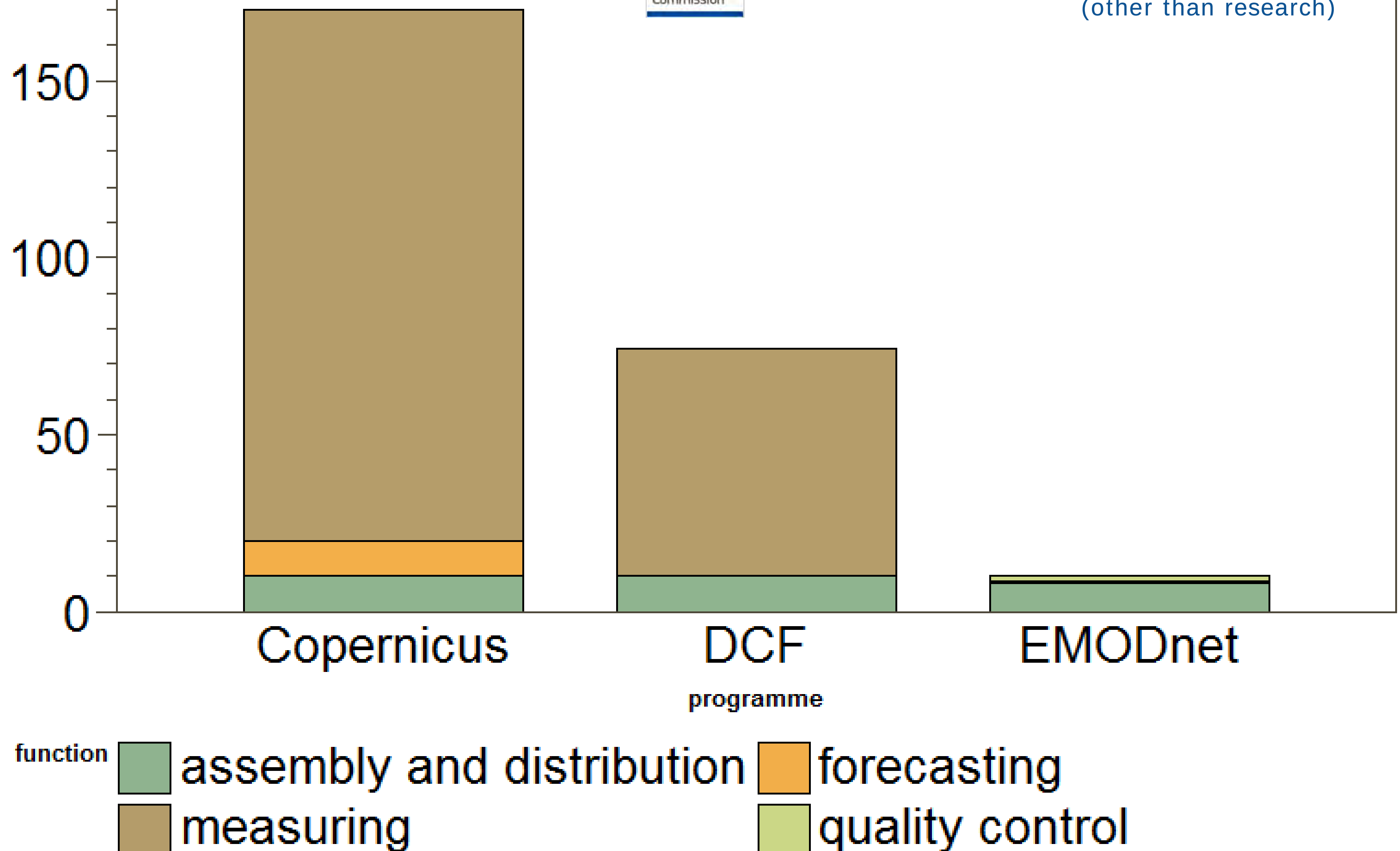
- why we are doing it
- what we are doing
- what we will do next

working together



annual EU spending marine data

(other than research)



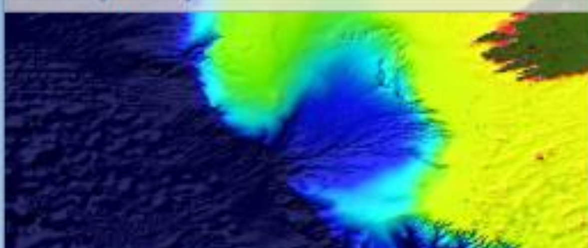
News Flash: EMODnet Open Conference outputs now available

The **first EMODnet Open Conference, Consolidating the Foundations, Building the Future** (October 20 2015), marked a major milestone in the development of EMODnet, providing the first opportunity for EMODnet developers and contributors to physically meet users and stakeholders, to consider progress to date, and prepare for future challenges and opportunities. Approximately 350 participants from the marine data and observing community, relevant policy fields and stakeholder groups participated. The main discussion points and recommendations have been documented in the **conference report**. The conference report, together with speaker presentations, feedback from the conference breakout sessions, a photo gallery and additional information are now available **on this overview page**.

The European Marine Observation and Data Network (EMODnet) consists of more than 100 organisations assembling marine data, products and metadata to make these fragmented resources more available to public and private users relying on quality-assured, standardised and harmonised marine data which are interoperable and free of restrictions on use. EMODnet is currently in its second development phase with the target to be fully deployed by 2020.

More information about EMODnet and its development process

Bathymetry



Data on bathymetry (water depth), coastlines, and geographical location of underwater features: wrecks.

Read more | Portal

Geology

Data on seabed substrate, sea-floor geology, coastal behaviour, geological events, and minerals.

Read more | Portal

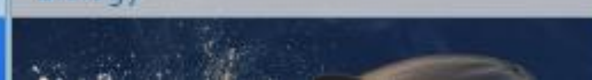
Seabed Habitats

Data on modelled seabed habitats based on seadbed substrate, energy , biological zone, and salinity.

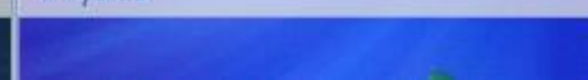
Read more | Portal

Chemistry

Biology



Physics



stress tests

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European Marine Observation and Data Network

European Commission

enges:

Wind Farm Siting | MPAs | Oil Platforms leak | Climate and Coastal protection | Climate change | Coastal protect

Fisheries management | Fisheries impact | Marine Environment | Eutrophication | River inputs | Bathymetry

Arctic | Atlantic | Baltic | Black Sea | Med Sea | North Sea

Wind Farm Siting

Atlantic - Wind Farm Siting

Baltic - Wind Farm Siting

budget

	Preparatory Actions	Transitional	European Maritime and Fisheries Fund			
			2014	2015	2016	total
			thousand euro			
thematic groups	**6,350**	**16,350**	**1,194**	**5,100**	**13,590**	**42,584**
bathymetry	2,175	2,000		5,100		9,275
biology	750	1,700			1,770	4,220
chemistry	700	4,000			2,820	7,520
coastal areas			1,194			1,194
geology	925	4,200			4,500	9,625
human activity		2,060			1,700	3,760
physical habitats	800	1,390			1,400	3,590
physics	1,000	1,000			1,400	3,400
stress tests		**1,695**	**4,175**			**5,870**
observation				**4,000**		**4,000**
central services		**520**		**4,700**	**180**	**5,400**
studies	**230**	**450**				**680**
total	**6,580**	**19,015**	**5,369**	**13,800**	**13,770**	**58,534**

- why we are doing it
- what we are doing
- what we will do next

EMODnet European Marine Observation and Data Network

Questions from Commisisoner

European Commission

- what are benefits for the economy, environment or society? What main benefits can be envisaged for the future?
- how can we engage industry (shipowners, wind farm operators, etc.) in contributing to ocean observation and mapping?
- If EU were to support programmes
  - what are the operational priorities?
  - what resources are needed and what exists already?
  - what could the EU's role be in addition to Member States, private sector and international partners?
  - what is the scope for and potential benefit of international cooperation?
- if choices have to be made, would you be prepared to see some EU research money spent on observation or mapping instead?

EMODnet
European Marine Observation and Data Network

European Commission

Any questions?

THOUGHTS ON A POSSIBLE WAY FORWARD IN EVALUATING OCEAN OBSERVATORIES

Claire Jolly
Head, OECD Space Forum / Ocean Economy Group
Directorate for Science, Technology and Innovation
Organisation for Economic Co-operation and Development

OECD Ocean Economy Group / AtlantOS project
Workshop: Exploring the Economic Potential of Data from Ocean Observatories
27 - 28 June 2016, Kiel, Germany

OECD BETTER POLICIES FOR BETTER LIVES

International context is favorable

- G7 initiative on the seas and oceans
- Galway Statement on Atlantic Ocean Cooperation
- Ongoing large-scale projects (AtlantOs Project…)
- Observations will remain *issue-driven*

The need to move forward…?

- More pressure to come with demands for more evaluation / impact assessment
- It remains key to maintain the effort in building **internationally** the **knowledge base** to provide:
  - Know-how and valid experiences to practitioners (avoiding reinventing the wheel)
  - **Evidence-based** information to **decision-makers and citizens** on benefits (and limitations) of ocean observations

Two complementary approaches

- The low hanging fruits…

- … and the longer-term let’s piece everything together

The low hanging fruits

- Some questions that were raised:
  - « What are ocean observations? What are we trying to measure? »
  - « What are the benefits of different observations ?»
  - « How to measure impacts of complex distributive systems? »
  - « Where is the value? »

➢ **Building on what exists**: Populating the « value chain approach »

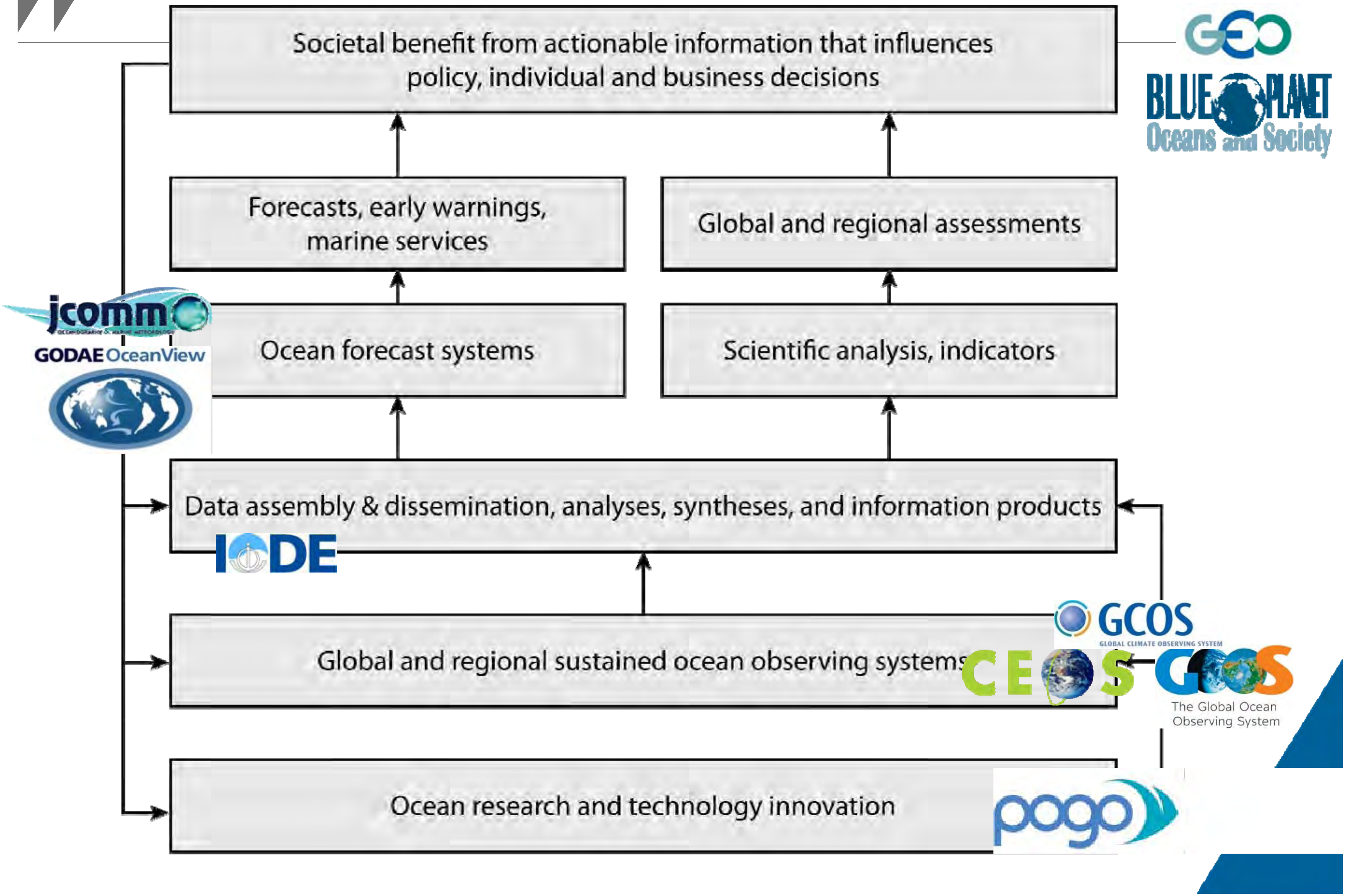
1. Forecast vs. Assessment
2. Needs of ocean-based industries (with added forward look)

Slide source: Visbeck, 2016

A value chain

Innovation, observations, data management, forecasts / science & assessment, societal benefit

Adapted from G7 Think Piece on Ocean Observations



Recent studies – OECD Ocean Economy in 2030

Ocean-based industries

Slide source: Rayner, 2016

Established		Emerging	
Capture fisheries	★	Marine aquaculture	★
Seafood processing		Deep- and ultra-deep water oil and gas	★★★
Shipping	★★	Offshore wind energy	★
Ports	★★	Ocean renewable energy	★
Shipbuilding and repair		Marine and seabed mining	★
Offshore oil and gas (shallow water)	★★	Maritime safety and surveillance	★
Marine manufacturing and construction		Marine biotechnology	
Maritime and coastal tourism	★	High-tech marine products and services	
Marine business services		Others	
Marine R&D and education	★		
Dredging	★		

The low hanging fruits

- Developing new relevant indicators to demonstrate
  - SPILLOVERS = Bibliometrics (from marine science to diverse economic sectors)
  - INTENSITY = Mapping intensity of data usage (time series on data downloads)
  - COST EFFICIENCY (if / when they exist) = Cost per measurement of systems used for selected essential ocean variables

Let’s piece everything together

- **Concept and methods** on assessing the (mostly public good) benefits of ocean observations
  - Best practices: cataloguing, agreeing and then diffusing them to the larger community
  - Building families of case studies

- **Industry surveys:** mapping commercial activities
  - On the besis of NOAA / UK studies: setting up together definitions and best practices
  - Encouraging other countries to develop surveys

Open issues

- Any other ideas?
- Would these efforts make a difference?
- Would these efforts make a difference in YOUR activities?

Next step for OECD evidence-based analysis: A focus on innovation

- Launch of a new OECD/STI programme of work on ***"Fostering innovation in the ocean economy"*** *(2017-18)*, complementing usefully international initiatives (no duplication).

- An advisory group of countries and experts for the project is forming.

- First meeting planned for **8-9 December 2016** in OECD, Paris.

Next step for OECD evidence-based analysis: A focus on innovation

Building on OECD report’s recommendations and large international consultation:

Research and analysis in 4 modules

1. New enabling technologies / innovations (born from sectoral interconnections and interdependencies)
2. New patterns of collaboration
3. New uses of economic valuation, analysis and tools
4. New policy mix in boosting innovation for greening marine and maritime activities

Proposed Module 3

Extend the frontiers of the use of economic valuation, analysis and tools further into areas of ocean-related activities (with the objective to underpin policy-design, decision-making and planning with better evidence-based indicators).

Strategic points of entry:

- evaluating economic benefits of large-scale ocean observation;
- upgrading the OECD Ocean Economy Database;
- creation of satellite accounts for the maritime sector;
- exploring economic concepts that comprehend both ocean industry and ecosystem assets and services;
- measuring ecosystem assets and services.

Fostering Innovation in the Ocean Economy: Main Outputs

- ✓ Expert workshops with themes linked to the different modules (Naples and Lisbon in 2017...)
- ✓ A series of expert OECD reports derived from each of the workshops;
- ✓ A final OECD synthesis report;
- ✓ An international symposium in 2018 in OECD to share the findings with decision-makers in the public and private sectors, and other events to highlight the findings of the work conducted.

The way forward

- The Ocean Economy makes a very significant contribution to the economy and in meeting global concerns.
- Increasing ocean-based activities add to already existing pressures on the health of the marine ecosystems.
- Innovation may be key to the economic success of the Ocean Economy and can help in reducing ocean health issues.

- **Via a new programme of work in 2017-18 contributing to more evidence-based, the OECD is ready to play a role in strengthening integrated and sustainable ocean management with interested countries…**

Ocean Observatories - Lessons Learned from Canadian Experiences

Exploring the Economic Value Potential of Data from Ocean Observatories
Kiel, Germany June 27-28, 2016

Jim Hanlon CEO

Institute for OCEAN RESEARCH Enterprise

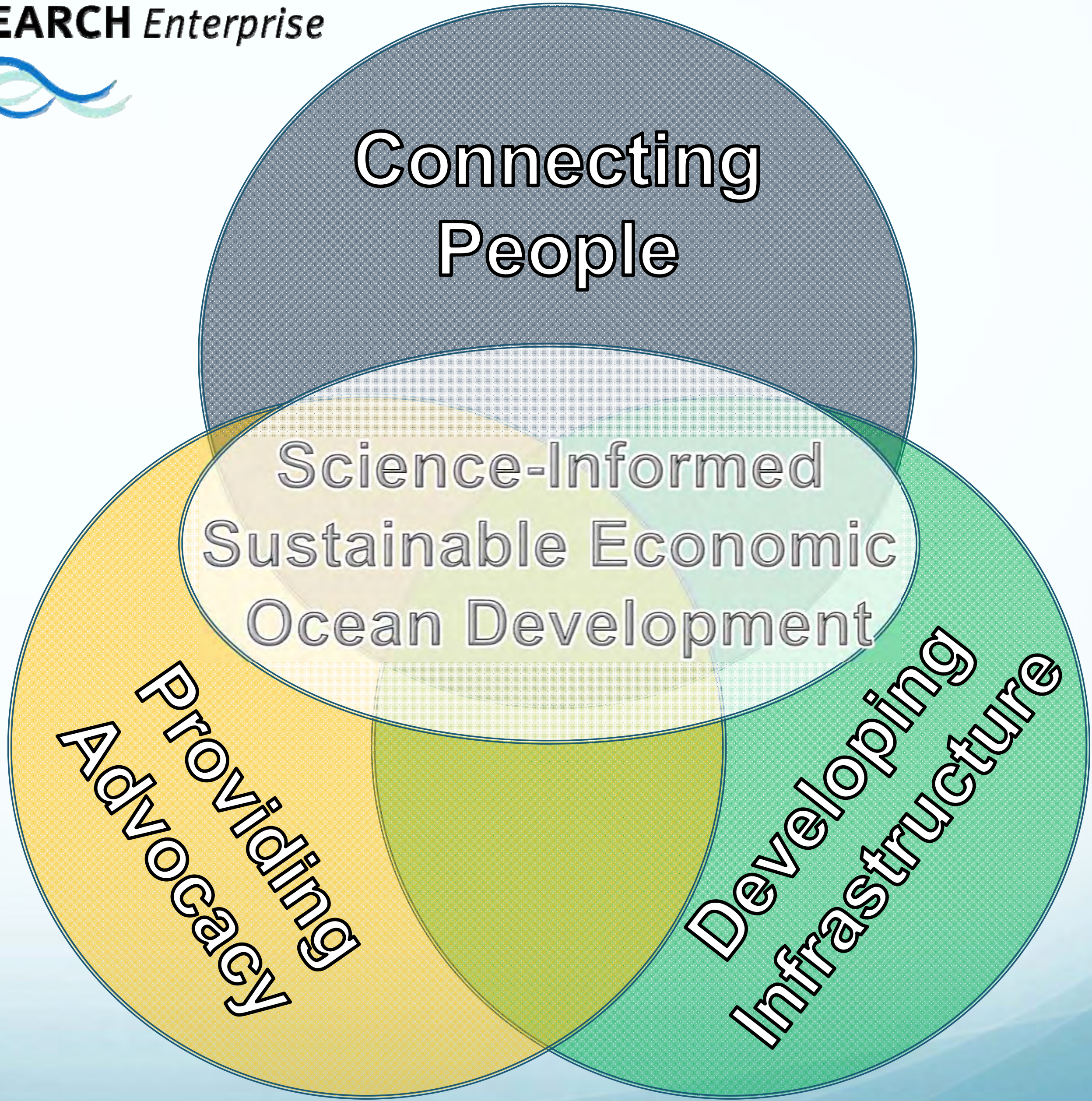
Institute for **OCEAN RESEARCH** *Enterprise*

An incorporated, not-for-profit, collaborative ocean research and marine innovation vehicle

Involvement from Colleges & Universities + Government Labs + Private Industry

Facilitates project engagement and product commercialization

Invests in shared infrastructure where appropriate



COVE

centre for ocean
ventures & entrepreneurship

Institute for **OCEAN RESEARCH** *Enterprise*

Canada's Challenge: Big Ocean – Small Economy

- **World's Longest Coastline >200,000 Km**
- **Population ~36 Million (37th)**
- **GDP ~1.8 trillion USD (11th)**
- **~2.1% of GDP is Oceans Related vs. 5% for US**

So, must be efficient & innovative

Institute for **OCEAN RESEARCH** *Enterprise*

Experience of Some Canadian Observatories

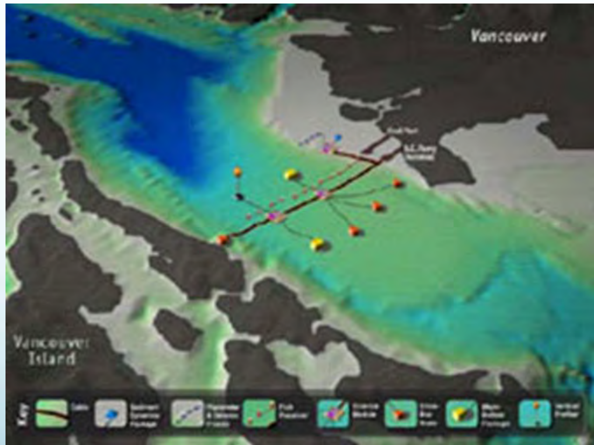
- Ocean Networks Canada
- CHARS
- FAST / FORCE
- SmartAtlantic
- Ocean Tracking Network

Ocean Networks Canada

- $250 million cabled observatory
- Back-end Data Management System
- Test bed for instruments
- Owned by U of Victoria
- Initial rationale was tsunami warning
- Funded by CFI, NCE and Province of British Columbia

Neptune Array

Venus Array



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Canadian High Arctic Research Station

- $250 Million of Capital Cost through 2018
- $26.5 annual operating budget

Funding from Environment & Climate Change Canada, Fisheries & Oceans Canada, Indian & Northern Affairs

Rationale is Northern Development – fisheries, transportation and training

Fundy Ocean Research Centre for Energy FORCE

- Monitors and Develops open flow tidal stream energy in Bay of Fundy
- Funded by Canadian Gov't, Province of Nova Scotia and Industry Partners
- Environmental Monitoring includes Fundy Advanced Sensor Technology (FAST) Platform

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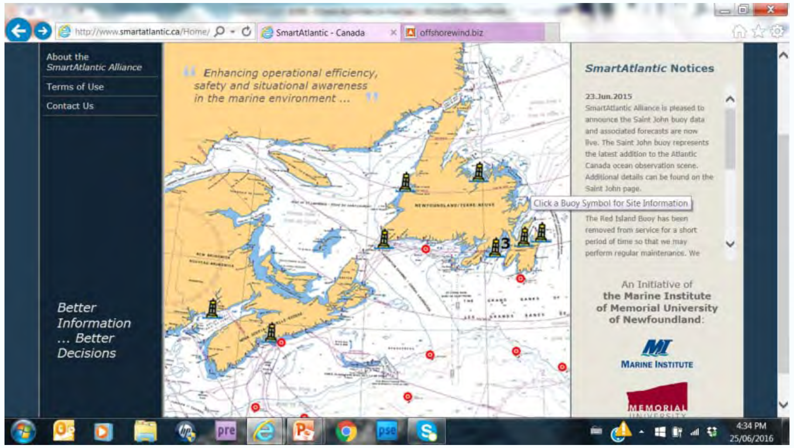
SmartAtlantic Network

- Network of 8 coastal buoys & associated predictive models
- Operational Users: port authorities, pilots, shipping companies
- Science Users: ocean modellers
- Funded by consortia of private companies and government agencies
- Operated by academic groups & NFP organization



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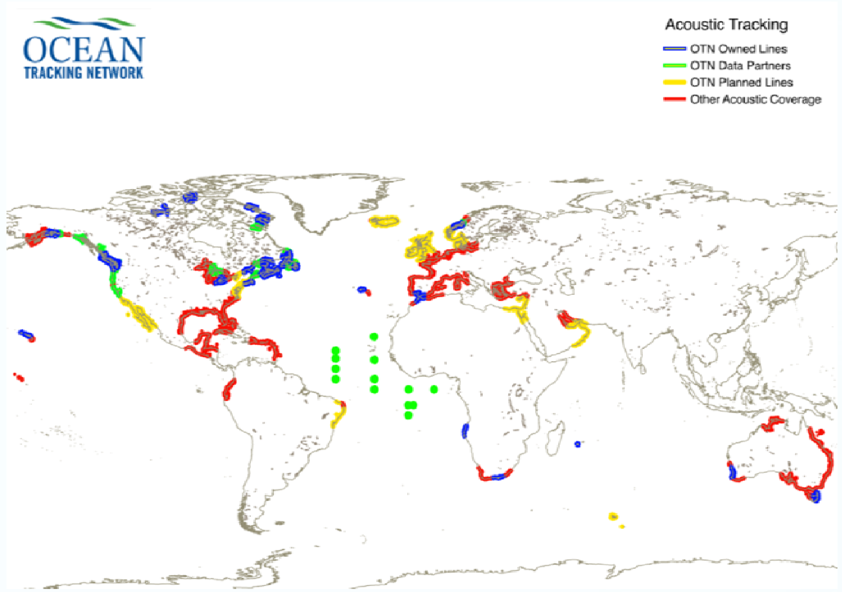
OCEAN TRACKING NETWORK

- Global marine animal tracking network
- 400 researchers in 19 countries
- Hosted by Dalhousie U
- ~$160 million funding from CFI, NSERC and private companies



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Funding Methods

- Pure Government Funding
  - CHARS
- Academic Led with Federal Funding from NCE / NSERC / CFI
  - ONC
  - OTN
- Private Sector Led with Federal Funding
  - SmartAtlantic
  - FORCE FAST

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Rationale for Funding

- Operationally Useful
  - Data is valuable
  - Testbed is valuable to tech developers
  - Evidenced by financial contribution
- Scientifically Useful Data
- Publicly Useful Data

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Canadian Challenges

- Multiple Levels of Government Mandate & Interest
  - Federal / Regional / Provincial / Municipal
- Data Rights – “Queen in Right of Canada”
- Ethical Differences between ocean scientists and ocean business (e.g. OTN data to fishers)
- Academic Funding can encourage redundant creation of infrastructure & can be short-term
- Capex easy – Opex hard; need to consider long-term viability at the outset

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Canadian Opportunities & Successes

- Private Sector Involvement Ensures Success – e.g. SmartAtlantic Halifax & St John’s
- Canadian Federal Government is now pro-science and pro-environment
- Virtually all ocean academic funding requires industry collaboration
- Move towards shared infrastructure & JOC model

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