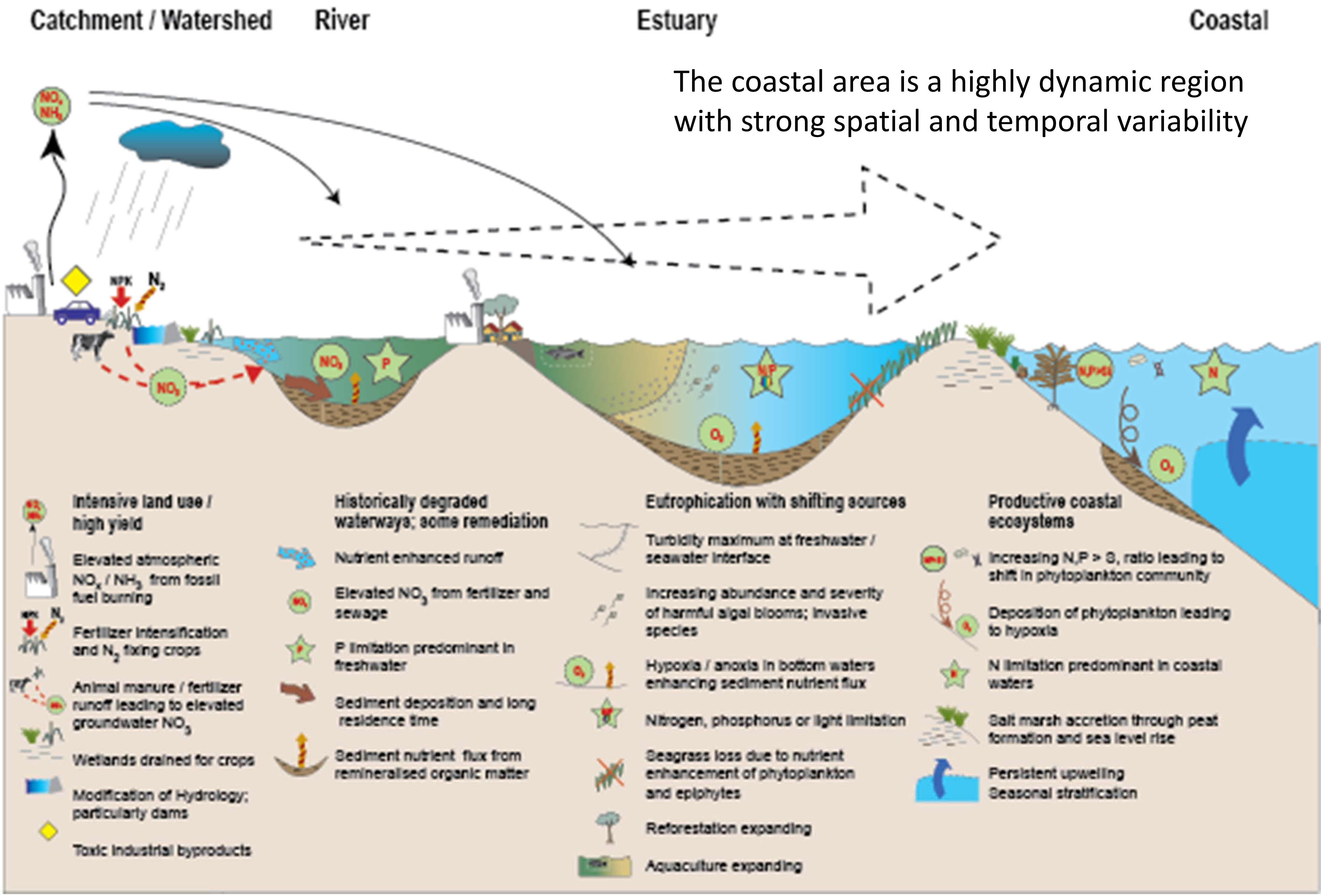
“The Coastal component of operational oceanography: State of the art and required forward steps

George Petihakis
Institute of Oceanography - HCMR

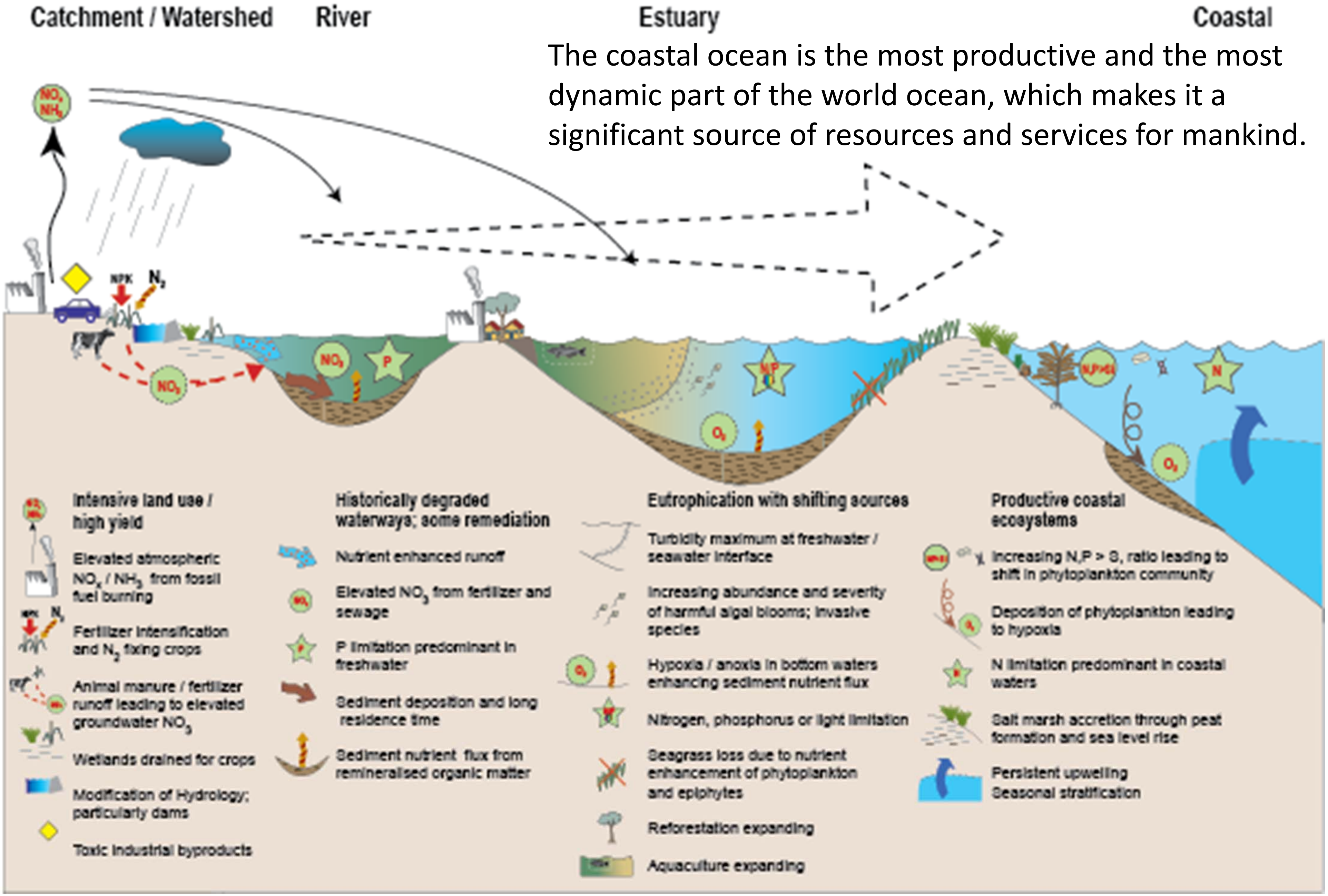
Temperate Coastal Ecosystem

The coastal area is a highly dynamic region with strong spatial and temporal variability



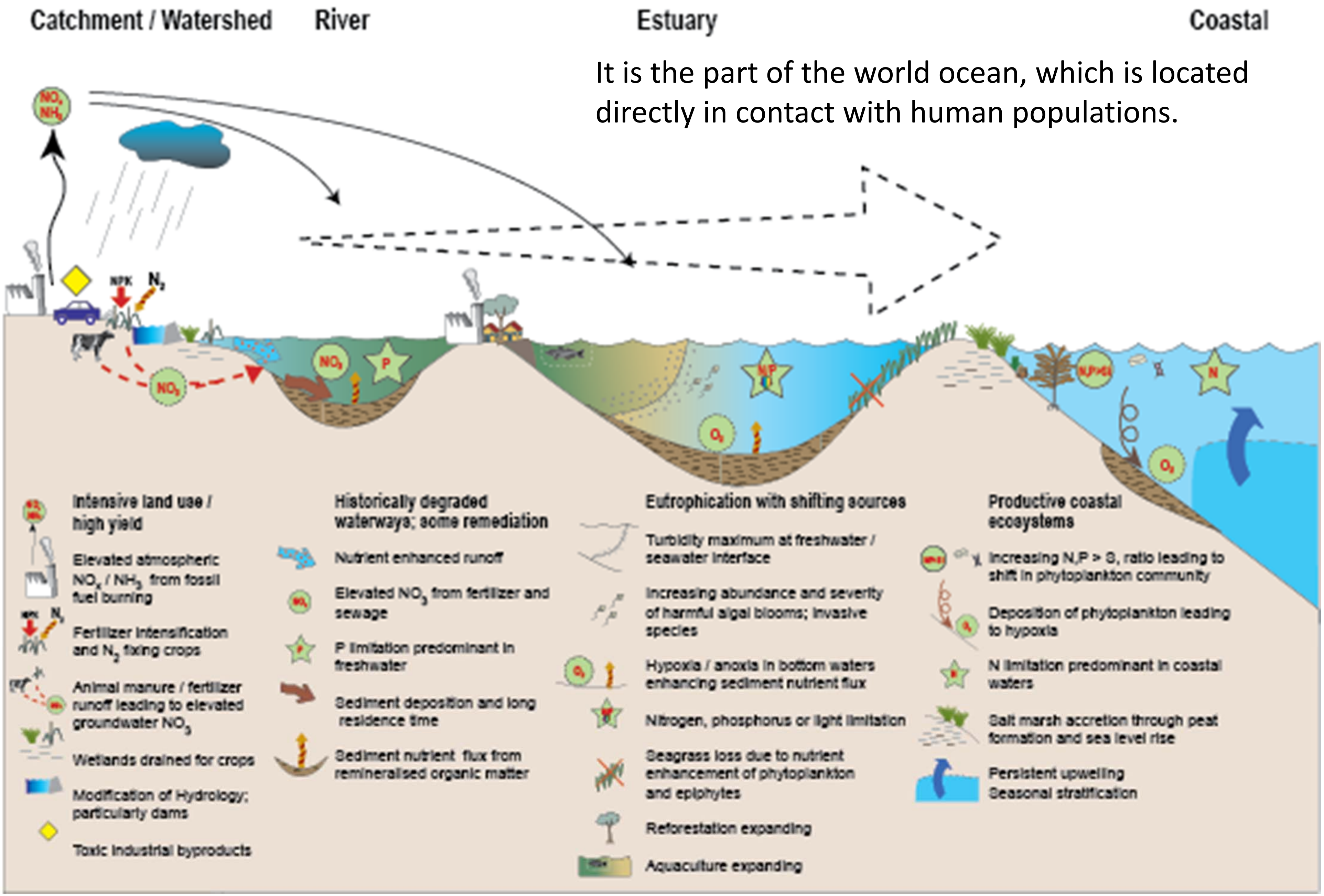
Temperate Coastal Ecosystem

The coastal ocean is the most productive and the most dynamic part of the world ocean, which makes it a significant source of resources and services for mankind.

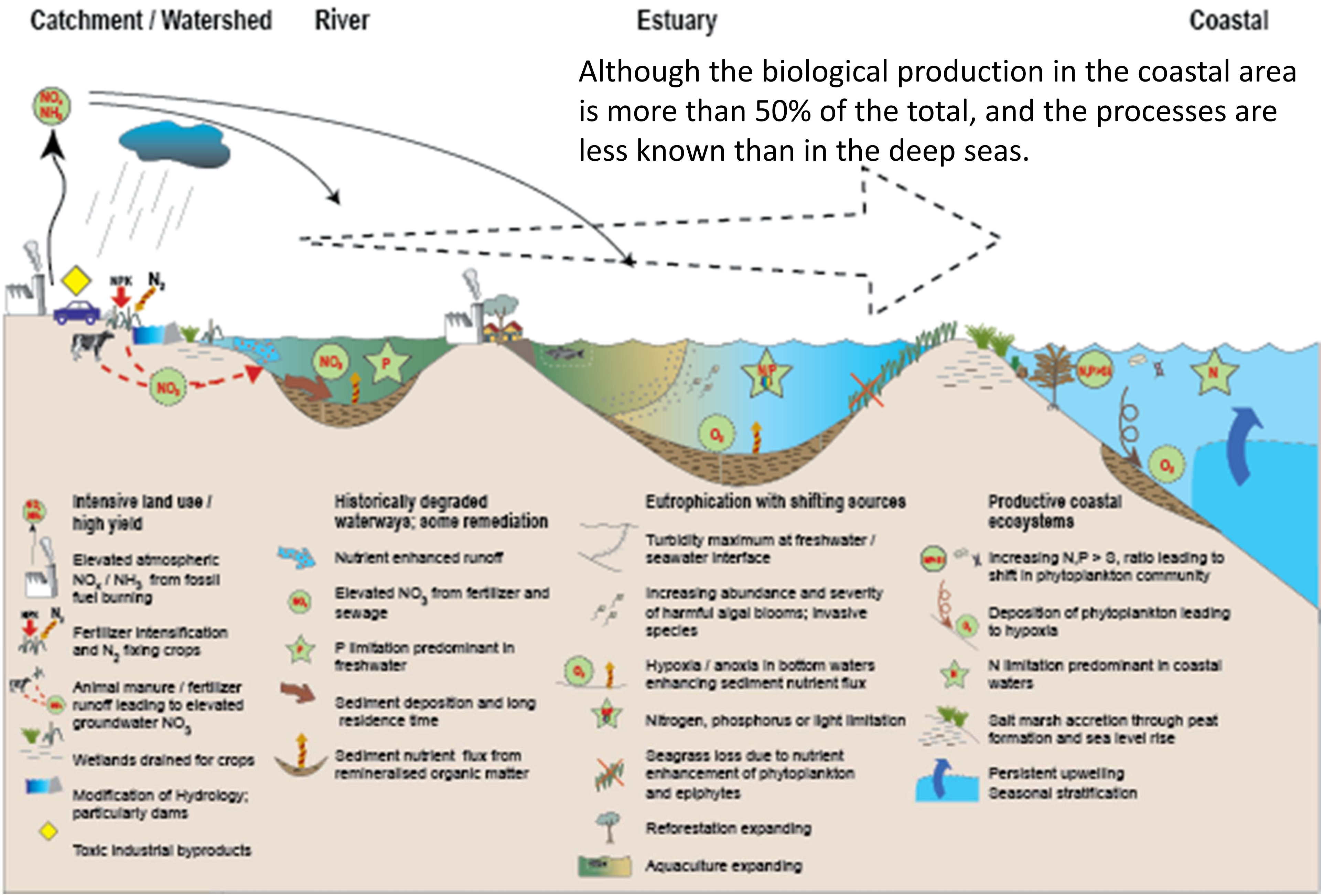


Temperate Coastal Ecosystem

It is the part of the world ocean, which is located directly in contact with human populations.



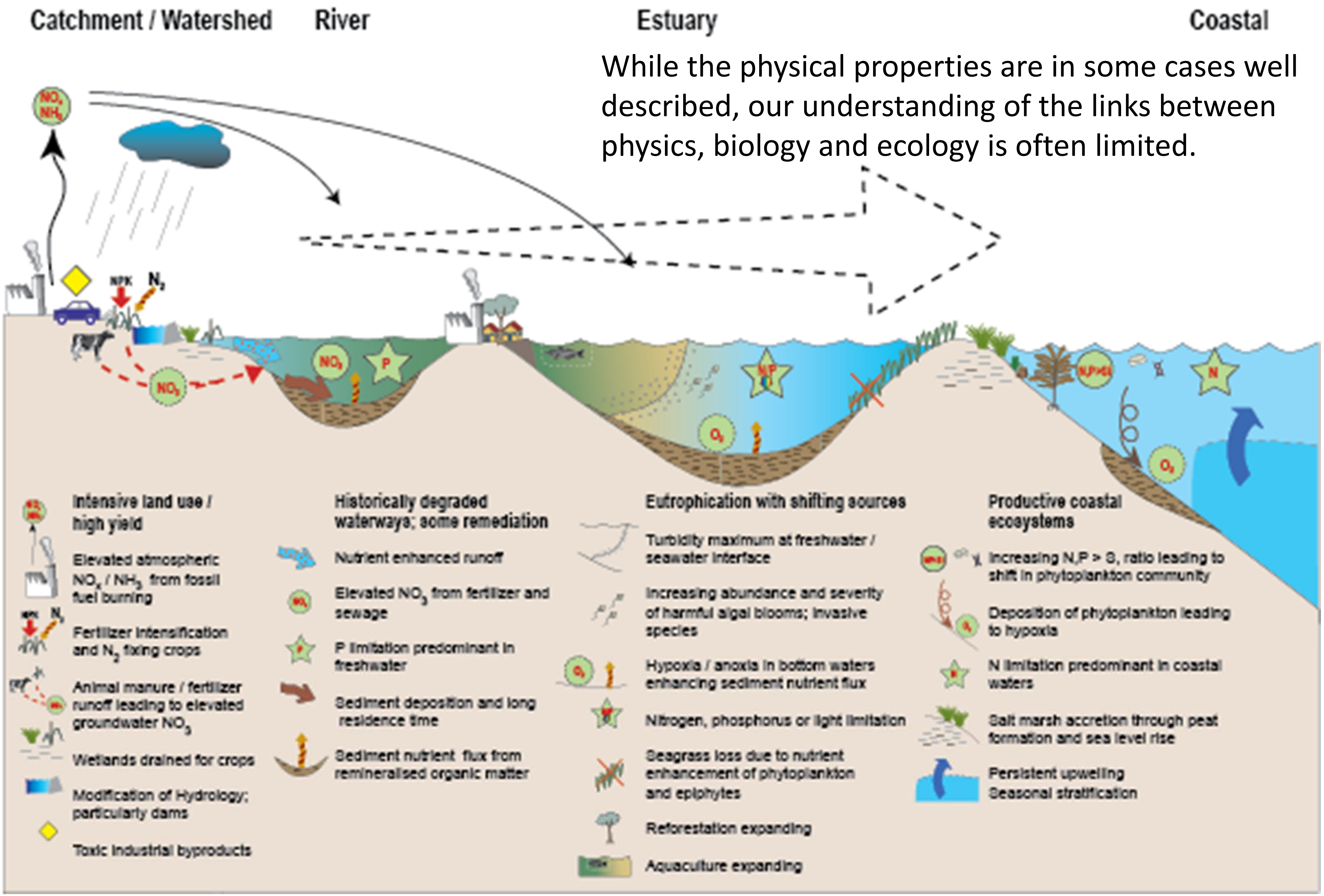
Temperate Coastal Ecosystem



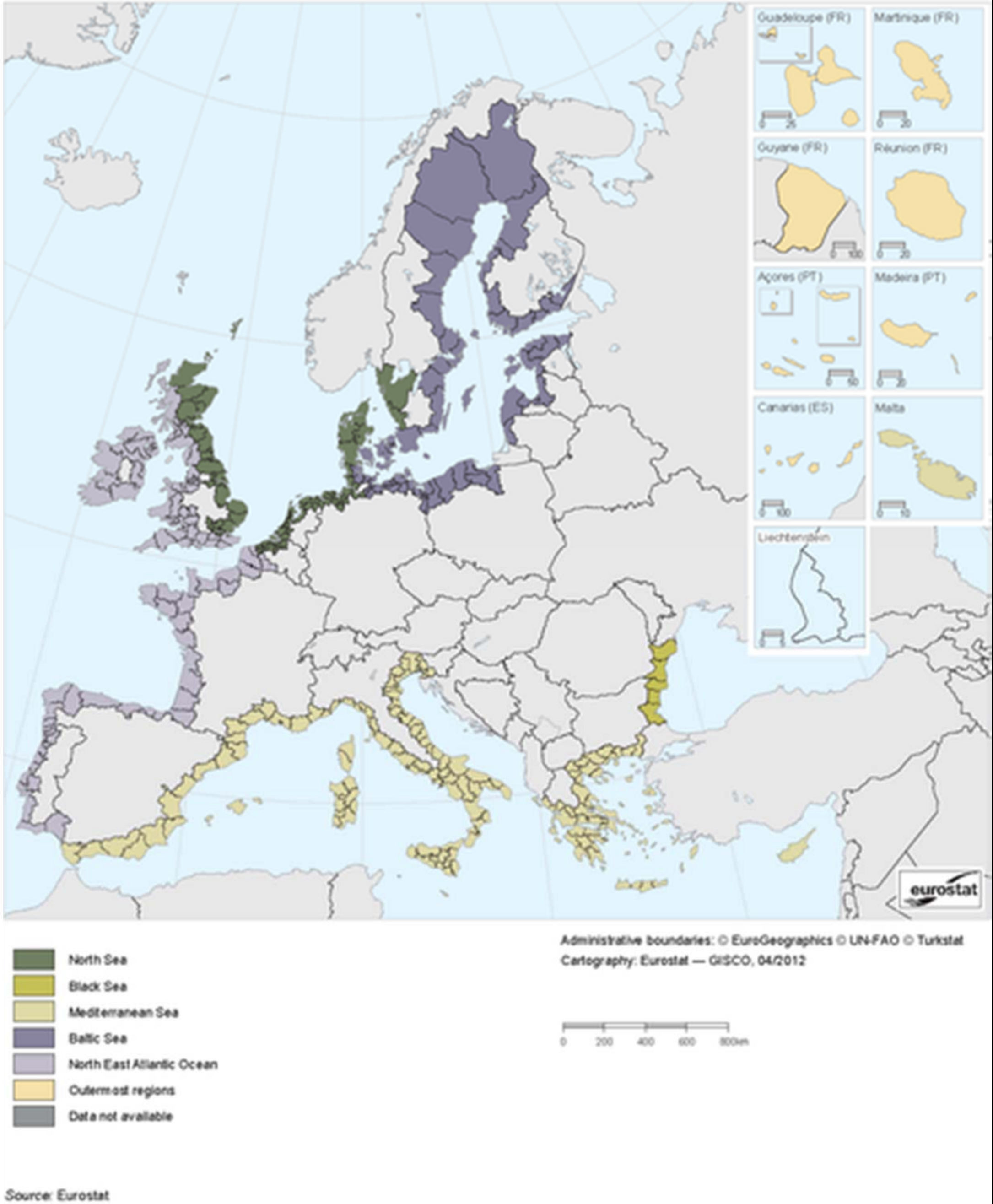
Although the biological production in the coastal area is more than 50% of the total, and the processes are less known than in the deep seas.

Temperate Coastal Ecosystem

While the physical properties are in some cases well described, our understanding of the links between physics, biology and ecology is often limited.

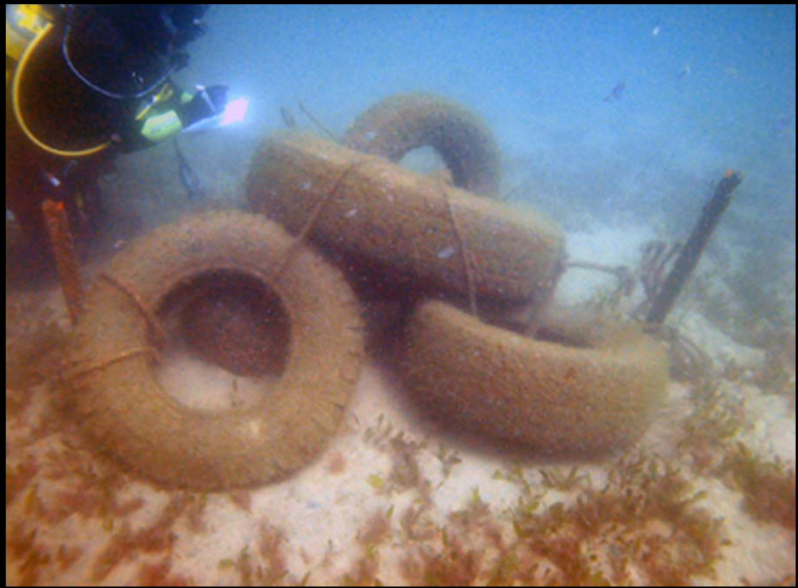


Coastal regions in the EU, by sea basin and by NUTS 3 regions



- The coastline of the European Union is just over 41,000 miles long.
- Coastal regions generate around 40 % of EU GDP
- Approximately 40 % of the EU population lives within 50 km of the sea, and this is growing
- In some parts of the Med coast in Spain and France, the population has increased by up to 50 % between 2001 and 2011
- In terms of tourism in the EU there are ~28.1 million bed places in hotels, campsites and other collective tourist accommodation
- 3/5 are in coastal regions
- 7.1 million bed places - 43.2 % of the total are around the Mediterranean Sea

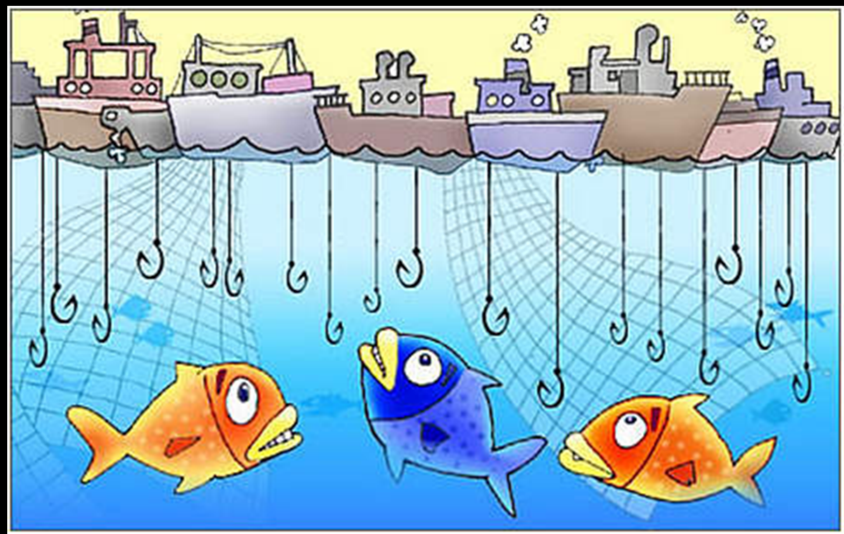
Increased pollution



Degradation of coastal habitats

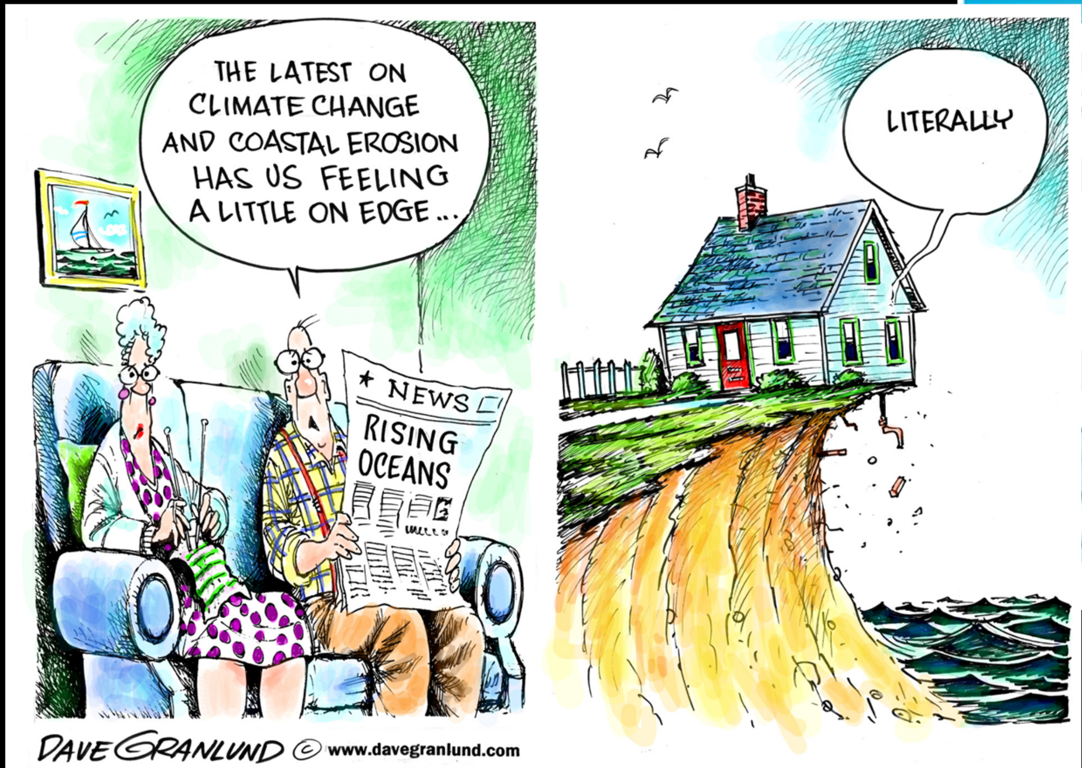
Greater demand for non-living resources (renewable energy),

Over-fishing that result in declines in ecosystem health and biodiversity



Coastal systems → Greater sensitivity to anthropogenic effects:

- climate change modifies natural biotic and abiotic cycles
- the human land-based activity generates fluxes of nutrients, contaminants and carbon dioxide which have a strong impact on the structure and functioning of coastal marine ecosystems.

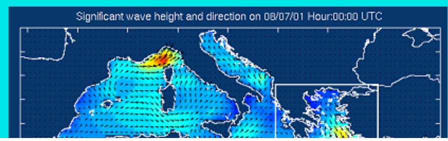


Marine ecosystem health, the understanding of the complexity of the webs, the loss of biodiversity and the coastline erosion are currently some of the main societal questions.

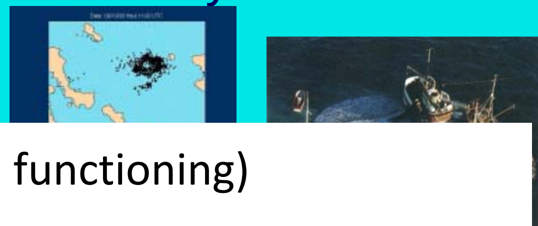
We need an integrated system able to support science, safety, environment and maritime economy

Observations

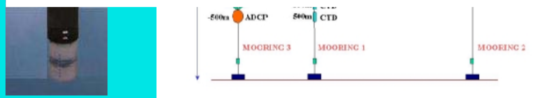
Processing & Modeling

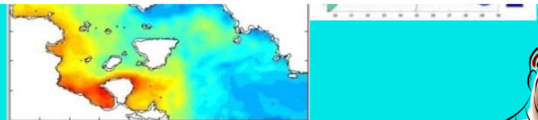


Information and Decision Support Systems



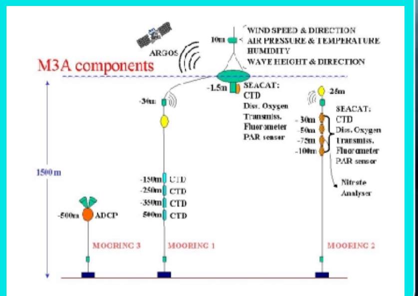
- **Research** oriented applications (climatic variability, ecosystem functioning)
- Support of **maritime transport** (forecasts, SAR)
- Environment **protection** (ecosystem health, oil pollution)
- Support of **tourism** industry (water quality, yachting, ..)
- **Fisheries** and aquaculture management
- **Coastal** zone management (erosion, etc)
- EU Directives - Water framework directive





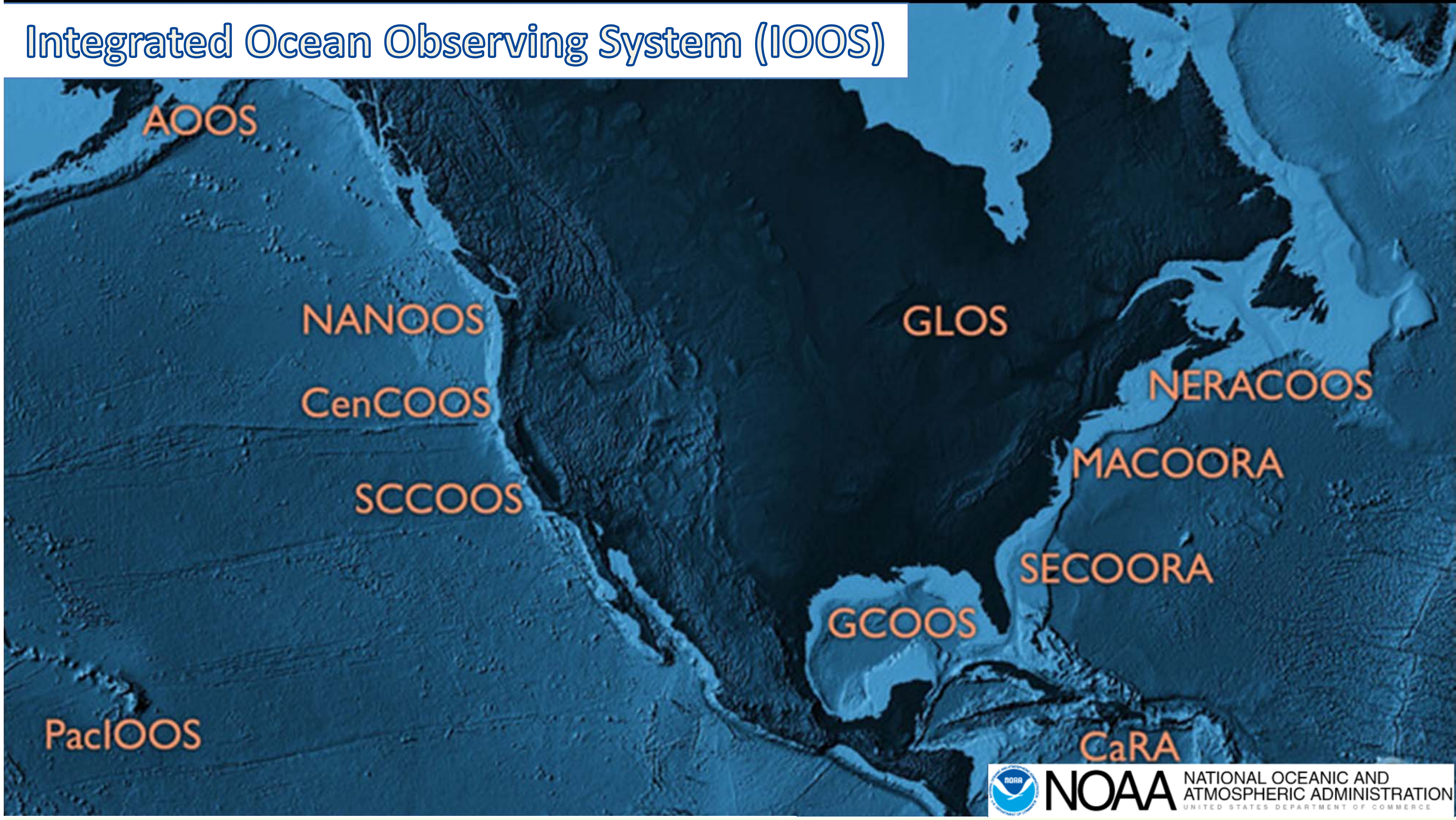
End Users

Observations



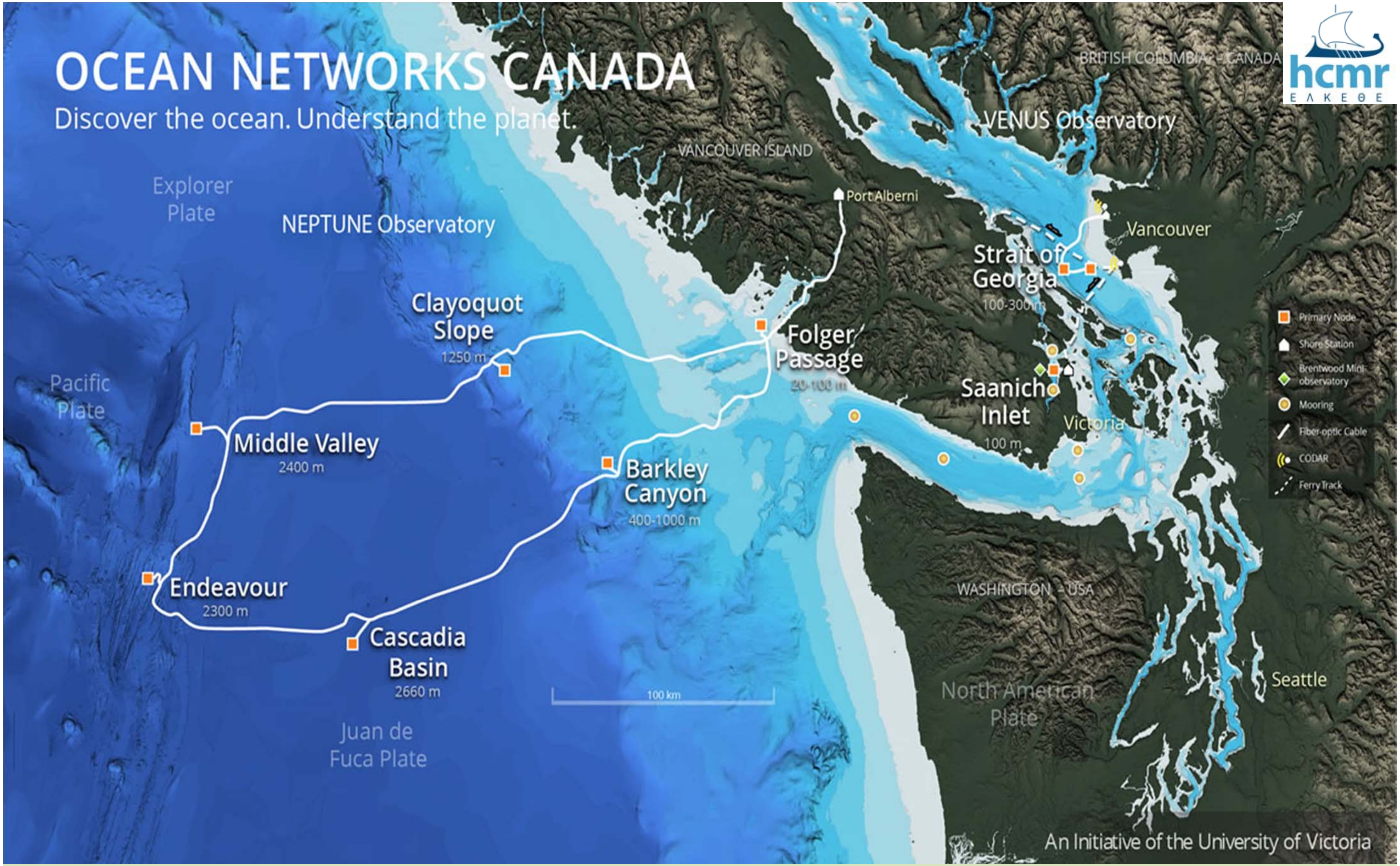
Coastal Observatories around the world

Integrated Ocean Observing System (IOOS)



11 Regional Associations

Alaska (AOOS)
Caribbean (CaRA)
Central and Northern California (CeNCOOS)
Gulf of Mexico (GCOOS)
Great Lakes (GLOS)
Mid-Atlantic (MARACOOS)
Pacific Northwest (NANOOS)
Northeast Atlantic (NERACOOS)
Pacific Islands (PacIOOS)
Southern California (SCCOOS)
Southeast Atlantic (SECOORA)



3 observatories
5 shore stations
850+ km seafloor backbone cables
11 instrumented sites (nodes)
32 instrument platforms
6 mobile instrument platforms (3 more on the way)

180 instruments online 24/7/365
3400 measurement sensors
2006 – the year VENUS observatory first went online
250+ terabytes of data archived
290 gigabytes of data collected every day
$0.00 – your cost to use the data

OCEAN OBSERVATORIES INITIATIVE

The Coastal Scale Nodes

- **Vision:** Long-term and high spatial-resolution sampling to understand the physics, chemistry, ecology, geology, and climate science of the societally important coastal regions.
- **Science drivers:** Variability in major currents such as the Gulf Stream and California Current; nearshore fisheries and regime shifts; coastal carbon budget; land-ocean transport of carbon, nutrients, sediments, and fresh water; shelf, shelfbreak, and slope exchanges; coastal hazards such as storms, tsunamis, and harmful algae.
- **Current technology:** Dispersed, non-networked installations of instrumented buoys and shallow-water observatories.
- **Observatory state of the art:** Surface and subsurface buoys with capabilities for power generation and satellite communications, cabled moorings, and profiling moorings. Fleets of autonomous underwater vehicles will augment coastal observatories, providing spatial coverage unachievable with stationary assets. There are two configuration types: (1), the relocatable Pioneer array placed around a region of interest for intensive studies lasting up to five years; and (2), the Endurance array, composed of permanent cross-margin lines of three to six moorings, some cabled to shore, to support sustained, high-frequency observations.

IMOS

Integrated **Marine Observing** System

hcmr
ΕΛΚΕΘΕ

Coastal Observatories in Europe

- European coastal observatories have different strengths and weaknesses arising from their geographical situations, their requirements and funding constraints.

- National funds have guided the development of coastal observatories:
  - Serving national priorities the major driver – lesser extent international conventions
  - Satisfying the demands with a single, affordable, monitoring system is a challenge
  - Very diverse systems (different technologies)
  - Often there are overlaps between neighboring countries
  - Sustainability is a key issue and in some cases sites with long term observations have been closed
  - Costs are high – low exchange of know how – no shared infrastructure like calibration labs

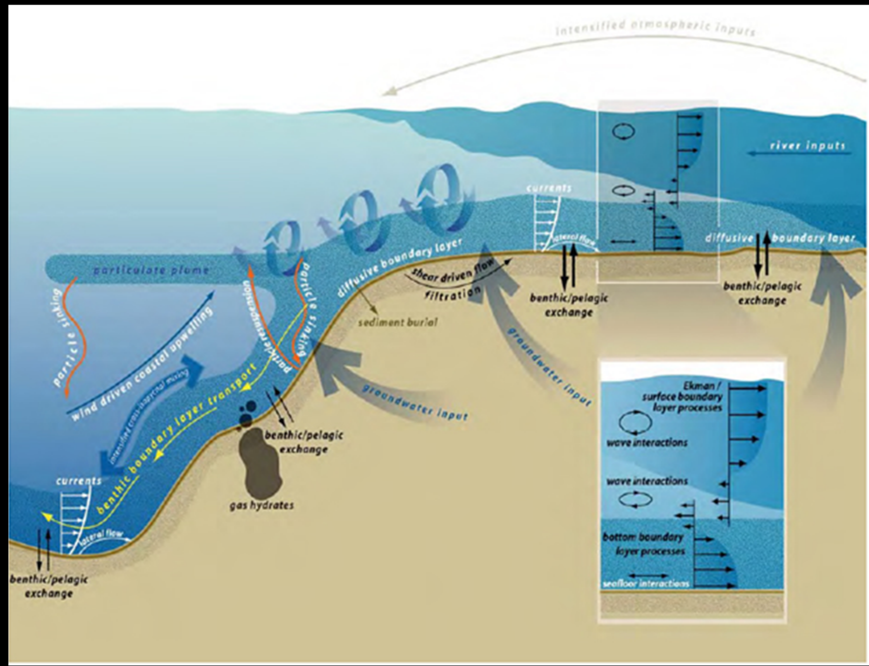
- Besides national priorities today Coastal observatories have also to support European legislation and a sustained Marine Core Service (MCS).

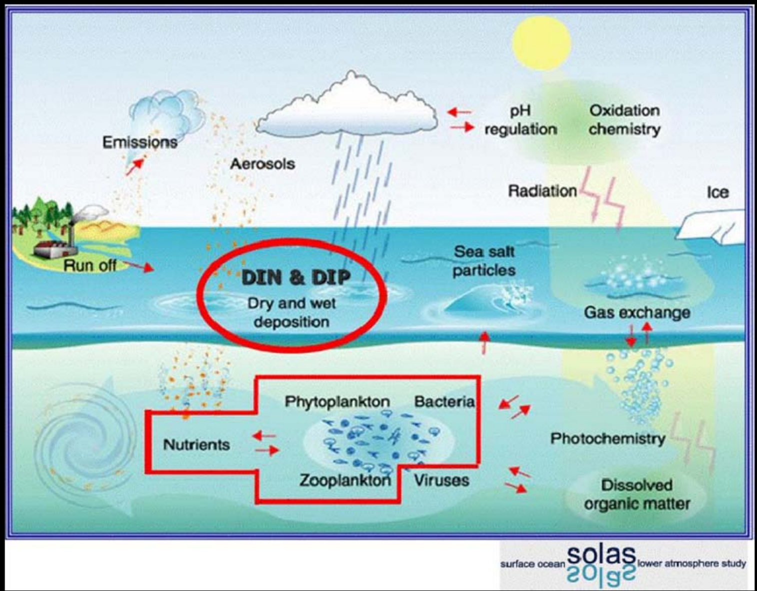
- Coastal observatories can play a big part in understanding and fulfilling these demands through the implementation, integration and assessment of multiple data types, and the establishment of long time series of coherent multi-disciplinary data.

- Europe has led the way in using instrumented ferries as platforms for measuring surface properties (http://www.ferrybox.org).

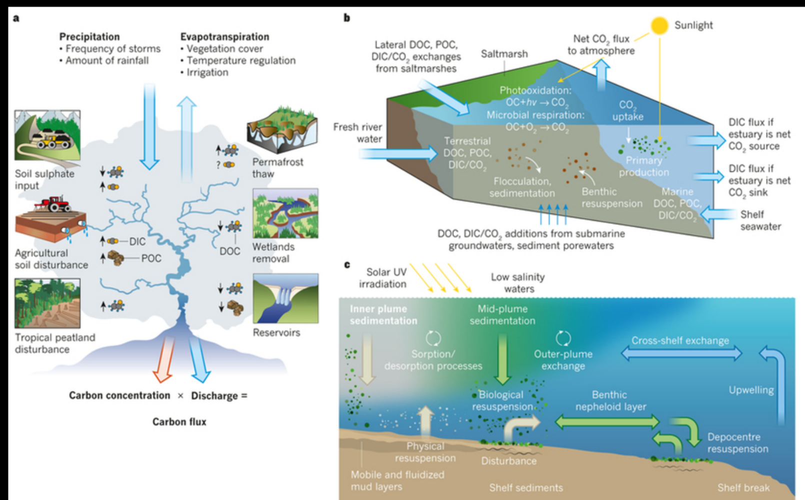
!!! But the Coastal system is VERY COMPLEX with many different processes operating at various spatial and temporal scales

Both in terms of physics

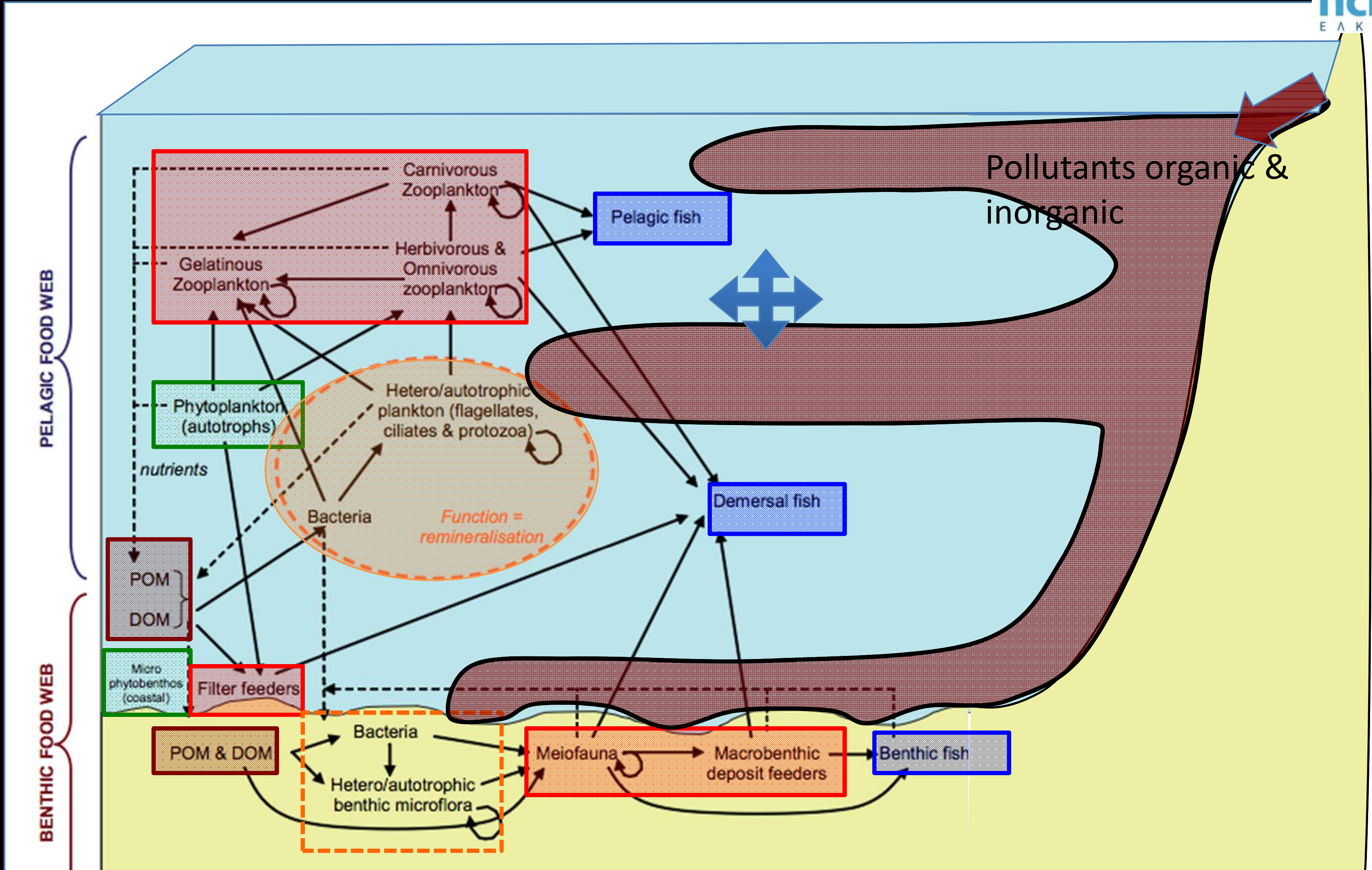




chemistry

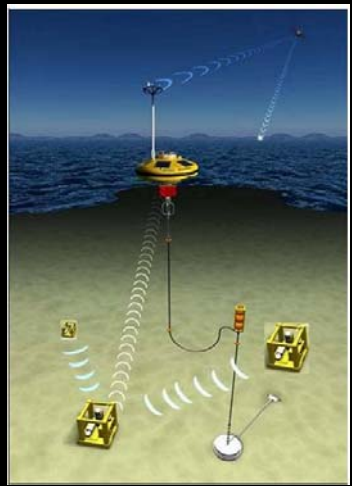


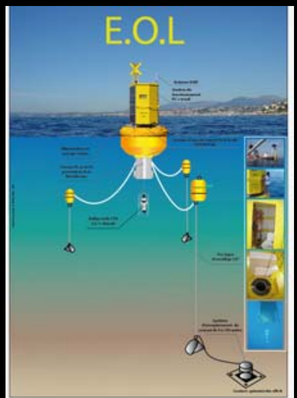
but especially in terms of biology

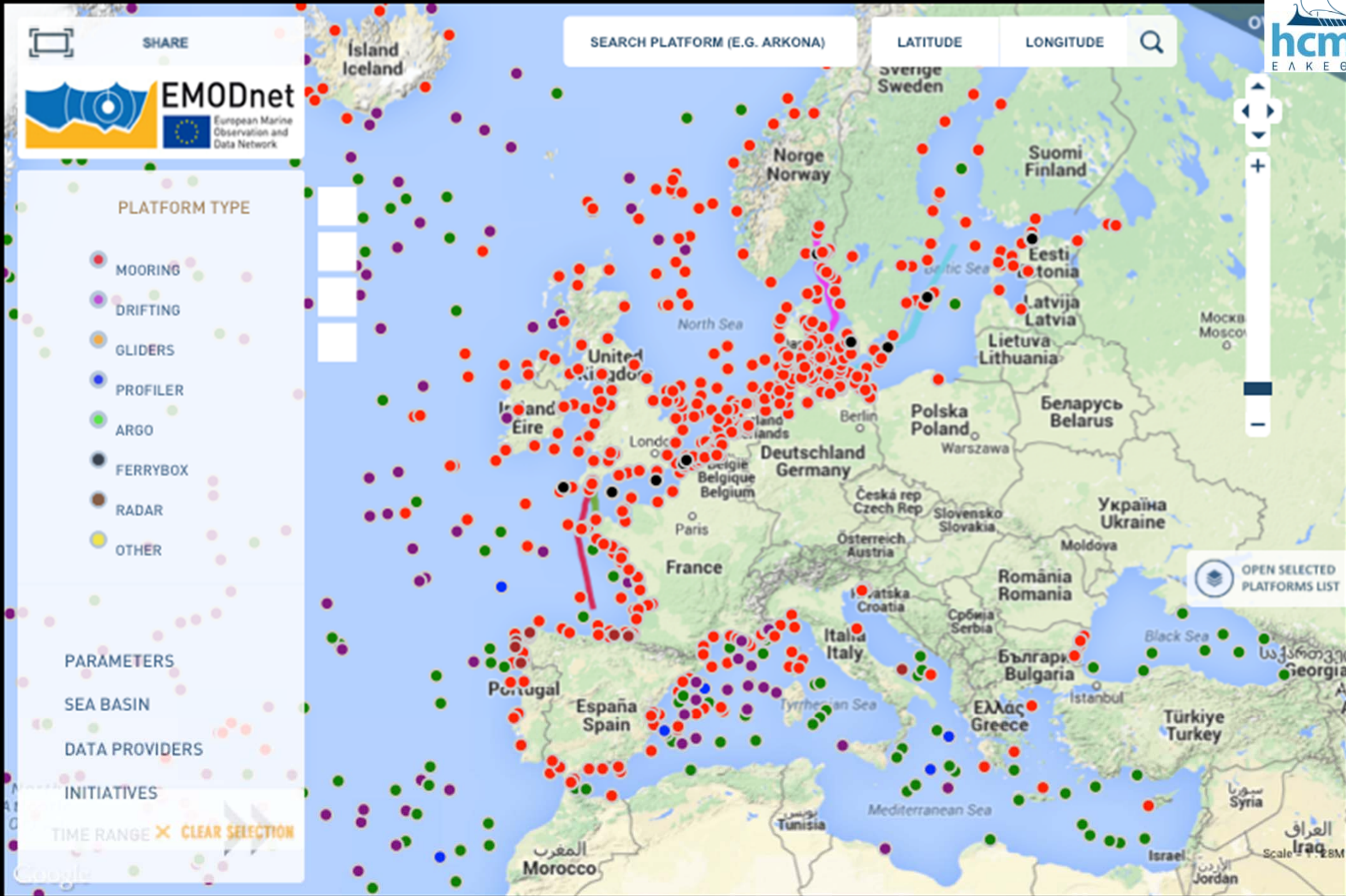


the monitoring of all living and dead 'particles' requires integrated (all trophic levels) and rapid methods

Multi platforms in appropriate multi scales (temporal and spatial)







They seem a lot and in particular in the coastal areas

Well Dots are quite big and.... don't forget the COMPLEXITY

MONGOOS Data Portal

Supported by: (http://www.hcmr.gr) (http://www.myocean.eu) (http://www.emodnet-physics.eu)

Eastern Med an "observation dessert"

FerryBox pros and cons

Advantages

- Cost effective (no costs for the platform)
- Real-time/near-real-time data
- High spatial and temporal resolution (repeat transects)
- Often covers regions of socioeconomic importance
- "Friendly" environment for the system
  - No energy limitations
  - Good for testing/operating new sensors that may be less robust, or sensors/ samplers that have high energy or sample size requirements
  - Easy maintenance and antifouling measures
- Water can be sampled/preserved for advanced analysis in the lab

Limitations

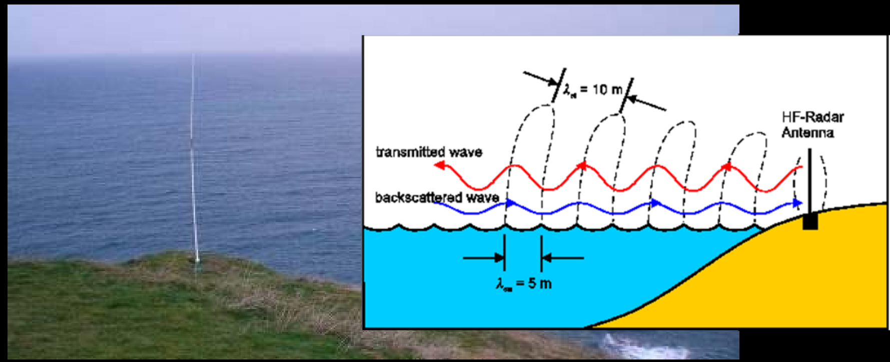
- Data limited to the transect
- No depth profiles, unless XBTs are used
- Voluntary ships/routes can change

EuroGOOS FerryBox Task Team

HF Radars pros and cons

Advantages

- Land based system with easy and relatively low cost of maintenance
- Real time high resolution and synoptic assessment of sea conditions
- Validation / data assimilation for numerical models
- Long Range radars coverage allow assessment in the buffer zone between Regional models (like Marine Core service) and downstream coastal models
- Scientific interest: Cover a wide range of spatio-temporal scales in a synoptic way to study ocean processes (HF, spatial structure)
- Operational key products for transport monitoring (Search & Rescue, pollution drift…), possibility of providing short term prediction forecast using only HF radar data.



Limitations

- No data coverage in the baseline between antennas that usually leads to poor coverage near the coast.
- Data coverage/quality in time change due to sea state conditions. Continuous QA/QC is required.
- Only water surface information (0-2 m)
- Second order information is limited (e.g. wave monitoring, tracking of discrete targets)

Julian Mader (AZTI) EuroGOOS HF Radar Task Team

Gliders pros and cons

Advantages

- They work 24 hours a day, 7 days a week.
- They cover large distances.
- They can go on long-term missions.
- They're autonomous, unmanned systems, so you don't need a large number of people on board, as you would on a boat. Therefore, they're much cheaper!
- They can include many different sensors to measure many kinds of data (temperature, salinity, chlorophyll, oxygen... even sounds!)
- They allow us to collect almost real-time data.

Limitations

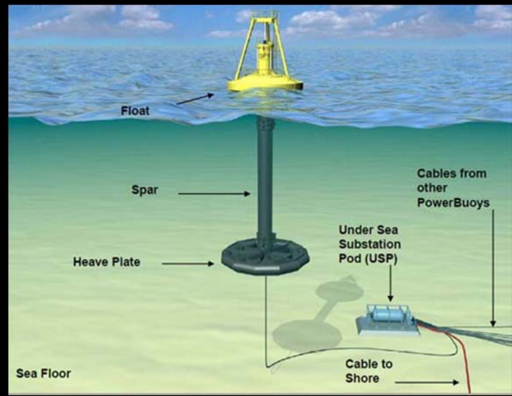
- They move very slowly.
- They can only go down 1000 meters. They can't go any deeper!
- They can't take samples on the spot. They don't have an arm that can take sand or water samples, for example. They can only collect data!
- Their sensors are still quite low-resolution compared to the ones available on boats.
- Their technology is very recent. They're still in the prototype stage, so things don't always work properly.
- Watch out! Danger! They can run into fishing nets, plastic objects, or collide with the sea floor or boats.Initial investment is high

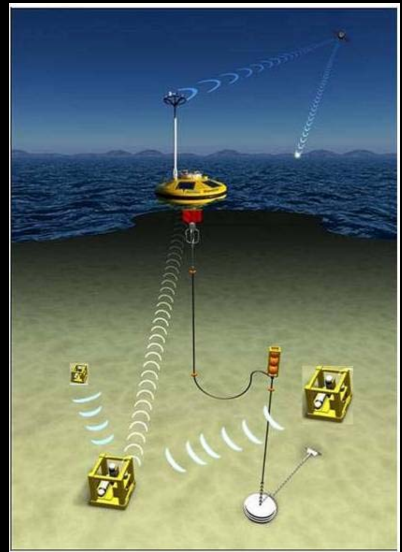
http://followtheglider.socib.es/en/estudiantes/whatisaglider/

Buoys/bottom platforms pros and cons

Advantages

- Can be located almost anywhere
- Portable
- Stable position – long term observations
- Very good vertical resolution
- Relative high temporal resolution
- Near Real time transmitting of data
- Validation / data assimilation for models
- Configuration flexibility - can host many different sensors
- Cabled Sea bed platforms
  - Unlimited power
  - Unlimited bandwidth - video
  - Payload
- Cabled buoys
  - Unlimited power
  - Unlimited bandwidth – video
  - Maintenance cost

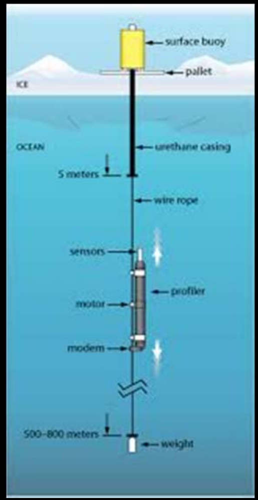


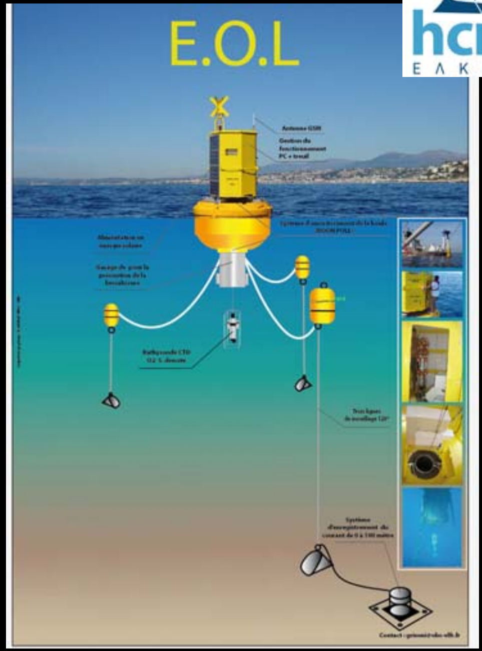


Limitations

- Can be expensive
- Biofouling
- Vandalism
- Energy
- Harsh environment – demanding for materials
- Need supporting infrastructure (calibration)
- Experienced personnel

Profilers pros and cons



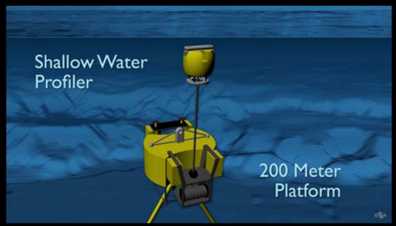


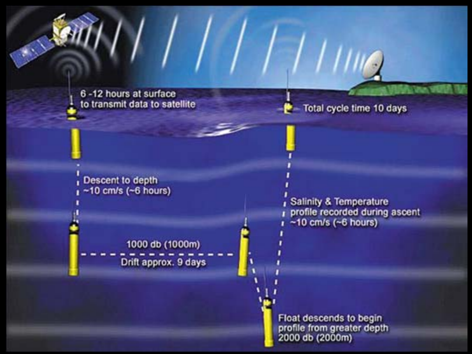
Advantages

- Vertical profiles of physical, biological, chemical and optical properties at a fixed geographical location.
- Sub-meter scale vertical resolution from 1-2 m above the water floor to the surface in water depths up to 100 m.
- Precise control of the profiler’s vertical position in the water column, especially in dynamic surface wave environments.
- Able to “hide” in heavy seas – no need for buoy.
- Removes the need for a permanent surface buoy and mooring cable.

Limitations

- Can be expensive
- Biofouling (less compared to buoys)
- Energy
- Harsh environment – demanding for materials
- Moored profilers climb up and down subsurface mooring cables
- Communication when there is no buoy





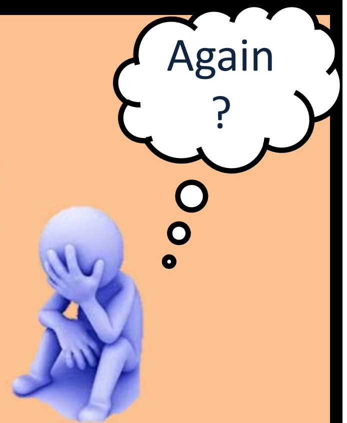
In situ Sampling pros and cons

Advantages

- E2E study
    - Nutrients
    - Size fractionated Chla
    - Bacteria to mesozoo
    - Temp(CTD)
    - O_2 (CTD)
    - Fluorescence (CTD)
    - ……
- High quality measurements
- Very good vertical resolution

Limitations

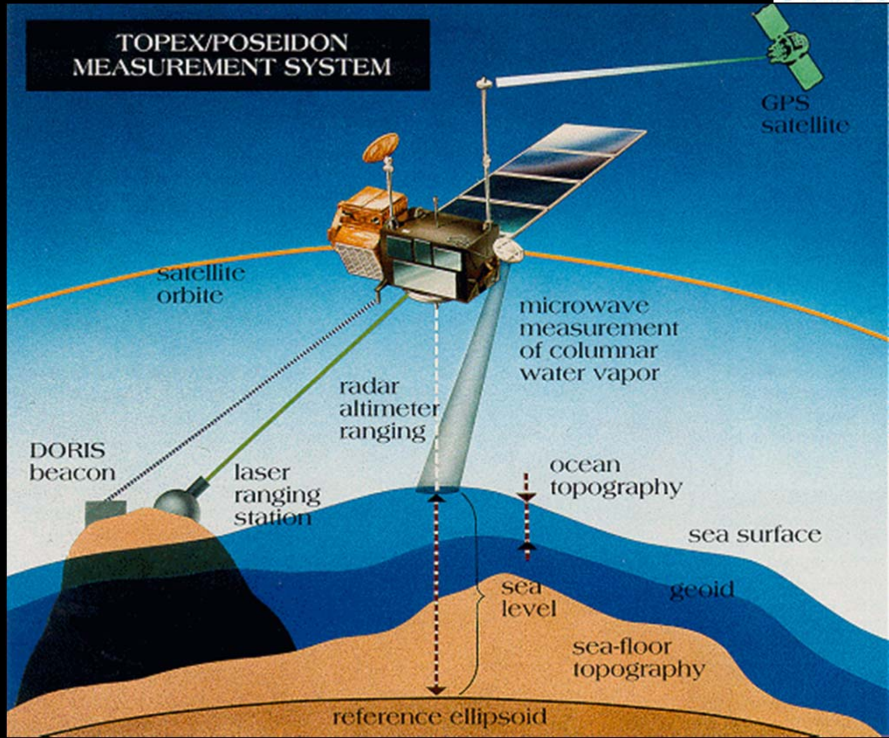
- Labour intensive
- Costly
- Delayed mode data
- Low temporal resolution
- Low spatial resolution
- Visits depend on weather



Remote sensing pros and cons

Advantages

- Observation of a large geographical area
- Temporal resolution
- Long-term and fast collection of data
- Lower collecting costs
- "Inaccessible" regions become accessible (e.g. Antarctica)
- Object is not being destroyed



Limitations

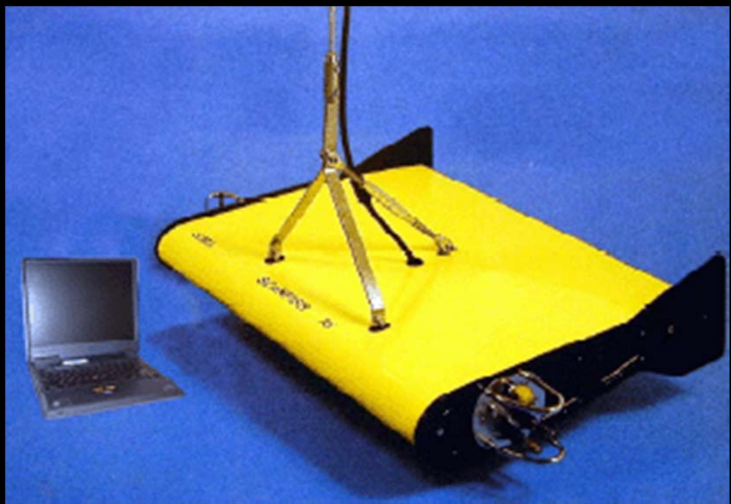
- 2D information for a 3D ocean
- Only clear days
- Algorithms in coastal areas can be problematic - Noise caused by another source than the desired one
- Lower spatial resolution
- Captured data need to be calibrated via in-situ data

Other methods

Animal telemetry

Drifters

Scanfish



New Technology

Vaimos

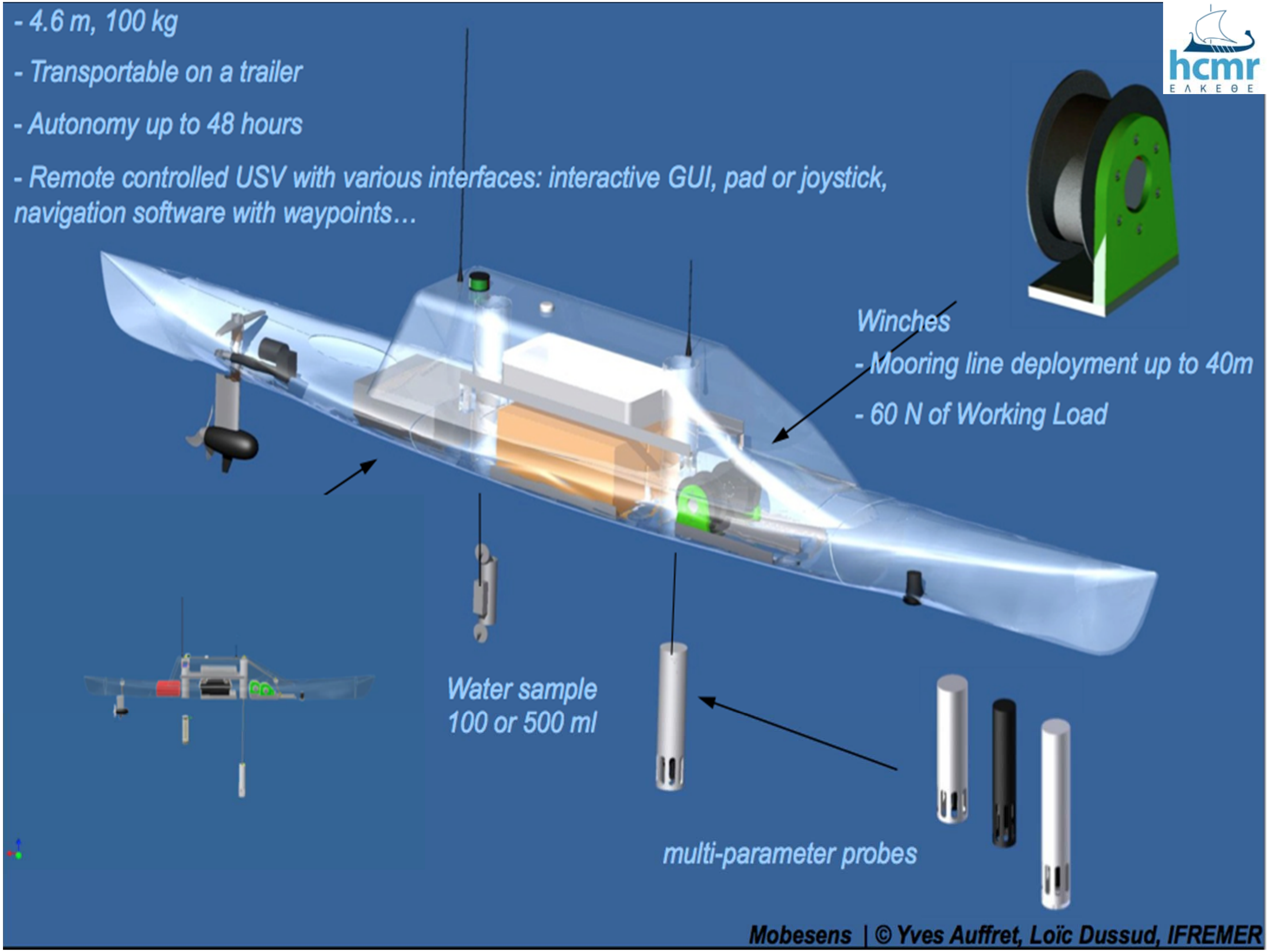
Laurent Delaney Ifremer

Objectives :

- Autonomous waypoint operation
- " Salinity and fluo measurement on the ocean surface layer
- " Surface layer perturbation at the minimum
- Solar panels
- Vertical wind energy mill
- Specific ringing adapted for automation
- Water inlet under hull and at the base of keel for
- Multiparameter probe measurement.

Mobesens

Laurent Delaney Ifremer


- 4.6 m, 100 kg
- Transportable on a trailer
- Autonomy up to 48 hours
- Remote controlled USV with various interfaces: interactive GUI, pad or joystick, navigation software with waypoints…
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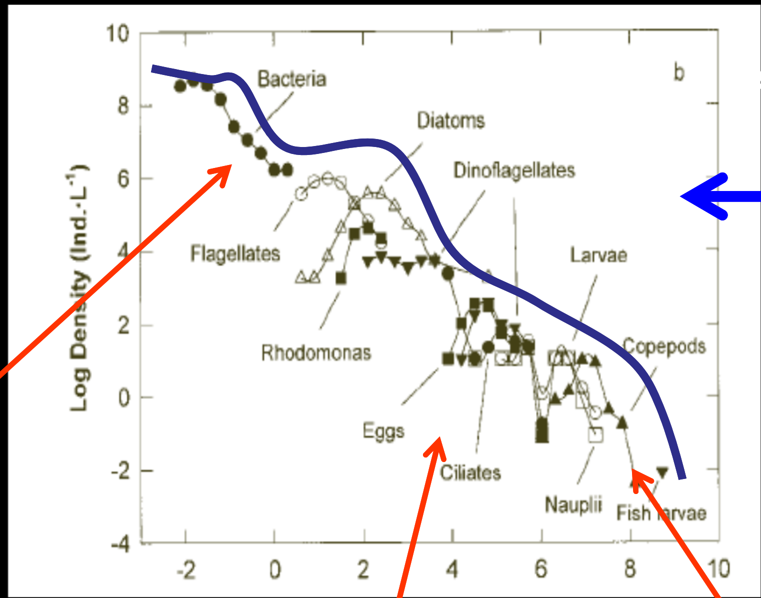
ΕΛΚΕΘΕ
Winches
- Mooring line deployment up to 40m
- 60 N of Working Load
Water sample
100 or 500 ml
multi-parameter probes
Mobesens | © Yves Auffret, Loïc Dussud, IFREMER

Pelagic ecosystem « end to end » monitoring using semi automated imaging systems

DELIVERABLE:
Common software for image analysis and data management for Flowcam, Zooscan.



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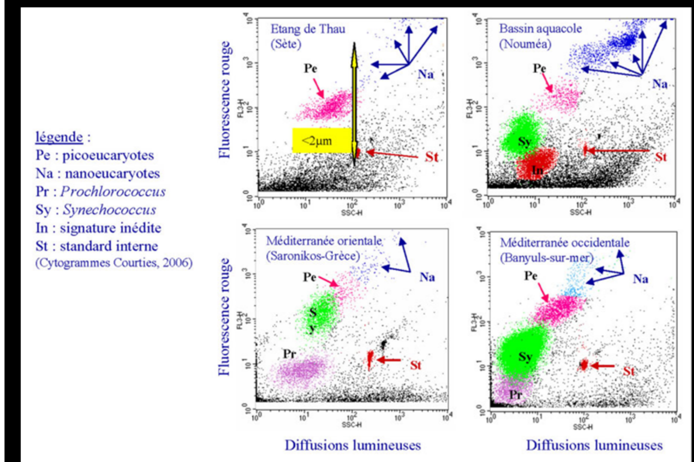
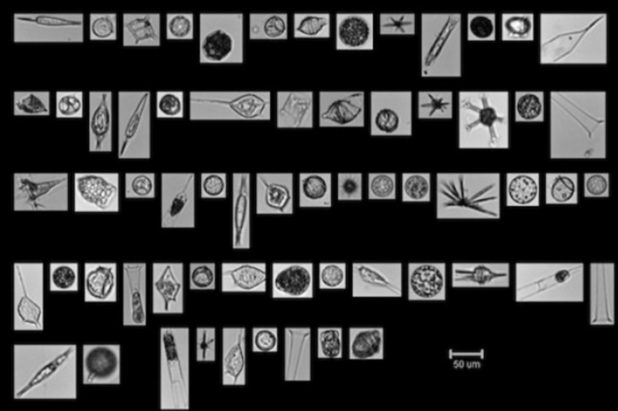
UVP, LISST

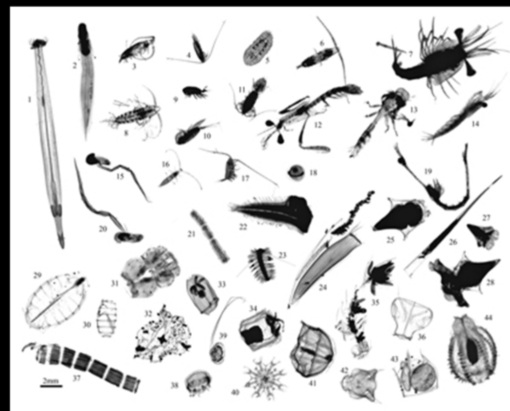
1: Flowcytometer

2: FlowCam

3: Zooscan



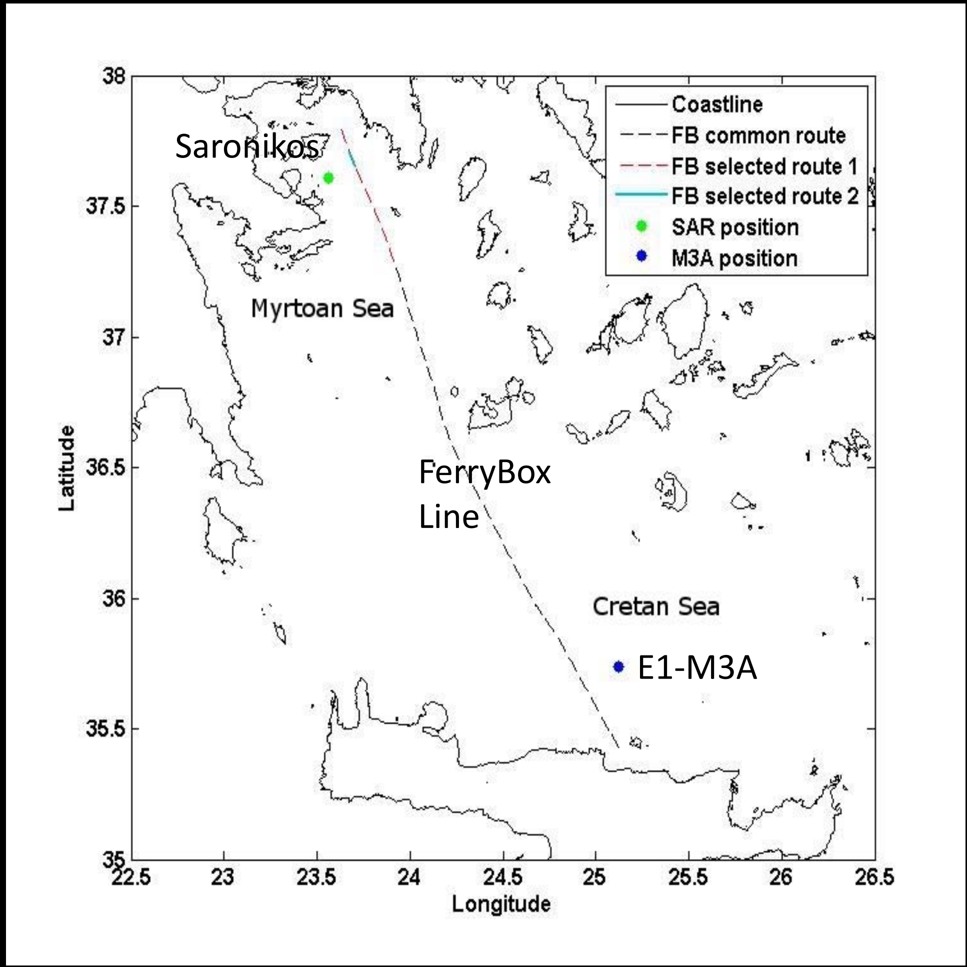


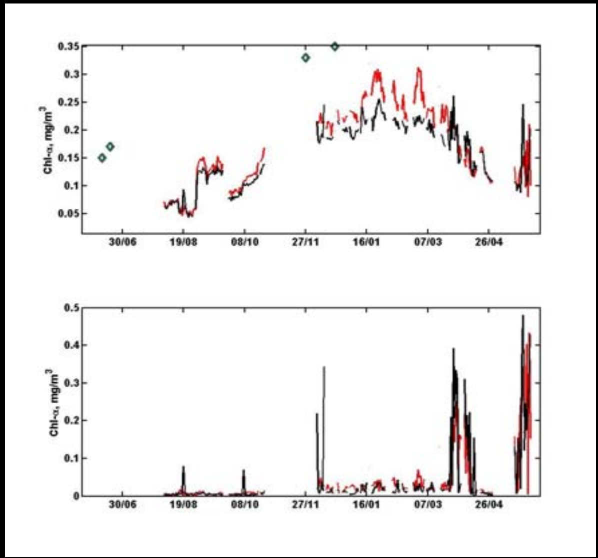


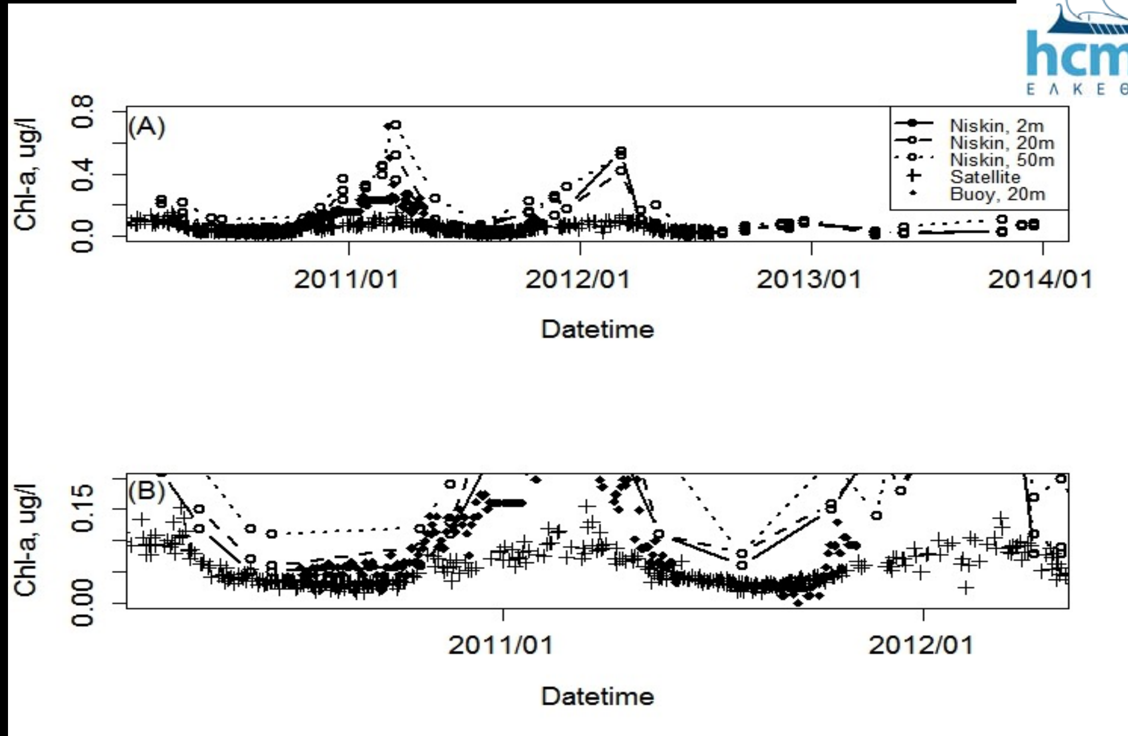
Do we need multiple platforms ?

Observations from different platforms in the Aegean sea are analysed and compared:

- Two fixed point observational buoys, operating since 2000&2007.
- A Ferry Box system installed on the F/B Olympic Champion, a high-speed ferry on the route Crete to Piraeus.
- *In situ* monthly measurements at the E1-M3A site, with CTD casts and Niskin bottle samples.
- High level (L3, L4 gridded) satellite products produced from one mission or the combination of more missions.







- All platforms suffer from inherent problems, which are attributed to physical, technical and structural limitations. The errors of the sensors are different from the errors of the platforms, even when two platforms are equipped with the same sensors. This difference can be as large as an order of magnitude. Combining the data from different methodologies, a part of the accuracy errors may be identified and removed.

- When information from different methods is combined, the surface and subsurface layers in the South Aegean are efficiently resolved in the horizontal direction. High spatial resolution FerryBox (<1Km) and satellite (~1Km) data suffice for servicing most applications and scientific study for temperature and chlorophyll but not salinity.

JERICO is the first project for Coastal Observing Systems.

Considering the importance of observing systems and the substantial investment made until now, an important task of JERICO is to describe best practices in all phases of the system (pre-deployment test, maintenance, calibration etc); to adopt common methodologies and protocols and to move towards the harmonisation of equipment which will help in reducing maintenance and calibration costs

Date	Title	Location
30 -31 August 2011	1st JERICO WP3 & WP4 common workshop on FerryBox	HZG, Hamburg
29th February – 1st March 2012	2nd JERICO WP3 & WP4 common workshop on Fixed Platforms	CNR, Rome
22 – 23 May 2012	3rd JERICO WP3 & WP4 common workshop on Gliders	IMEDEA, Palma
4-5 October 2012	4th WP3 & WP4 common workshop on Best Practices	HCMR, Heraklion
23rd April 2013	WP3 & WP4 status workshop	SYKE, Helsinki
13th March 2014	Dissolved Oxygen calibration / What are the best procedures? An interactive workshop to identify the best practices about dissolved oxygen calibration procedure.	FCT, Oceanology 2014, London

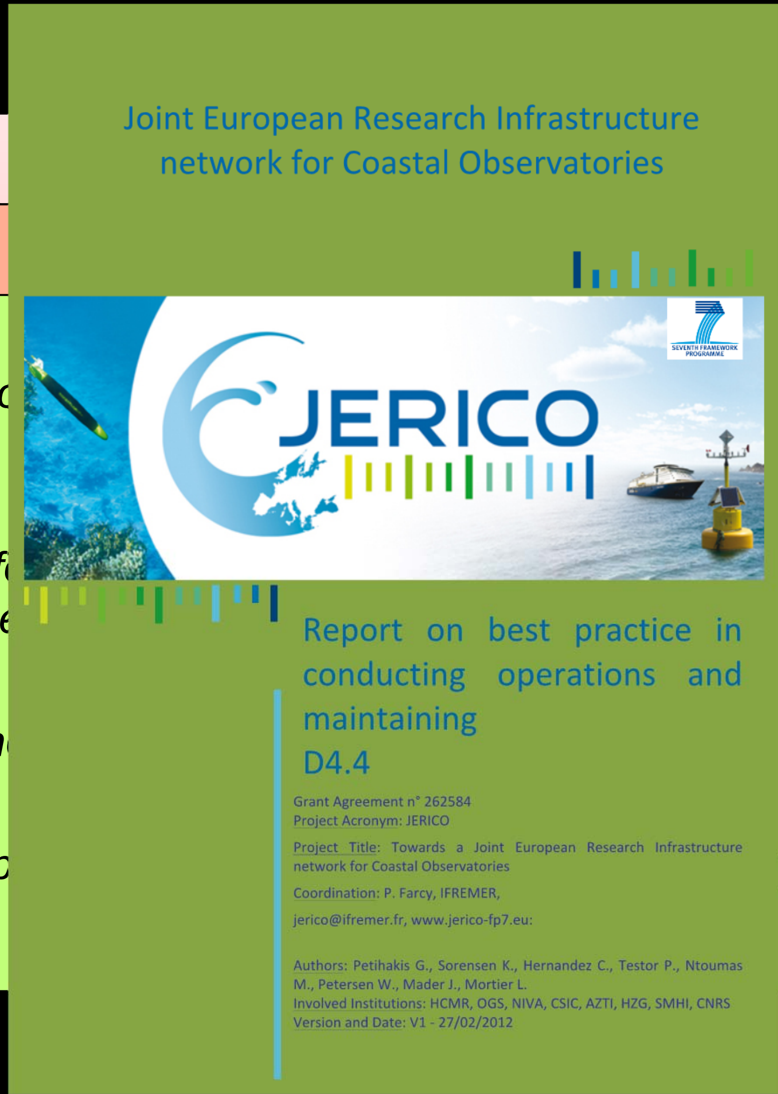
Quality assurance

Gliders

FerryBox

Fixed Platforms

- Many different designs produced bo custom builds.
- In most cases, designs follow a fit-f environment in which they are place
- The environmental constraints in th
- The variability of sensors that can b y high


Joint European Research Infrastructure network for Coastal Observatories

JERICO

Report on best practice in conducting operations and maintaining

D4.4

Grant Agreement n° 262584
Project Acronym: JERICO

Project Title: Towards a Joint European Research Infrastructure network for Coastal Observatories

Coordination: P. Farcy, IFREMER,

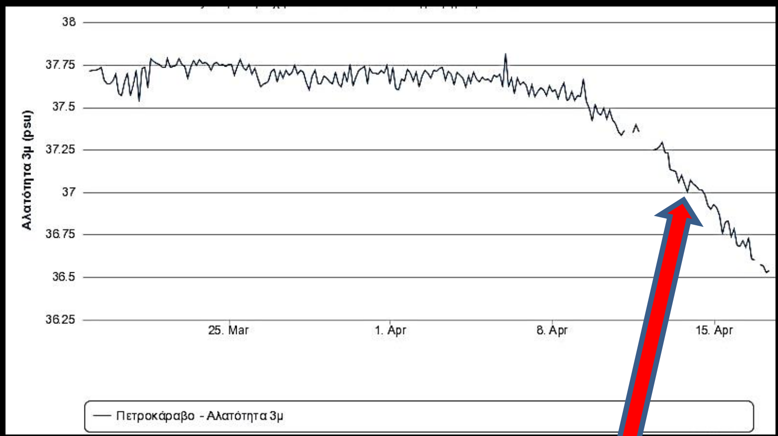
jerico@ifremer.fr, www.jerico-fp7.eu:

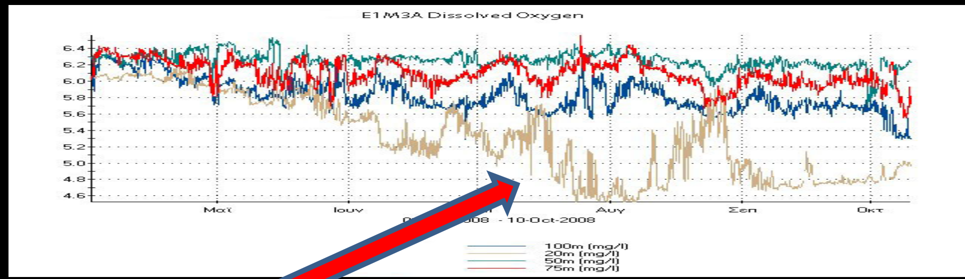
Authors: Petihakis G., Sorensen K., Hernandez C., Testor P., Ntoumas M., Petersen W., Mader J., Mortier L.
Involved Institutions: HCMR, OGS, NIVA, CSIC, AZTI, HZG, SMHI, CNRS
Version and Date: V1 - 27/02/2012

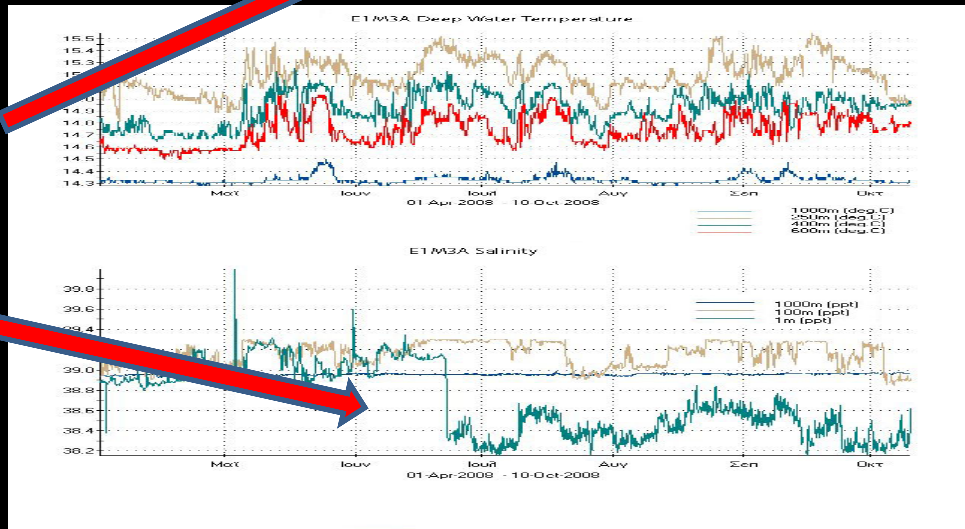
Supporting Infrastructure

Observational Target

Long term – accurate measurements







Drift

"Quantifying" biofouling?

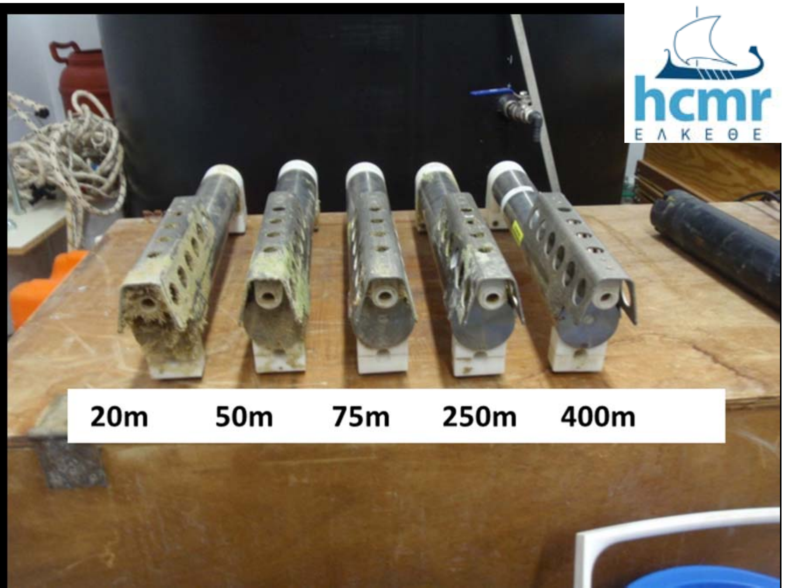
$$Drift_{overall} = Drift_{sensor} + Drift_{biofouling}$$

Moored sensor data VS In situ data

Calibration Lab (pre-, post-calibration)

?

"Quantifying" biofouling?



Reality ?????

Care of Conductivity Sensors in the Field

SBE

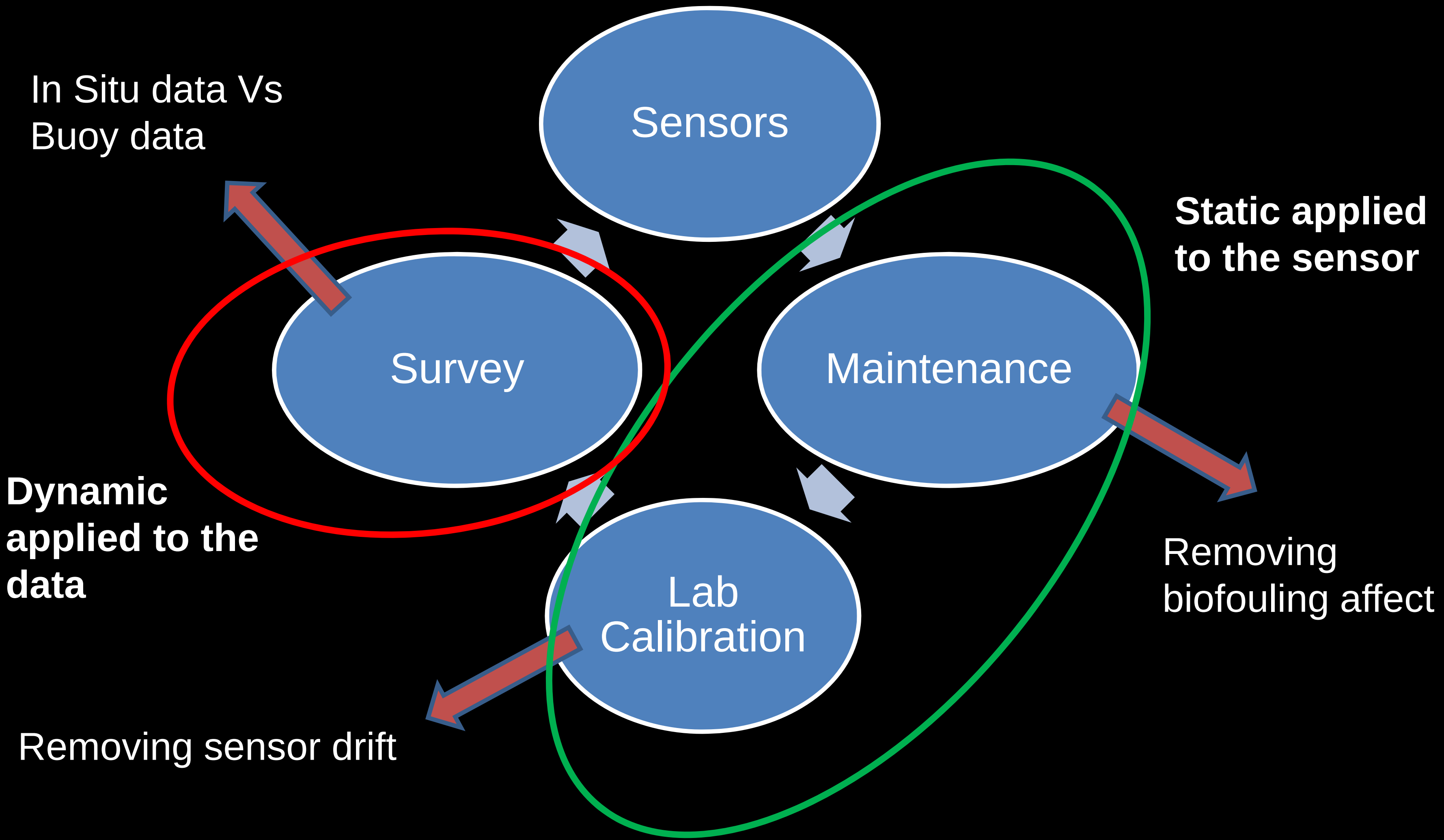
- Conductivity cells are very sensitive to coatings on inside of cell

$$\text{Salinity Error} = 35\left(1 - \frac{\textit{fouled diameter}^2}{\textit{clean diameter}^2}\right)$$

$$= 35\ (1 - (3.998)^2 / (4.000)^2) = 0.035\ \text{PSU}$$

Assuming 0.002 mm diminished diameter

Static and dynamic calibration



Joint European Research Infrastructure network for Coastal Observatories

Report on Calibration Best Practices
D4.2

Grant Agreement n° 262584
Project Acronym: JERICO

Project Title: Towards a Joint European Research Infrastructure network for Coastal Observatories

Coordination: P. Farcy, IFREMER, jerico@ifremer.fr, www.jerico-fp7.eu:

Authors: George Petihakis, Michael Haller, Wilhelm Petersen, Rajesh Nair, Jukka Seppälä, Florence Salvetat
Involved Institutions: HCMR, HZG, OGS, SYKE, IFREMER
Version and Date: V1.3 – 27/06/2014

Joint European Research Infrastructure network for Coastal Observatories

Report on Biofouling Prevention Methods
D4.3

Grant Agreement n° 262584
Project Acronym: JERICO

Project Title: Towards a Joint European Research Infrastructure network for Coastal Observatories

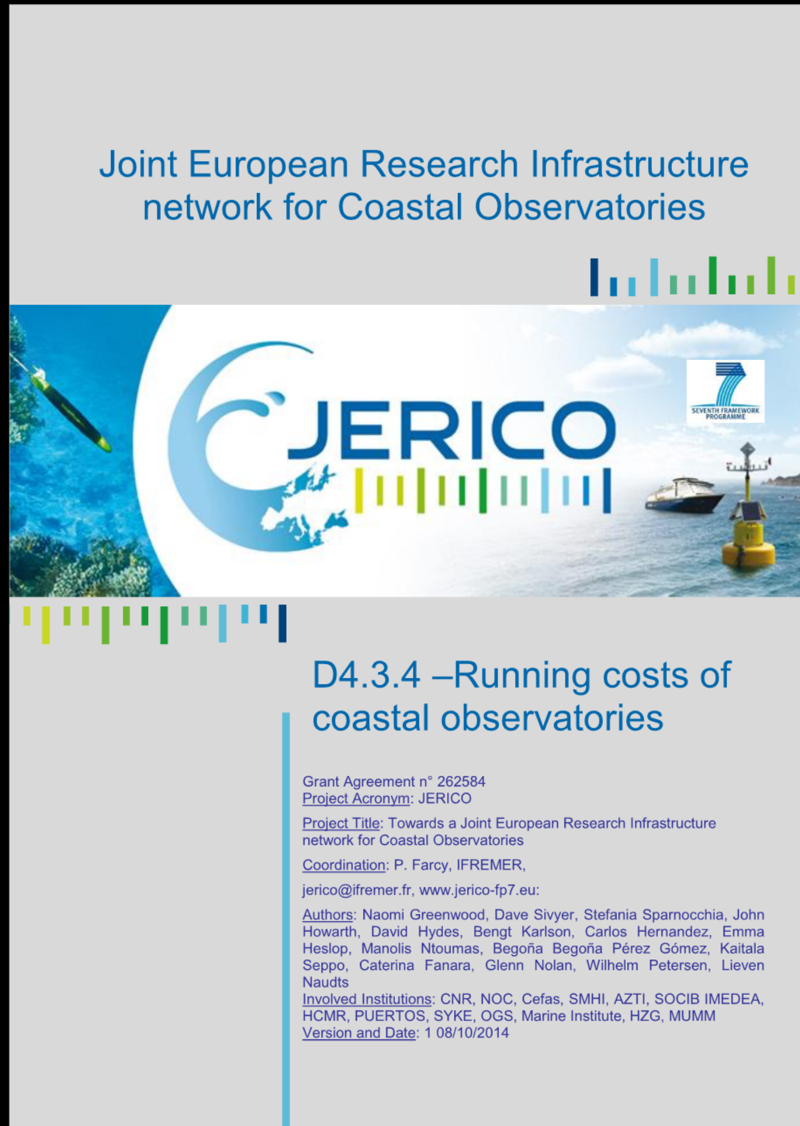
Coordination: P. Farcy, IFREMER,

jerico@ifremer.fr, www.jerico-fp7.eu:

Authors: M. Faimali, G. Pavanello, G. Greco, I. Trentin, S. Sparnocchia
Involved Institution: CNR
Date: V1.1 - 28/04/2014

Costs

- The cost of setting up and operating such systems can be significant and in some cases may determine the sustainability
- It is the first time that costs are recorded for
  - Fixed Platforms
  - FerryBoxes
  - Gliders
  - Calibration labs


Joint European Research Infrastructure network for Coastal Observatories

JERICO

D4.3.4 –Running costs of coastal observatories

Grant Agreement n° 262584
Project Acronym: JERICO
Project Title: Towards a Joint European Research Infrastructure network for Coastal Observatories
Coordination: P. Farcy, IFREMER,
jerico@ifremer.fr, www.jerico-fp7.eu:
Authors: Naomi Greenwood, Dave Sivyer, Stefania Sparnocchia, John Howarth, David Hydes, Bengt Karlson, Carlos Hernandez, Emma Heslop, Manolis Ntoumas, Begoña Begoña Pérez Gómez, Kaitala Seppo, Caterina Fanara, Glenn Nolan, Wilhelm Petersen, Lieven Naudts
Involved Institutions: CNR, NOC, Cefas, SMHI, AZTI, SOCIB IMEDEA, HCMR, PUERTOS, SYKE, OGS, Marine Institute, HZG, MUMM
Version and Date: 1 08/10/2014

Initial investment costs:

- Gliders 222,545 €
- FerryBoxes 110,298 €
- Fixed Platforms 86,526 €
- Calibration 118,333 €

Annual running costs:

- Gliders 134,014 €
- Fixed Platforms 139,358 €
- FerryBoxes 90,520 €
- Calibration 48,500 €

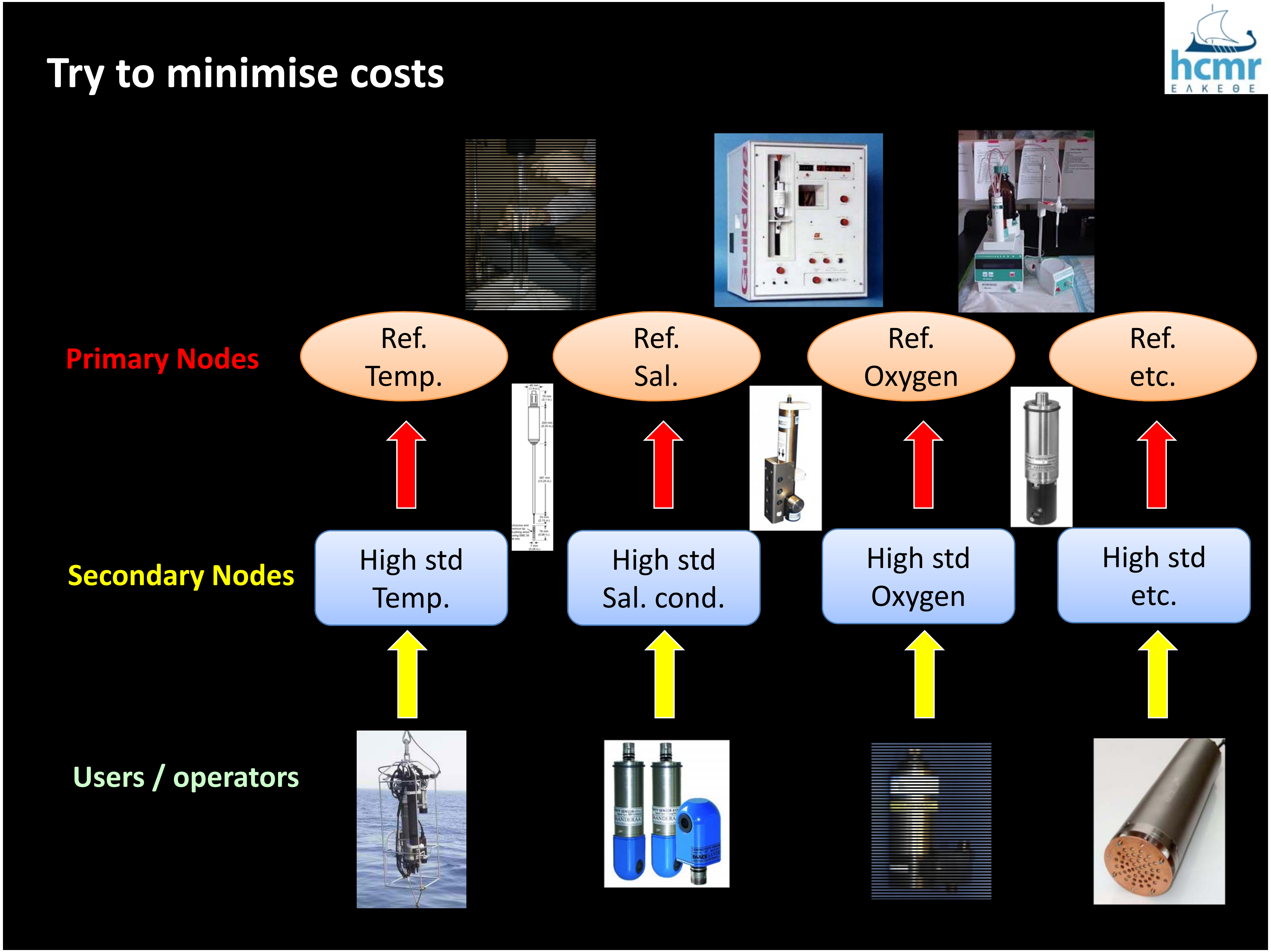
A large proportion of the total annual running costs (27%) of fixed platforms is associated with boat charter

Personnel annual costs:

- Gliders 44%
- Fixed Platforms 49%
- FerryBoxes 55%
- Calibration 57%

Overall

There is a large variability in costs between laboratories reflecting the different types of platforms and parameters being measured


Try to minimise costs
Primary Nodes
Ref.
Temp.
Ref.
Sal.
Ref.
Oxygen
Ref.
etc.
Secondary Nodes
High std
Temp.
High std
Sal. cond.
High std
Oxygen
High std
etc.
Users / operators

Joint European Research Infrastructure network for Coastal Observatories

MS15 - Constitution of a permanent JERICO Working Group for Calibration Activities

Grant Agreement n° 262584

Project Acronym: JERICO

Project Title: Towards a Joint European Research Infrastructure network for Coastal Observatories

Coordination: P. Farcy, IFREMER,

jerico@ifremer.fr, www.jerico-fp7.eu:

Authors: G. Petihakis, R. Nair, W. Petersen, J. Seppala, F. Salvetat, L. Coppola, M. Ntoumas, I. Puillat.

Involved Institutions: HCMR, IFREMER, OGS, HZG, SYKE, CNRS

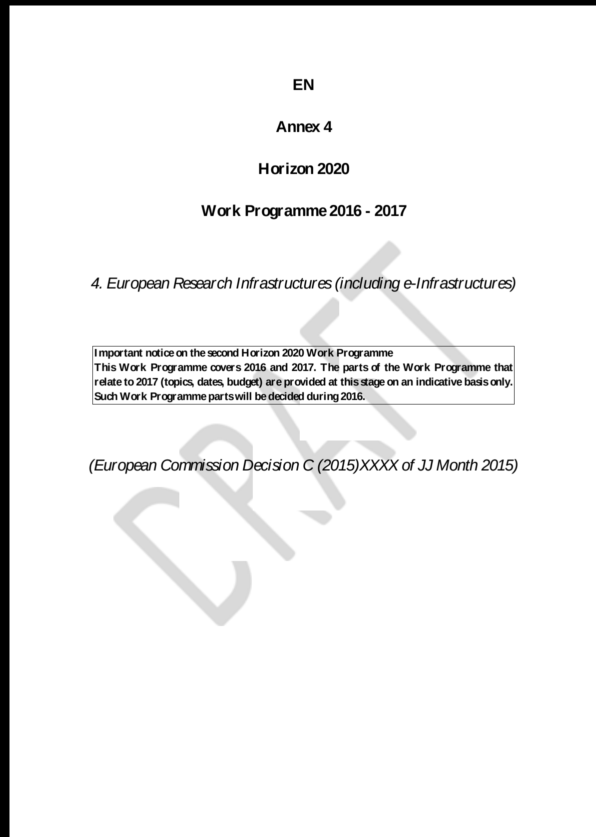
Version and Date: Version 0.1 20 November 2014

FCT or AMT

INFRAINNOV-02-2016: Support to Technological Infrastructures

Proposals should address:

- the definition of key techniques and trends which are crucial for the further development of Research Infrastructures, in close partnership with the industrial partners, especially with innovative SMEs;
- the definition of roadmaps and/or strategic agendas together with industrial sector actors for key technologies for R&D and for the construction and upgrade of Research Infrastructures as well as for key technologies to be explored by industries;
- the identification of the domains of societal applications and potential markets beyond Research Infrastructures;
- the implementation of a strategy addressing the training of young engineers, technicians and scientists in an environment of strong industrial relevance and scientific excellence;
- the exchange of good practices between user communities and managers of research infrastructures as regard benchmarking performance of technology platforms, harmonisation of tests, standards, reference materials, interoperability and data handling.



EN

Annex 4

Horizon 2020

Work Programme 2016 - 2017

4. European Research Infrastructures (including e-Infrastructures)

Important notice on the second Horizon 2020 Work Programme
This Work Programme covers 2016 and 2017. The parts of the Work Programme that relate to 2017 (topics, dates, budget) are provided at this stage on an indicative basis only. Such Work Programme parts will be decided during 2016.

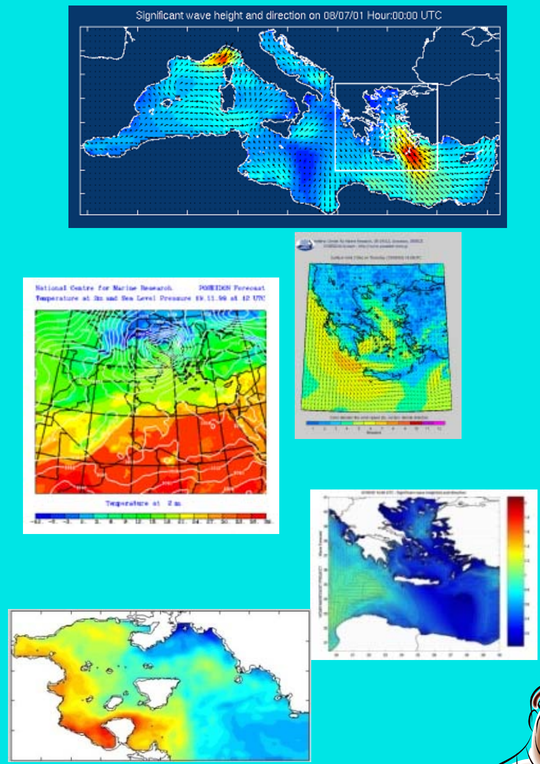
(European Commission Decision C (2015)XXXX of JJ Month 2015)

DRAFT

We need an integrated system able to support science, safety, environment and maritime economy

Observations

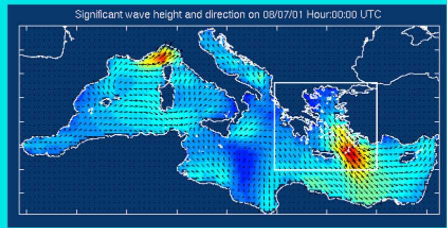
Processing & Modeling

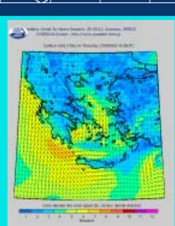


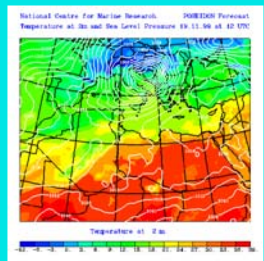
Information and Decision Support Systems

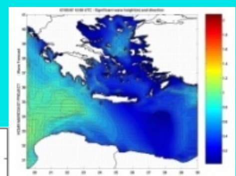
End Users

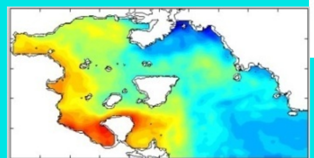
Processing & Modeling



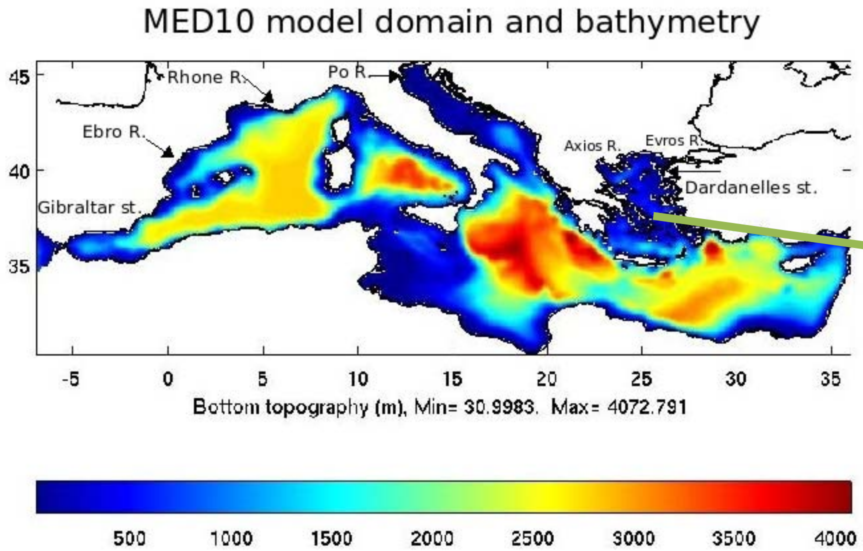




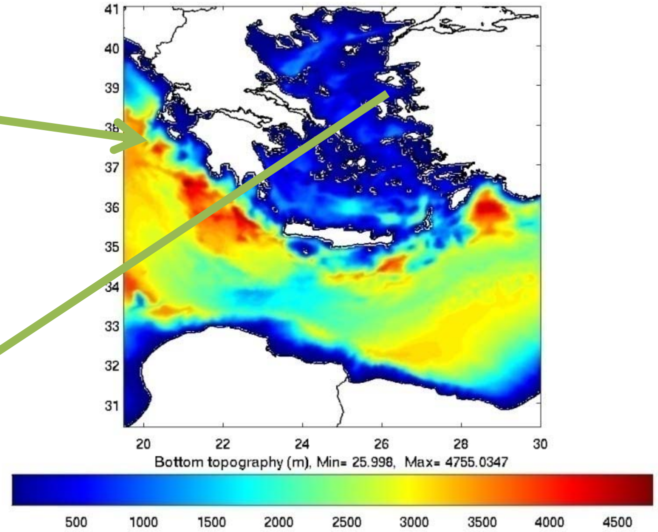




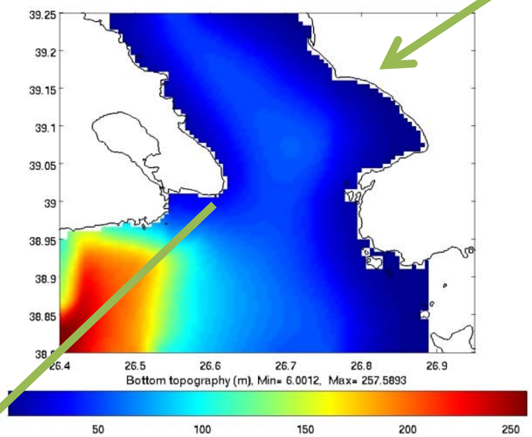
hcmr
ΕΛΚΕΘΕ



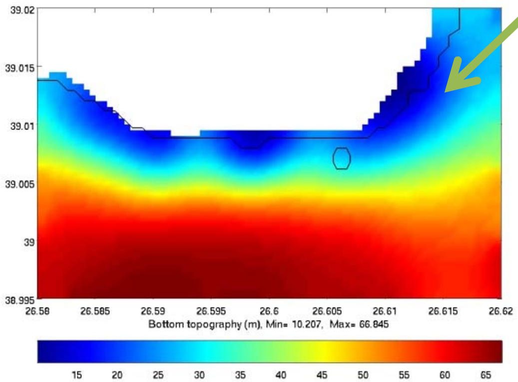
30° 25 N - 45° 75 N
07° 00 W – 36° 00 E
1/10° (~10Km)



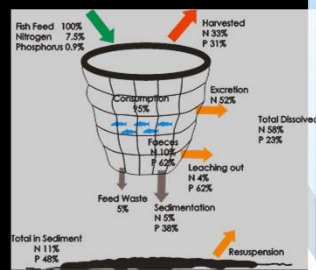
38° 80 N - 39° 25 N
26° 40 E - 26° 95 E
1/180° (~500m)
100 x 82 points

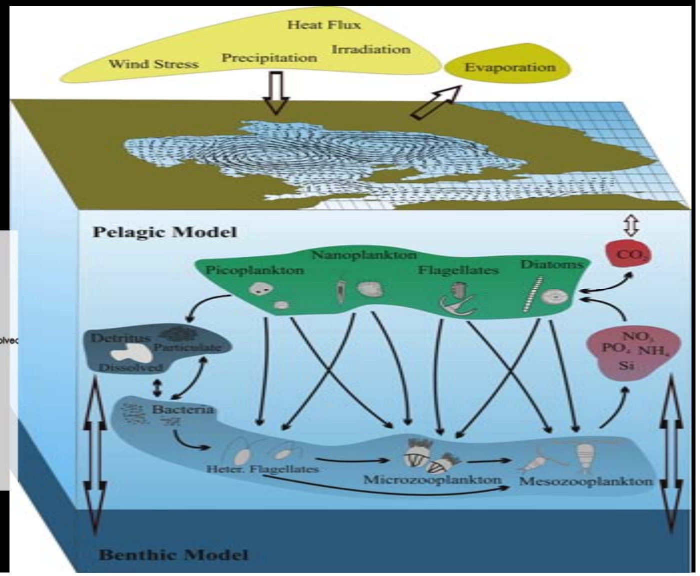


30° 50 N - 41° 00 N
19° 40 E - 30° 00 E
1/30° (~3Km)



38° 995 N - 39° 02 N
26° 58 E - 26° 62 E
1/2000° (~50m)
81 x 51 points

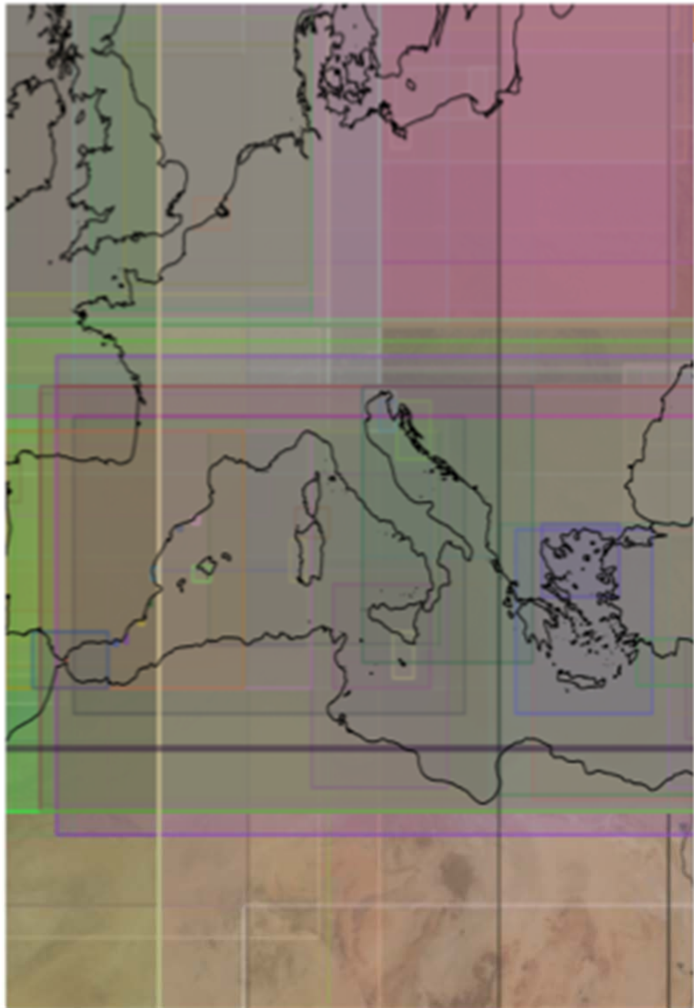




EuroGOOS (http://eurogoos.eu/models/)

The information on this page is based on a modelling inventory made by the GOOS Regional Alliances (GRAs). The information has been provided by modelling experts in the respective GRAs.

- Black Sea GRA
- EuroGOOS
- IMOS
- IOGOOS
- MONGOOS
- PI-GOOS
- US IOOS



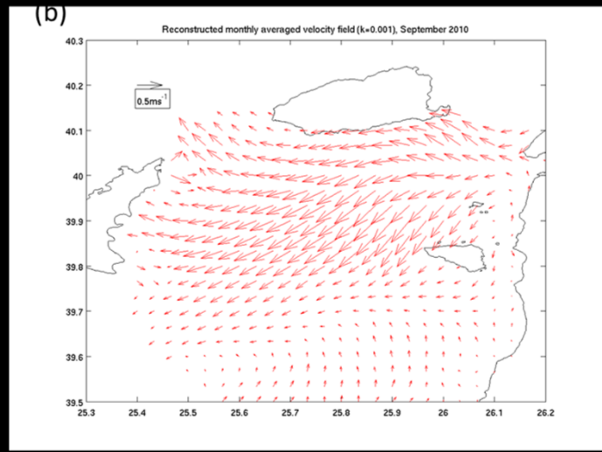
Summary

Number of models: 46

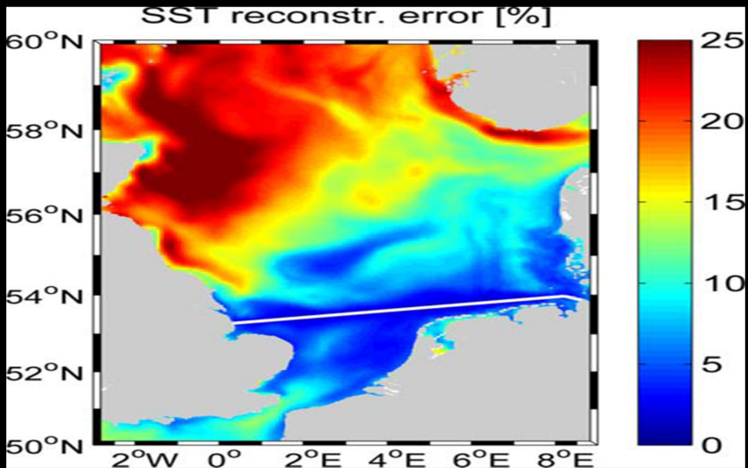
Parameters

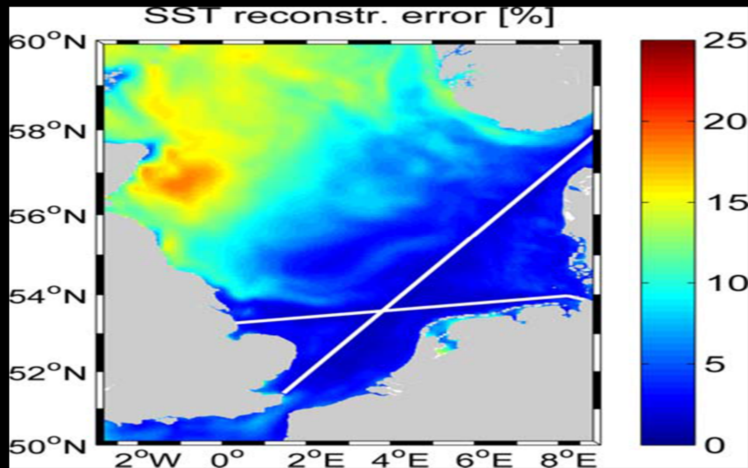
- **Water temperature:** 1
- **sea surface temperature:** 1
- **salinity:** 11
- **sea surface height:** 1
- **and sea-ice concentrations.:** 1
- **wind velocity and direction:** 1
- **wave height:** 1
- **period and direction:** 1
- **direction and height of primary and secondary swell:** 1
- **3D temperature:** 1
- **zonal and meridional currents:** 1
- **2D surface height:** 1
- **water level:** 5
- **currents:** 15
- **temperature:** 8
- **and/or salinity":** 2
- **water level:** 3
- **Waves:** 1
- **waves:** 6
- **Waves and Wave potential Energy:** 1
- **sea level and waves:** 1
- **heat flux:** 2
- **wind stress and water flux:** 2
- **and/or salinity:** 2
- **wave integrated parameters (swh:** 1

Observation System Experiments (OSE) → assess the impact of existing observational platforms on estimates of coastal processes

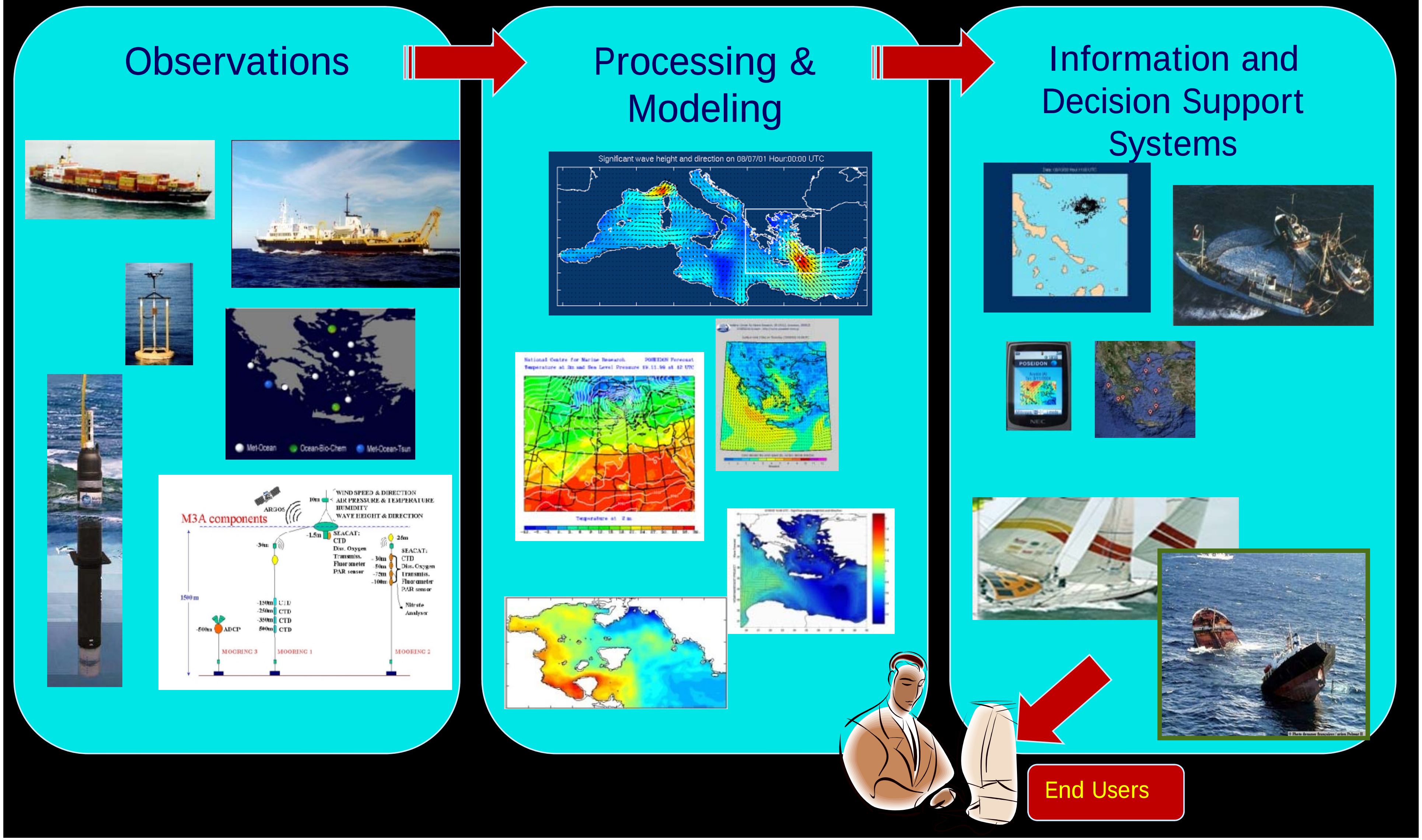


Observing System Simulation Experiments (OSSE) → planning the deployment of future observational platforms.





We need an integrated system able to support science, safety, environment and maritime economy



Information and Decision Support Systems

End Users

Measurements → Services

- Real-time ocean obs. (T, S, irradiance/reflectance)
- Real-time meteorological obs. (T, humidity, wind, radiance)
- Satellite products validation (T, reflectance/radiance, Chl-a)
- Macronutrient concentrations
- Phytoplankton biomass and community structure
- Ocean acidification (pCO_2, pH, alkalinity, CO_3^-)
- Pollutants and emerging contaminants, microplastics
- Environmental quality: O_2, high T, eutrophication, contaminants (MSFD/WFD indicators)
- Molecular and microarray techniques (harmful algal species, aquaculture parasites/viruses, contaminants etc.)
- Sensor and sampler development

1) Operational oceanography and weather
(industry, government, research)

2) Climate change, ocean acidification
3) Ocean productivity, C cycling
4) Management of fish stocks
(research, government, industry)

5) Water quality framework directives
(government, research, industry)

6) Aquaculture
7) Human health
(industry, government, research)

8) Technology and innovation
(industry, research)


Thank you!