

JERICO WP10 Workshop Report

Grant Agreement n° 262584

Project Acronym: JERICO

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

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Version and Date: Version 3.0 15th July 2014

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1. Document Description

1.1. REFERENCES

Annex 1 to the Contract: Description of Work (DoW) version of the 22 Feb. 2011

DOCUMENT INFORMATION	
Document Name	Report after the JERICO WP10 Workshop
Document ID	
Revision	3.0
Revision Date	July 7 th 2014
Author	
Security	

HISTORY			
Revision	Date	Modification	Author
3.0	07/0714	Inclusion of author abstracts and notes	G.Nolan and WP10 partners

DIFFUSION LIST				
Consortium beneficiaries	X			
Third parties	X			
Associated Partners	X			
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2. Executive Summary

A workshop was held on October 16th to 18th 2013 at the Villefranche observatory to outline progress on emerging technologies within the JERICO FP7 project (Work-package 10). A particular focus of the workshop was to invite researchers outside the project consortium to:

- Learn of technology developments within JERICO and
- Present results of their own experiments and technology development

The workshop was a mixture of invited talks and practical demonstrations of some of the technologies involved. There were a total of 24 invited talks and 2 additional practical demonstrations.

The talks focused on 5 key tasks within the emerging technologies area:

- 10.1 Biological compartments
- 10.2 Contaminants
- 10.3 Profiling technologies
- 10.4 Ships/vessels of opportunity
- 10.5 Ferrybox Quality Control algorithm development

In parallel to the workshop, DO sensors inter-comparison exercise has been done in Villefranche/Mer (following the calibration experiment done in IFREMER, Brest). The objective was to compare the accuracy and precision of existing sensors used in coastal oceanography. Five sensors have been selected: SBE43 and SBE63 (SEABIRD), optode 4330 and 3975 (Aanderaa) and one HOBO (Onset). These sensors have been deployed 2 times at 2 depths (October and December 2013) with successive oxygen Winkler sampling (used as reference).

Sensor	Depth	DOXY	O2 Winkler	Difference
SBE43	25m	184.6	240.5 ± 1	56 ± 1
SBE63	25m	218.9	240.5 ± 1	19 ± 1
SBE43	50m	190.5	241 ± 1	51 ± 1
SBE63	50m	220.9	241 ± 1	15 ± 1
Optode 3975	6m	308	244 ± 4	60 ± 4
Optode 4330	6m	285	244 ± 4	37 ± 4

The table here summarizes the results of oxygen measurements from the different deployment operated at the Villefranche/Mer bay. If we compare the results (raw data) with the O2 reference, the SBE63 (optical) seems to be the most accurate sensor. Some explanations can be suggested here: the SBE43 (electrochemical) is very sensitive to biofouling issue and needs systematically a correction



of coefficients calibration. The foil of the optode (optical) is very sensitive to the sunlight and needs regular calibration (multi-point methods). More details will be available on the report (in preparation).

This report contains a summary of the work presented by various researchers who attended the workshop. The slides of each presentation are listed in this report, section by section.



3. Attendees

Names	Institutes	Country	E-mail
Brendan O'Connor	Aquafact	Ireland	boc@aquafact.ie
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4. WP10 Workshop Programme

WEDNESDAY 16 OCTOBER 2013

9h30 Introduction to the Oceanological Observatory in Villefranche/Mer (G.Gorsky Director)

9h40 Introduction of WP10 activities by G. Nolan (MI)

9h45-12h30 Task 10.1*: Development of new tools for the monitoring of key biological compartments and processes (chairman: D.Durand)

Presentations of task leader and participants (JERICO and others)

- Antoine Gremare : overview of task 10.1
- Jean Claude Duchène : Demonstration of sediment profile image analysis software.
- Jean Claude Duchène : Demonstration of video transect image analysis software.
- Brendan O'Connor : Sediment Profile Imagery (SPI) analyses

Coffee break (15 min)

- Florent Colas: System development for fish egg and zooplankton imaging
- Simone Marini: Underwater image acquisition and processing from fixed and Lagrangian platforms
- Romagnan, J-B., Elineau A., Picheral, M. , Stemmann, L., : Development of new tools and strategies for the monitoring of bottle and net collected plankton. A system based on image acquisition and semi-automatic analysis.

Discussions from the morning presentations

** 15 min for the presentation and 5-10 min for questions*

12h30-14h00 Lunch near the meeting room



14h00-18h00 Task 10.1* Practical session where users in different institutes interact with tools developed (chairman: G.Nolan)

- Demonstration of the Flowcam and Zooscan. (1 hour)
- Felipe Artigas : Presentation and first results of the INTERREG DYMAPHY project
- Guillaume Wacquet : The flowcam/PhytoImage project

Coffee break (15 min)

- Elvire Antajan : Plankton Identifier, a free software for automatic identification of plankton: new features, and application example
- Méliotus Thyssen, Pascal Morin: High frequency phytoplankton observation using autonomous cytometer installed on vessels (Cytosense)
- Veronique Creach: Flow-cytometer online with ferrybox in a research vessel

Discussions from the afternoon presentations

** 15 min for the presentation and 5-10 min for questions*

Visit to Zooplankton collection and Zooscan Laboratory, Villefranche (L.Coppola, G.Gorsky)



THURSDAY 17 OCTOBER 2013

9h00-10h00 Possible strategies and potentials for JERICO to become a network for biodiversity observation (chairman: P.Morin)

- Sander Wijnhoven: Network for biodiversity observation

Coffee break (15 min)

10h15-12h15 Task 10.2*: Developments of physico-chemical sensors and implementation on new platforms (chairman: P.Morin)

- Kai Sorenson: Contaminant sensors
- Willy Petersen: Pco2 and pH sensors
- Jukka Seppälä: LED fluorometers for monitoring phytoplankton accessory pigments
- Stefan Simis: The state-of-the-art of variable fluorescence fluorometry for the ferrybox

12h15-14h00 Lunch near the meeting room

14h00-16h00 Task 10.2*: Developments of physico-chemical sensors and implementation on new platforms - continuation (chairman: P. Farcy)

- Victoire Rerolle: pCO₂ and pH at NOCS
- Laurent Coppola: pCO₂ Contros tests in laboratory: calibration with in situ measurements experiment
- Bengt Karlson: Results from reference sampling and measurements of optical in situ parameters, pH and CO₂ in the Baltic Sea and the Skagerrak-Kattegat.

Coffee break (15 min)

16h00- 18h00 Task 10.4 Ships of opportunity, next generation fishing vessel probes (chairman: P. Farcy)

- Laurent Delauney: Novel platforms
- Michela Martinelli: From FOS to FOOS: Advances in use of Fishing vessels for oceanographical purpose in the Adriatic Sea
- Patrick Farcy: New RECOPECA developments proposed by NEXOS

** 20 min for the presentation and 10 min for questions*

Diner to Villefranche/Mer restaurant ("Le Cosmo" 20h)



FRIDAY 18 OCTOBER 2013

9h00-10h30 Task 10.3* Emerging technology: profiling technology, inter-comparison with mature technology (chairman: L. Coppola)

- Rajesh Nair: Adriatic Sea experiment
- Laurent Coppola: EOL buoy : an autonomous coastal profiler in the Ligurian Sea

Coffee break (15 min)

10h45-12h00 Task 10.5* FerryBox data Quality Control Algorithm (short update of 15 minutes) (chairman: L. Coppola)

- Wilhelm Petersen: status of QA algorithm development

12h00-12h30 Conclusion

** 20 min for the presentation and 10 min for questions*



5. Report after WP10 Workshop of JERICO project

5.1. New tools for the monitoring of key biological compartments and processes

5.1.1. Introduction to the Oceanological Observatory in Villefranche/Mer (G.Gorsky Director)

G. Gorsky welcomed the workshop and introduced JERICO in the European research context. G. Gorsky outlined that JERICO is well in line with the EC plan to create a pan European integrated research network.

5.1.2. Introduction to the WP10 Workshop (Glenn Nolan, MI)

5.1.2.1. Reminder of WP10 objectives

G. Nolan provided the context for the JERICO project in the European observing system, including Eurofleet, Euro Argo, FixO3, GROOM/EGO, E-Surfmar etc...

End to end oceanographic systems were presented with a focus on how in situ technologies Eg. buoys, VOS, gliders etc. form part of an overall oceanographic system that comprises in situ observation, modelling, satellite products, data archive systems and tools for their exploitation to ultimately produce decision support or answers to questions that end-users have.

5.1.2.2. WP10 Workshop objectives

The WP10 tasks 10.1 to 10.6 were presented, the first day being entirely dedicated to task 10.1 “Biological compartments” with subsequent days of the workshop focused on tasks 10.2 to 10.6 (see figure below)

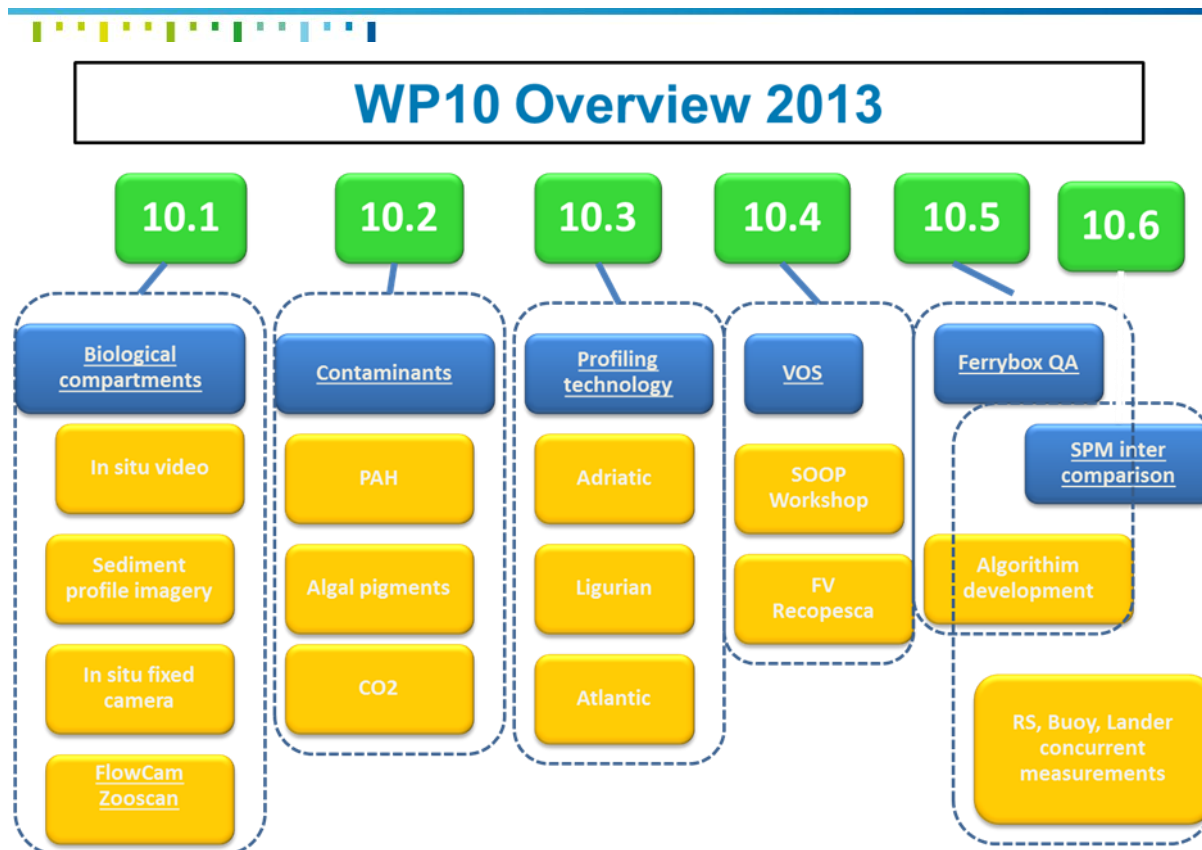


Figure 5.1 Overview of tasks contained within JERICO Work-package 10

5.1.3. Development of new tools for the monitoring of key biological compartments and processes (Task 10.1)

5.1.3.1. Antoine Gremare (CNRS/EPOC, France) : overview of task 10.1

A. Gremare presented the 10.1 task. He explained that biology is more important in coastal areas. While we are dealing with coastal oceanography, we are still missing methods and instruments dedicated to the monitoring of biology. One focused technique is video imaging. Four principal techniques are developed:

- 1st development is on in situ video images of the sediment interface acquired using ROV or other mobile systems
- 2nd development is on in situ sediment profiler camera
- 3rd development: video sequences, obtained with fixed platform
- 4th development: dealing with pelagic ecosystems analysis of images obtained with Flowcam, Cytoflow and Zooscan systems.

In order to promote these techniques and to get user feedback a follow on demonstration survey should be organised. (see recommendations)

A first result is already published. Indeed A. Gremare introduced the first JERICO article 'Semi-automatic analysis and interpretation of sediment profile images by Romero Ramirez et al. published in Environ. Modelling and Software, vol. 47 (2013).



5.1.3.2. Jean Claude Duchène (CNRS/EPOC, France): Demonstration of sediment profile image analysis software.

This presentation concerns the program developed in Arcachon in the Frame of the WP10, Task 10.1.

The three parts of the presentation concern:

1. The development of a tool to analyze in situ sediment profile images. The SPI device (Sediment profile Imager) provides information on the ecological quality status of benthic habitats. The software, developed in the frame of Jerico, allows enhancement of the interpretation of features observed on SPIs. Image analysis, coupled with use of database and learning processes facilitate image management and structures visualization, as well as inter-calibration of profiles coming from different areas.
2. The video imaging by fixed cameras allows the survey of recruitment on substrates, as well as the growth characteristics of fouling organisms. Image analysis is used to track the animals settling on the substrate, measure their interactions and growth rates;
3. The video imaging of water-sediment interface is developed to analyse films coming from ROV, AUV, etc. A user-friendly interface has been developed for dynamic image analysis on fast moving environments. Script editors allow building adapted filters to treat video and count animals or features present on or around the sea floor. Filters, coupled with geo-localisation and image segmentation help extracting information on the presence of moving objects, or structures present on the sediment. A 3D module allows the mapping of features counted on a 3D map of the sea floor. The system can provide animated gif files. Objects are classified by the system, not pixels. The system can work with images generated by any image acquisition system though it depends on the size, codec, acquisition speed, and the characteristics of the acquisition frame.

These 3 developments are now grouped inside a common program giving access to the different modules.

A. Gremare remarked that a user can build up their own learning set, anywhere. It is very flexible. There are 2 possibilities for the future use of the software:

- People will train the system for their own area
- People will build their own meta database of local images.

5.1.3.3. Brendan O'Connor (Aquafact, Ireland: Sediment Profile Imagery (SPI) analyses

This presentation focused on a sediment profile imagery which differs from the previous one because the surface 2D structure is also taken in account in order to inform of the environmental condition (for instance surface O₂ etc.), in other words on the possible structures that are found in the sediment profile.

Standard interpretation approaches to image analyses

Factors such as redox depth, successional stage, surface and subsurface structures have been used to determine the quality of muddy sand communities for sediment profile images.



Table 5.1. Criteria used by Nilsson and Rosenberg (1997) to calculate Benthic Habitat Quality Index (BHQ). $BHQ = \sum A + \sum B + C$.

A: Surface structures	Faecal pellets	1
	Tubes ≤ 2 mm in diameter	1
	Tubes > 2 mm in diameter	2
	Feeding pit or mound	2
B: Subsurface structures	Infauna	1
	Burrows 1 – 3	1
	Burrows > 3	2
	Oxic void at ≤ 5 cm depth	1
	Oxic void at > 5 cm depth	2
C: Mean depth of apparent RPD	0 cm	0
	0.1 – 1.0 cm	1
	1.1 – 2.0 cm	2
	2.1 – 3.5 cm	3
	2.1 – 3.5 cm	4
	5 cm	5

Criteria for use in interpreting images from sediments other than muds and muddy sands.

As none of these features are applicable to sands and gravels, the Nilsson-Rosenberg BHQ index cannot be applied to sands and gravels. Features such as type of bed forms present, types of algae or phanerogams present and epifauna are regular features in sediment profile images from such habitats. Indeed, it is difficult to explain how quality indices for such habitats can be described as anything but good.

Jansson (1967), working on interstitial fauna described grain size as a super parameter as it controls other factors such as permeability, porosity and oxygen content. Grain size has also been found to be an important factor in determining the distribution of some polychaete genera. Data from substrate selection studies and descriptive work suggest that sediment type plays a large part in determining the species composition of a community and adds that, if this is the case, it should be possible to relate community structure to sediment type. As grain size is to a large part regulated by current velocity, we suggest that if the physical oceanography of an area is known, it may be possible to predict what sediment occurs and additionally what species may be present.

5.1.3.4. Florent Colas (Ifremer): System development for fish egg and zooplankton imaging

Traditionally plankton and fish eggs are characterised by binocular, involving long duration methods. A faster method needs to be developed. Flowcam and Zooscan were not adapted initially, so had to be redesigned. The updated system has the same architecture as the Flowcam but a 10 mm thick flow cell with a stirring system included. The system has been tested at sea recently with CUFES samples, ie. stations where eggs and fishes were counted. The new system accounts well for eggs, as a $R^2 =$



0.99 is found between traditional methods and automated systems. The system recognises the organisms types including copepods, flagellates, etc. The system can acquire 15 images per minute.

5.1.3.5. Simone Marini (CNR-ISMAR): Underwater image acquisition and processing from fixed and Lagrangian platforms

This system is designed as a stand-alone, low cost, low power instrument for long term deployment on fixed or autonomous platforms, for open ocean research at various scales. The system comprises an image acquisition systems mounted on Arvor C float. The processing allows algorithms to be run for image processing and recognition. It is programmable. The communication system is still in development. Some specific applications include recognition of jelly fish by feature and supervised learning and fish recognition by background subtraction. This consists of subtracting a background image from the input image. Burrow recognition is also possible by image segmentation and clustering. Image quality with low light must be improved (time exposure & sensor quality). Future work will include 3D reconstruction from stereo images. There are some concerns regarding energy consumption on the Arvor-C float. This requires further investigation.

5.1.3.6. Romagnan, J-B., Elineau A., Picheral, M. , Stemmann, L., : Development of new tools and strategies for the monitoring of bottle and net collected plankton. A system based on image acquisition and semi-automatic analysis.

Marine communities are essential in the context of sustainable use of coastal ecosystems. Their monitoring is still largely based on time consuming and expensive procedures, which are not suitable high frequency monitoring or for extensive spatial coverage. In the planktonic realm, difficulties result from analyzing plankton on a size range which encompasses tiny phytoplankton to large zooplankton. Recently developed imaging instruments and image analysis techniques now enable the fast and reliable enumeration and measurement of both phytoplankton and zooplankton. The Zooscan and its associated open source software, the Zooprocess, offers a solution for analyzing the zooplankton which is affordable, efficient, now widely used, and completely open for users. Open source software allows users to develop specific applications which can be shared in the community. In the framework of the JERICO WP10, we upgraded and tested the open source, free, Zooprocess which now has specific modules and dedicated toolboxes for analyzing Zooscan, FlowCAM and Underwater Vision Profiler outputs. It also offers the possibility to analyze images coming from other various imaging devices through a “generic” module. This module has been successfully tested with images coming from HD wide field of view inverted microscopy, ISIIS and composite images. Eventually, the Zooprocess offers an economic and technically robust solution for analyzing images of plankton from 3 µm ESD to several centimeters ESD, thus encompassing tiny phytoplankton to large zooplankton in a completely consistent and homogenous manner.



5.1.3.7. Morning Discussions, conclusions and next actions

Dominique: Durand:

We have seen a great progress on software and techniques related to image analysis for biology. One step forward is the integration. Most presentations show the concept of big data: more and more images, we are at the centre of the analysis issue in the context of big data.

Antoine Gremare:

Interaction with potential user is very important for the development of the 10.1 task. Need to make a demonstration

5.1.4. Practical session where users in different institutes interact with tools developed

5.1.4.1. Demonstration of the Flowcam and Zooscan: postponed at 5 pm, to 10-person group in a building next to the workshop building.

Most of the workshop attendees had the opportunity to take part in the Flowcam and Zooscan demonstration provided by Jean Baptiste Romagnan. This was an excellent practical session where both technologies were used on real samples. The demonstration included a detailed discussion on the practicalities of running the systems and the post processing, analysis and archival of images for future use.

5.1.4.2. Felipe Artigas : Presentation and first results of the INTERREG DYMAPHY project

DYMAPHY: Development of DYNAMIC observation systems for the Assessment of MARine water quality, based on PHYtoplankton analysis. The purpose is to monitor phytoplankton community structure in real time, with standard operational procedures. This included a presentation of the Pulse-shape recording flow cytometer: CytoSense Benchtop (CytoBuoy BV, NL). The CytoSense records the optical profile of each single cell or colony and is useful for species recognition by flow cytometry and phytoplankton abundance dynamics. It has been compared to Multi-spectral fluorometer measurements. It is a step towards an automatic recognition of phytoplankton by flow cytometry:

- Different approaches were tested so far: unsupervised, supervised and semi-supervised
- Approaches based both on cellular optical features and directly on cytometric profiles by elastic matching
- Algorithms developed for a multi-group semi-supervised classification

The system has been implemented in a pocket ferrybox. It allows the continuous measurement of many environmental parameters during a ship cruise, in sub-surface waters (salinity, temperature, turbidity, fluorescence). The next step for this technology is the association of the spectro-



fluorometer and the cytometer in order to integrate the physico-chemical and biologic parameters at high spatial resolution, in cruises.

5.1.4.3. Guillaume Wacquet : Optical detection and automatic classification of phytoplankton by the coupled system FlowCAM/PhytoImage

Phytoplankton, representing one of the most dynamic biological compartments, has been selected as a key parameter for the classification of the ecological status of water bodies. The interest in high-resolution monitoring of phytoplankton communities has contributed to the development of innovative methods allowing to reduce analysis time and to perform a variety of measures. The FlowCAM (Flow Cytometer And Microscope), associated with a suite of software for image processing (PhytoImage), allows to have new insights into the dynamics of phytoplankton assemblages through the acquisition of digital images and automatic recognition of the particles. The experiments conducted for the optimization of the digitization protocol helped to highlight the importance of samples treatment and parameters related to water flow.

As part of the network to monitor phytoplankton and phycotoxins (REPHY) and others regional networks controlled by IFREMER, a learning set was developed and optimized to reduce the prediction errors induced by supervised classification algorithm. The analysis of recognition performance showed a correct identification of major phytoplankton taxa present in the Channel and North Sea (global identification rate of 70-80%). The results observed in this study highlight the relevance of the coupled FlowCAM/PhytoImage system for the automatic recognition of particles in a sample. However, this encouraging result is not definitive because numerous improvements can be brought.

5.1.4.4. Elvire Antajan¹, Maxime Lédée¹, Franck Coppin¹, and Stéphane Gasparini² : Plankton Identifier, a free software for automatic identification of plankton: new features, and application example.

1Ifremer, Boulogne-sur-Mer, France, 2UPMC-Paris 6, Laboratoire d'Océanographie de Villefranche-sur-Mer, France

Plankton Identifier, a free software for automatic identification of plankton: new features, and application example.

Plankton Identifier is a free software dedicated to automatic identification of objects (planktonic organisms and/or particles) from a set of images (.jpg) with their associated data (.txt). Sample analysis using imaging system follows 4 main steps: Sample preparation, Image acquisition, Image Processing and Object identification. *Plankton Identifier* is only concerned by the last step. It allows automatic identification of objects using supervised learning methods, and visual validation of the predicted identification obtained by taxonomist experts. This software is compatible with output files generated by *ZooProcess* and *PhytoImage* softwares used for image acquisition and processing with the ZooScan and FlowCAM imaging systems. After 7 years of utilisation we have decided it was time to make a new version of the software, to add new functions that were expected by users. The presentation gives an overview of these new functions.



5.1.4.5. Méliotus Thyssen, Gérald Grégori, Michel Denis. Integration of phytoplankton structural and functional diversity in monitoring programs: Automated and remotely controlled flow cytometry

Determining phytoplankton community structure at the frequency needed to simultaneously establish the influence of both cellular dynamics and environmental changes is a real challenge for oceanographers. Phytoplankton community structure triggers the trophic status of the marine ecosystem and its impact on the quality of marine habitats makes phytoplankton one of the main indicators in coastal monitoring programs. Sudden and pulsed event (storms, winds, atmospheric dust deposits, hydrologic changes) impacts on the trophic web are closely linked to the phytoplankton-community-structure response that could be event-dependent and reacts at the hourly scale. These sudden events may drastically change the biomass balance of a basin through the perturbation of the community succession scheme and through the settlement of productive events such as blooms. The only way to study phytoplankton community structure under several meteorological conditions is to use automated sensors. One of the upper most achieved instrument that accounts for phytoplankton functional diversity, abundance, and dynamics is the automated remotely controlled and “image in flow” flow cytometer. This kind of instrument enables single cell analysis from 1 up to 800 μm in width and several mm in length, analyzing up to 5 cm^3 . The Cytosense instrument has demonstrated its reliability in time, as it was deployed on the EOL buoy in the Bay of Villefranche sur Mer as well as on the ferry ‘L’Armorique’ from the Brittany ferries in the frame of the Marinexus EU project for several months. The collected data provide tremendous new information on phytoplankton community structure at the sub-meso-scale and at the hourly scale. Local and global observing systems should soon be supplemented with such automated flow cytometers to link phytoplankton dynamics to environmental changes and better address the impact of global change.

In terms of anti-fouling strategy, chlorination is used on the EOL buoy while the ferrybox has a cleaning procedure which also cleans the flow cytometer.

The system can be deployed on a fixed platform for up to 4 months (one sample every 3 hours) and for up to 1 year on a ferrybox.

5.1.4.6. Veronique Creach (CEFAS): Flow-cytometer online with ferrybox in a research vessel

CEFAS has developed on-line flow cytometric measurements with the following key features:

Fully automated measurement and analysis in real-time

- Cost effective solution
- Already operational for different platforms
 - Long term time series for fixed platforms
 - Large Geographic coverage with research vessel and ferry
- Quantitative and qualitative estimation of life forms for the state-space method(UK Marine Strategy for the MSFD, May 2013)
- Validation of biogeochemical and size-based model

Conclusions from conference or workshop UK-IMON September 2013



- We have to combine several chemical properties on different cruises to save money
- Need of standardization in data capture, storage, QA/QC
- Need to better interface observations and models and promote interaction between biologists and modelers
- Need sensors to be interoperable to be compatible with the widest possible range of platforms

5.1.4.7. Afternoon Discussions, conclusions and next actions

Introduction of discussions by G. Nolan:

We need to work on technologies, what is best technology dedicated to phytoplankton monitoring, zooplankton monitoring, and for bacteria? On what platform? What is the operational status? What are the development opportunities?

Dominique Durand: we are at the mid stage in JERICO, what will be then next step?

Simone Marini: interested in acoustic development for zooplankton, phytoplankton.

USA: imaging of zooplankton can be applied to cyanobacteria in the Baltic sea: a potential research topic

A. Gremare: 2 lines of research to be carried out in JERICO.

With regards to morning presentations: always the same process: classification, learning. We need to optimise the weak points by putting people together. We promised a demonstration survey and it has been underlined this morning that the future of the software depends on the interaction between users and developers,(ref JB Romagnan presentation). Romagnan added that there is a need to standardize outgoing data format.

A. Gremare: This demonstration should be organised in 2 steps: first the experts see what they can do together= 1 wkshop, then a wkshop with users.



5.2. JERICO a potential network for biodiversity observation

5.2.1. Possible strategies and potentials for JERICO to become a network for biodiversity observation

Sander Wijnhoven – Monitor Taskforce, NIOZ-Yerseke, the Netherlands: Possible strategies and potentials for JERICO to become a network for biodiversity observation

Presentation related to WP1 – Task 1.4

The potentials for JERICO to develop into a network for biodiversity observation (as well) were discussed. Three strategies can be identified: 1) Implementation of sensors, indicative for biodiversity state, in the existing or foreseen JERICO observatory network, 2) Linking of JERICO network to existing or developing initiatives of biodiversity networks or pan-European biodiversity measurement programmes, 3) Optimization of sensors delivering for biodiversity relevant explaining or modelling parameters already present or foreseen in the JERICO network. A combination of the three might be the most promising strategy. The workshop particularly focussed on a discussion of a gross list of potential biodiversity sensing methodologies divided into the categories: Primary Production, Community composition, Camera observation, Size distribution, Biomass, Acoustic sensors, Tag detection, Artificial substrates, Pigment analysis, Genetic detection and Cytometry, which were scored for the aspects: Data type (single, frequent, continuous observation), Area of observation (spatial scale), Integrability in the JERICO network of observatories, Indicator value towards biodiversity, Current status of operability and Estimated costs. In the second part ongoing Pan-European biodiversity initiatives (i.e. EEA, LTER, GEO BON, ICES, LifeWatch, EMBOS and several deep sea and/or open ocean initiatives, were discussed on the potentials for JERICO to link to those or to adjust mutual initiatives. The valuable input from the workshop participants will be implemented and discussed in a concept report which will be distributed for discussion to those interested at the end of 2013, to come to a widely agreed strategy and roadmap for the future.

5.2.2. Task 10.2: Developments of physico-chemical sensors and implementation on new platforms

5.2.2.1. Kai Sorenson and Chris Harman: Status on the contaminants experiments on Color Fantasy

On the Color Fantasy Ferrybox system operated between Oslo and Kiel a passive sampler unit has been used to test the passive approach for different contaminants.

The unit consists of 6 stainless steel chambers where semi-permeable membranes device (SPMD) can be exposed for water in a flow through system. Tests have been done with both SPMD with triolin oil and also Low Density Polyethylene membranes (LDPE) without oil. Five of chambers are exposed in 5 different areas and one chamber is used as reference. In between the exposures the units and membranes was stored in nitrogen gas. After exposures the membranes are analyzed for PAH. The



membranes are spiked with a performance reference compound (PRC) with 6PAH with known concentration.

A 14 days exposures was performed in August 2013 of the five units using a flow rate of 7 l/min gave effective from 7.8 to 28 m³ of seawater through the chambers due to different exposure areas/ship distance. The effective exposures relative to days are between 1 and 3 days. After the exposure the membranes was analyzed for 19 PAHs.

The results from LDPE showed that the system accumulated Σ PAH up to 150 ng/sampler, which is enough for analytical confidence and much more than from standard water sampler. The results show expected PAH congener pattern and the air contamination are small. The PRC data fits model for pattern, but not the amount which suggests unexpectedly high dissipation into storage gas in between successive water exposures. Water concentration calculations were therefor not possible. A solution could be to replace the in situ calibration with a lab calibration using PRC to derive accurate sampling rates.

5.2.2.2. Steffen Aßmann, Willy Peterson, Carsten Frank (Pco2 and pH sensors)

The ocean is facing a rapid change due to the increased uptake of CO₂ from the atmosphere leading to ocean acidification. Coastal areas (e.g. North Sea) have large uncertainties in their contribution to the global CO₂ budget. Underway systems (e.g. FerryBoxes) are suitable platforms for continuous monitoring of the surface ocean. The carbonate system can be described by the four classical carbonate parameters, carbon dioxide partial pressure ($p\text{CO}_2$), pH, total alkalinity (TA) and dissolved inorganic carbon (DIC). For a full characterization of the carbonate system, only two out of these parameters must be known. Spectrophotometry is currently the technique used to detect pH and total alkalinity providing high precision measurements. Spectrophotometry can characterize the abundance of two forms of a suitable indicator mixed in a small volume of seawater. The equilibrium of these forms is directly connected to either pH, carbonate ion, or after acidification of the sample to total alkalinity (A_T). A combined instrument based on sequential injection analysis (SIA) has been developed to measure pH and A_T quasi continuously in flow-through systems. The precision was 0.0007 for pH and 5 $\mu\text{mol/l}$ for A_T . The reached accuracy was about 0.003 for pH and 1 $\mu\text{mol/l}$ for A_T . The next step will be to integrate such sensors in FerryBox systems.

5.2.2.3. Jukka Seppälä: LED fluorometers for monitoring phytoplankton accessory pigments

Presentation reviewed established LED fluorometer technology for detection of Chlorophyll a and phycobilin fluorescence, which are used in the estimation of bulk phytoplankton biomass and cyanobacteria counterparts. Multiwavelength techniques for evaluation of taxonomic composition of phytoplankton were presented. Different wavelength settings of commercial instruments were shown and the principal statistical tools for data analysis were described. Results from laboratory based tests and field trials for phycoerythrin and multiwavelength fluorometers were shown, demonstrating the state of development during the Jerico project. Issues for calibration of phycobilin and multiwavelength fluorometers were discussed.



5.2.2.4. Stefan Simis: The state of the art of fast repetition rate fluorometry for the ferrybox

The first commercially available fast-repetition rate fluorometer designed specifically for flow-through systems and with dual excitation light sources, is being tested onboard MS Finnmaid, a ship-of-opportunity travelling the Helsinki-Travemünde route in the Baltic Sea. The optical configuration of the instrument follows the recommendations for optimal sensitivity to cyanobacteria and algae with two excitation channels (450 and 590 nm) and a narrow (10 nm) emission band centred at 685 nm. Implementation of the instrument on a ferry is facilitated by user definable protocols for control of valves and pumps, allowing dark acclimation of the sample, recirculation between two sample chambers, flushing of the instrument between measurements, and a web server API. Seawater flowing through the second (non-measurement) sample chamber keeps the sample at seawater temperature. An open-source wrapper (Python) library is being developed to interface between the ferrybox or user and the instrument web server, providing (meta)data handling and data storage. Results from the first test implementation on the ferry showed sufficient sensitivity in bloom and post-bloom periods.

5.2.3. Task 10.2: Developments of physico-chemical sensors and implementation on new platforms - continuation

5.2.3.1. Victoire M. C. Rérolle (1), Cedric F. A. Floquet (2), Matt C. Mowlem (2), Andy J. K. Harris (2), Eric P. Achterberg (1)

University of Southampton, National Oceanography Centre, Southampton, Southampton SO14 3ZH, UK, (2) National Oceanography Centre, Southampton SO14 3ZH, UK, **DEVELOPMENT OF A SHIPBOARD/IN SITU SENSOR FOR SEAWATER pH BASED ON THE SPECTROPHOTOMETRIC METHOD**

High quality carbonate chemistry measurements with good spatial and temporal coverage are required to apprehend ocean acidification phenomena.

Our aim is to develop an accurate and precise autonomous *in situ* pH sensor for long term deployment on remote platforms. The system is based on the spectrophotometric approach implemented on a simple micro-fluidic platform with low power and reagent consumption. A robust optical set up is achieved with the use of a custom-made polymeric flow cell coupled to a three wavelength LED. The measurement is made close to *in situ* temperature (+0.2 °C) in the continuous flow of the ship's underway seawater supply.

The system features a short term precision of 1 mpH unit (n=20) and an accuracy within the range of a certified Tris buffer (4 mpH units). The pH sensor has been deployed on research cruises for a period of two months in summer 2011.

Next step of the miniaturisation will be the replacement of the spectrophotometer by a single photodiode and modulate the LEDs in frequency to enable measurement at several wavelengths.

Technical details of the sensor with an emphasis on the microfluidic design were presented as well as the pH data obtained during the RRS cruise D366 in summer 2011.



5.2.3.2. L.Coppola, E.Diamond, F.Gazeau, JP Gattuso, JM Grisoni: pCO₂ Contros tests in laboratory: calibration with in situ measurements experiment

Understanding ocean acidification needs to improve resolution of the carbonate system and its variability. Until now, few data on carbonate chemistry are available in the Mediterranean Sea. However, since 2010, the GCOS defined the pCO₂ as an Essential Climate Variables (ECVs) with a high impact on the requirements of the UNFCCC and IPCC. Consequently pCO₂ should be implemented in the existing oceanic observing network.

In the JERICO project, we planned to implement a new pCO₂ sensor developed by CONTROS (<http://www.contros.eu>) on fixed coastal platform located in the Villefranche bay (EOL buoy) in order to intensify the present CO₂ time series. Until now the carbonate system is measured through DIC and alkalinity measurements with biweekly seawater sampling. This method is not sufficient to understand the temporal variability of the pCO₂ content.

Before the pCO₂ sensor installation on the EOL buoy, we tested the accuracy and the precision of the pCO₂ data acquired by the CONTROS sensor (HydroC). We made different lab tests (seawater tank during 1 month with a measurement every 6 hours) for adjusting the flush time and measurement frequency (respectively 15 and 30 min). During this test, we also compared the pCO₂ data from the HydroC with the in situ sampling (AT-CT used to estimate pCO₂). We obtained a difference less than 10 uatm that is consistent with the technical characteristics provided by the manufacturer.

The next step is to test in the lab this pCO₂ sensor with a SeaFET pH sensor from SATlantic before deploying both sensors under the EOL buoy in the spring 2014.

5.2.3.3. Bengt Karlsson: Results from reference sampling and measurements of optical in situ parameters, pH and CO₂ in the Baltic Sea and the Skagerrak-Kattegat.

Evaluation of sensors for CO₂, pH, and optical sensors for detecting phytoplankton biomass, i.e. chlorophyll and phycocyanin fluorescence in the Baltic Sea and the Kattegat-Skagerrak-North Sea area continues. An article on a novel pH method has been published in *Analytica Chimica Acta* (Hakonen et al. 2013). The FerryBox system on the ship TransPaper is used for continuous measurements covering the Baltic Sea and the Kattegat twice every week. Reference sampling is carried out every two weeks. The correlation between chlorophyll a from water samples and chlorophyll fluorescence is low. The effect of sunlight, in the form of photoquenching of chlorophyll fluorescence is evident and will be further investigated. In a detailed study in July 2013 phytoplankton samples, and samples for HPLC analyses of pigments and molecular biological analyses of the plankton community were collected. The study coincided with a cyanobacteria bloom in the Baltic proper. Samples are being analysed in cooperation with the University of Gothenburg and the KTH Royal Institute of Technology. Results are expected to be available early in 2014. During the one week study the sea surface was automatically photographed to document surface accumulations of cyanobacteria. An automated image analysis method for detecting the surface accumulations could be investigated within JERICO. Three surveys of the Skagerrak-Kattegat front have been carried out in cooperation with the University of Gothenburg who supplied a research vessel and personnel. Data from these surveys has been combined with FerryBox data from the area, i.e. from the ships TransPaper, Lysbris, and Color Fantasy. In the frontal area deep chlorophyll fluorescence maxima were prominent. In August 2012 the harmful alga *Karenia mikimotoi* was abundant in these layers. During the May 2013 cruise an Argo float was deployed north of Skagen.



Data on near surface salinity and temperature was collected when the device drifted with the currents to a location south of Bergen on the Norwegian Atlantic coast until mid-July 2013.

5.2.4. Task 10.4 Ships of opportunity, next generation fishing vessel probes

5.2.4.1. Laurent Delauney : novel platforms

In the framework of the Workpackage 10 and Task 10.4 "Ship of opportunity, next generation fishing vessel probes", a presentation has been done titled : "USV Novel Platforms".

Four categories of USV platforms have been presented :

- - USV for shallow water
- - ASMV (Autonomous Self Mooring Vehicle)
- - Coastal USV
- - UOV (Unmanned Ocean Vessel)

USV for shallow water are dedicated to Hydrographic survey, most of the time their specific specification is a compact size and a reasonable weight which allows handling by one or two persons. Quite rapid, this kind of USV allows fast survey mapping with few sensors on board and real time telemetry. Commonly, echo sounders, GPS and camera are part of the set up. There is very little feed back on chemical sensors in the literature. In this category, we can mention the Z-Boat 1800 from ocean science group.

ASM (Autonomous Self Mooring Vehicle) is a very specific category in which there are not many candidates. We can mention the C endure platform from ASV Limited (UK). It consists of a medium size platform which can hold various kind of sensors (passive acoustic, meteocean, seismic and environmental). The idea is to get 3 months autonomy with the help of solar panels and windmill. The platform can remain in a stationary position and has still some possibilities to move at low speed (4 knots) over a 4000 mile range.

Coastal USV and UOV (Unmanned Ocean Vessel) are two categories which overlap and which are actually developing quickly. The main purpose of these systems are to perform environmental survey over a specific area, or around an oceanographic vessel or for some quite still very specific campaign along transects across large areas. Commonly, these systems are designed in order to be able to use environmental oceanographic sensors, to transmit data in pseudo real time via satellite and offer a large autonomy. Some systems are noticeable in terms of energy harvesting. The most common one is an automatic sailing boat (Vaimos) equipped with a wind mill which consequently can theoretically navigates without any limit. Another very promising system is the Wave Glider from liquid robotic which uses the movement of the surface wave to animate some underwater parts which make the system to move on. This US company is very engaged in this technology since they are the only one to offer to customers the possibility to control and manage the wave gliders at sea from a central office from their company. Finally, we must mention the Mobesens electric USV which is the only one to offer the possibility to perform vertical profiles with the on board sensor pack and with the water withdraw unit.



5.2.4.2. Michela Martinelli: From FOS to FOOS: Advances in use of Fishing vessels for oceanographical purpose in the Adriatic Sea

The Fishery Observing System (FOS) experience started in 2003 for CNR, when 7 commercial vessels fishing for small pelagic species in the north and central Adriatic Sea were equipped with an integrated system for collecting data regarding catches, position of the fishing operation, depth and water temperature during the haul in the framework of the EU-FP5 project MFSTEP. Since then, this system still in place produced a great amount of data helpful both for oceanographic and fishery biology purpose. Thanks to JERICO and other national and international projects (e.g. SSD-Pesca, RITMARE, NEXOS), the Italian FOS is now being upgraded in FOOS: Fishery & Oceanography Observing System. The FOOS is able to collect more parameter, with more accuracy, and send them to a data center in near real time. The first trial installations are already in place

5.2.4.3. Patrick Farcy: New RECOPECA developments proposed by NEXOS

A participative approach to collect data on fishing activities and environmental parameters:

- Integrated multidisciplinary system
- A sample of voluntary fishing vessels fit out with sensors (data logger)
- Recording data on fishing effort, catches and physical parameters (temperature and salinity, turbidity coming soon) ☑ Concrete achievement of participative approach
- A sample of vessels representative of the whole fishing fleets, at a national scale
- A modular and affordable system adapted to active or passive gears
- Housed in different types/lengths of vessels

RECOPECA IN JERICO consists in :

- Upgrade with new probes: more parameters, near real time (collaboration with NKE)
- Evaluation of new sensors (typology, precision, accuracy, size, suitability for the purpose...)
- Demonstration surveys: simultaneous use of CTD and probes + trials on the sensors mounted on fishing gears

NEXOS future developments:

- The aim of the RECOPECA new developments in NEXOS FP7 OCEAN project is to develop a new sensor system for implementing the ecosystem approach to fisheries management for cost-efficient and multifunctional measurement of stock-relevant parameters.
- This will add **fluorescence** (as a proxy of chlorophyll-a) and **dissolved oxygen** to the currently measured physical parameters in one system.



5.3. Emerging technology and FerryBox data quality control algorithm

5.3.1. Task 10.3 Emerging technology: profiling technology, inter-comparison with mature technology

5.3.1.1. JM. Grisoni, L. Mousseau, L. Coppola, O. Passafiume. Autonomous profiler platform in coastal water (EOL3)

Rapid processes appear in coastal waters which require a high frequency observation system. To perform such observation, coastal buoys are the best platforms: they can deliver data in real-time and detect any rapid change that appears in the water column (e.g. bloom). Coastal buoys allows the plugging in of any power hungry sensor (thanks to solar panels) and can offer an anti-biofouling system to limit sensor drift.

In the Villefranche/Mer Oceanological Observatory (CNRS-UPMC), we developed since 2004 a new type of coastal buoy (MOBILIS) with an autonomous profiler (down to 100m depth) equipped with an anti-biofouling system (chlorination by electrolysis). This concept has been tested for 4 years: buoyancy, winch, energy and software have been validated as well as data transmission system (GMS and wireless). The robustness of the chlorination system has been also validated through the test of the conductivity accuracy (post calibration slope around 1.0001454 after 5 years deployment).

Since the first version, three versions of the EOL buoy have been developed. The last version, which has been deployed in April 2013, is larger and higher and allows the installation of more sensors. Since the installation, EOL3 is performing a daily CTD profile near the monitoring site Point B (SOMLIT station). The next plan is to install biogeochemical sensors (O₂, fluorescence) on the profiler and to implement pCO₂ and pH sensors under the buoy.

5.3.2. Task 10.5 FerryBox data Quality Control Algorithm

5.3.2.1. Mark Hartman and Wilhelm Peterson (Ferrybox QA algorithm development)

The huge amounts of FerryBox data require a reliable real-time data quality control and adequate data storage and data handling tools (e.g. relational databases, web-based visualization tools). In task 10.5 algorithms for optimizing the FerryBox data-processing are developed in order to facilitate the utilization of the data e.g. by models through data assimilation.

At HZG real-time flagging algorithms are developed according to MyOcean/SeaDataNet flagging scheme and to the recommendations of the DataMEQ group (EuroGOOS). Data are checked for spikes, frozen values, global range etc. Subsequently these qualified data are transferred to a MyOcean ftp site in near real-time. Currently these flagging algorithms are limited to physical parameters (S, T, Turb, DO). For delayed mode algorithms are partly available in MatLab code (Mark Hartman, Southampton) for use also by other partners. Next steps will be to develop common criteria for all FerryBox data, to make the checks more specific (e.g. including regional climatology) and also to include more biological parameters such as chlorophyll-a etc.

5.3.3. Task 10.6: Market study

In the framework of this task, a market study has been performed to select the most appropriate smart buoy to establish the relationship between surface (measured in situ and remotely) and near-bed (in situ tripod) concentration of suspended particulate matter (SPM). The acquisition of a smart buoy however appeared to be out of financial scope. Therefore it was decided to acquire a self-contained OBS-5+ system that could be attached to a navigation buoy.

In close cooperation with DAB Vloot, the owner of the navigation buoys, the AW-buoy was selected, which lies in a water depth of about 10 m, at a distance of about 6 km from the Zeebrugge harbor (see Figure 1).

Before deployment, series of calibration tests, both in lab and in situ, were performed on the OBS-5 sensor.

A first test with the OBS-5+ sensor was executed on September 25 2013 to test the attachment of the sensor to the navigation buoy. From September 26 2013 till October 16 2013, the OBS-5+ sensor was deployed for a period of 20 days, during which a storm passed by (October 8-9 2013). The deployment worked well and a good series of measurements were collected (see Figure 2).

The OBS-5+ sensor was redeployed on November 28 2013 and will collect surface SPM concentration measurements in continuous mode.

Once sufficient data have been gathered, covering enough variation in vertical and temporal SPM concentration, correlation with both satellite imagery and data from the benthic lander coastal observatory, will be investigated.

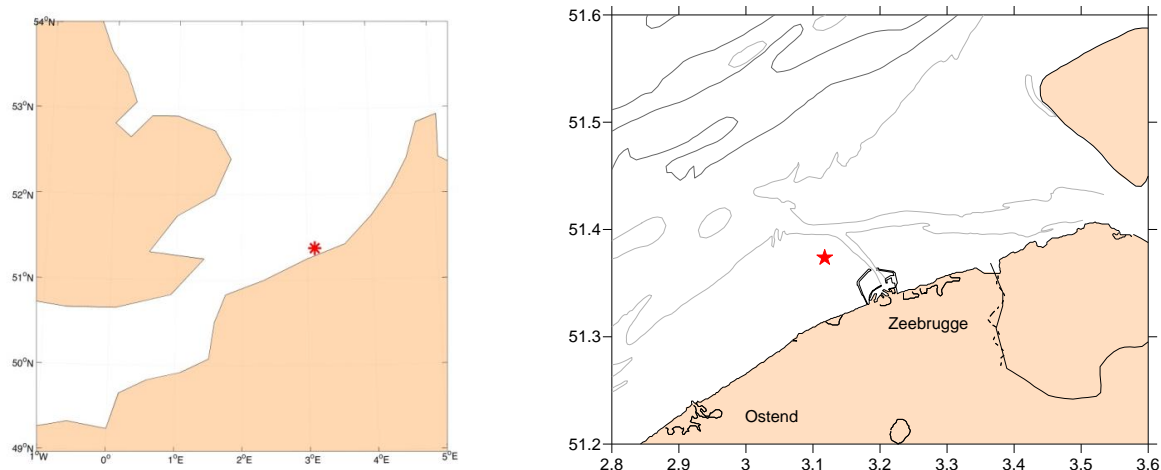


Figure Location of the OBS-5 sensor, attached to the AW-buoy.

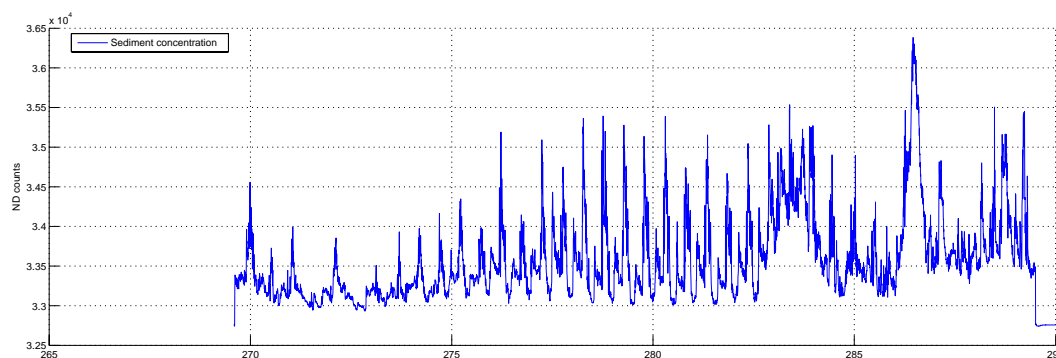


Figure Data series of OBS-5 sensor, unprocessed Near Detector counts. Time in Julian days. First trial.

5.4. Conclusions and summary of main decisions and actions

5.4.1. General remarks and conclusions

A comprehensive array of new research was presented during this workshop. The research presented comes from within the JERICO consortium and from many contributors outside the JERICO project who were interested in disseminating their work to the wider community. The JERICO consortium will need to make some recommendations on terms of the state of the art of key future technologies, many focused on biological compartments. To that end, JERICO needs to compile a list of the technologies presented at the workshop and to consider the following key aspects:

- Suitability of the technology to particular applications
- The most appropriate platform to deploy the technology from
- Operational readiness of the technology
- Research and development opportunities (highlighting current gaps)

The workshop also broadened the connections of the JERICO community to a variety of other researchers

5.4.2. Task 10.1

Four principal techniques are developed in this task:

- 1st development is on in situ video images of the sediment interface acquired using ROV or other mobile systems
- 2nd development is on in situ sediment profiler camera
- 3rd development: video sequences, obtained with fixed platform
- 4th development: dealing with pelagic ecosystems analysis of images obtained with Flowcam, Cytotflow and Zooscan systems.

In order to promote these techniques and to get user feedback, a follow on demonstration survey should be organised. The future of the software depends on the interaction between users and developers. There is also a need to standardize data formats.



5.4.3. Task 10.2

For online measurement of algal pigments, new commercial solutions using several wavelengths or with hyperspectral scanning properties have emerged and tested in various sea areas. Novel instrumental solutions and algorithms to estimate primary production with fluorescence induction techniques have been tested. Future work should focus on developing better algorithms for data analysis to retrieve taxonomic information. This work involves comparison of optical methods with traditional techniques (microscopy, pigment analysis, 14-C incubation) and with other new techniques (e.g. FlowCam). Integration of instruments for various platforms should be encouraged. When starting to work with new sensors, as soon as possible the user groups should decide on best practices for calibration and instrument maintenance (WP4) to allow collection of coherent data-sets

5.4.4. Task 10.3

Solid progress is reported for the EOL buoy experiment in the Ligurian Sea. The MAMBO/PAGODE inter-comparison in the Adriatic Sea is now underway with results expected in early 2014. An open ocean profiler experiment is being planned at present (Atlantic/Celtic Seas).

5.4.5. Task 10.4

A workshop was held in the early part of the JERICO project on using ships of opportunity. An overview of unmanned surface vehicles (USVs) was presented at this workshop to highlight some of the developments that have taken place in that regard. The reader is referred to the workshop presentations for more detailed information. Considerable progress was reported for the Italian Fisheries Operational Oceanographic System (FOOS) where equipping fishing vessels with sensors (eg. temperature, salinity, catch weight and net drum rotations) is becoming a mature and well understood technology. The focus is shifting towards making useful products for fishermen from the data collected from sensors on board fishing vessels.

5.4.6. Task 10.5

Existing Ferrybox quality control schemes were evaluated and discussed at the Ferrybox workshop in Helsinki (April 2013) with a view to developing new algorithms in the September 2013-2015 period. This task brings together the collective experience of Europe's Ferrybox operator in the development of new algorithms that will be made widely available to FB operators. The algorithms are adapted from the recommendation of the EuroGOOS Data-MEQ group for quality control of real-time in-situ data. The algorithms are applied either directly after measurement (e.g. HZG) or before central storage (NIVA) of all FerryBox data within the MyOcean project.

5.4.7. Task 10.6

RBINS OD-Nature have now identified a platform that they have access to in Belgian coastal waters to conduct this inter-comparison experiment. A Campbell Scientific OBS5+ sensor was attached on a buoy (in water depths of ~10 m) in the direct proximity of the benthic tripod frame. The turbidity sensor has been collecting data since end of September 2013 and has witnessed several storm events. It will continue to gather data until mid September 2014.

