**Project**  |  312463 - Fixed Point Open Ocean Observatories Network
---|---
**Work Package number**  |  WP3
**Work Package title**  |  PROCEDURAL HARMONISATION
**Deliverable number**  |  D3.1
**Deliverable title**  |  Common workshop on procedures
**Description**  |  All procedures used within the network have been described and documented through the collection of the existing protocols. During the workshop the procedures have been assessed in order to produce the contents of the “Handbook on Best Practices”.
**Lead beneficiary**  |  HCMR
**Lead authors**  |  Manolis Ntoumas (HCMR), Laurent Coppola (CNRS)
**Contributors**  |  CNRS, IEO, NOC, OGS, 52° North, UAC
**Submitted by**  |  Sofia Alexiou
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Executive Summary

Day to day operations on fixed installations is crucial and often very demanding. Fixed observatories around Europe have been developed by individual institutional efforts and thus, to a large extent, in an uncoordinated way guided by national priorities and funds. Furthermore, a wide variability of procedures adopted across Europe demands harmonization actions aiming towards the adoption of best practices and the subsequent reduction of costs.

To answer the procedural harmonization issues across the network, the FixO$^3$ community will undertake the following steps:

a) Assessment of operational procedures for sustained Eulerian observations
b) Further development of principles of “best practice”
c) Development of the FixO$^3$ observatories “label” building on ESONET and in collaboration with JERICO

A workshop was held on December 4th to 5th 2014 in Athens to assess the procedures used within the FixO$^3$ network of observatories (Task 3.1). The aim of the workshop was to further evaluate and discuss all the procedures of operating open ocean fixed observatories and select those that will be adopted as principles of “best practice” for FixO$^3$.

Introduction-Background
(The participants list can be found in Appendix A)

In the early stages of the FixO$^3$ project, the Hellenic Centre for Marine Research (HCMR) collected protocols and Standard Operating Procedures (SOP) from FixO$^3$ partners (Task 3.1). These protocols describe all the procedures used within the network, such as maintenance, service, calibration, pre-deployment, data transfer etc., and are necessary in order to operate an open sea observatory. The collected material included documents and SOPs of different formats describing all or some of the procedures/stages of the operational cycle for different types of observatories. Partners’ protocols, the presentations of the observatories technical aspects from the FixO$^3$ General Assembly held on 14th to 16th of October in Heraklion, Crete and the FixO$^3$ Deliverable D2.2: Review of the current marine fixed instrumentation were used by the workshop organizers to outline the themes that should be discussed during the meeting.

The orientation of the workshop was to move a step forward regarding the “procedural harmonization” and agree on the structure and the contents of the FixO$^3$ Best Practices Handbook. In order to address this, the organizers invited, apart from the principal investigators of the FixO$^3$ network of observatories, the technicians and scientists who actually operate the stations. The agenda of the workshop was configured accordingly and
rather than including general presentations of each observatory, focused on the common procedures and challenges of operating an open sea observatory.

The workshop was attended by 24 persons representing 14 FixO³ partners. It was a mixture of presentations and discussions covering the following categories:

- Common problems and solutions - Towards harmonization through best practices
- Sensors maintenance and calibration
- Anti-fouling techniques
- Deployment procedures
- Data qualification
- Providing observations in a standardized way - the Sensor Observation Service -
- Linking to ESONET Yellow Pages

Workshop Organization

The Common workshop on procedures was announced during the FixO³ GA in Heraklion (14-16 October 2014) and partners confirmed their participation through a web-hosted list. The meeting was organized and financed by WP3 Leader (HCMR) and took place at Electra Palace Hotel in Athens (http://www.electrahotels.gr). All the travel and accommodation were arranged by Ourios Travel, Tourism Services Bureau (www.ourios.gr) in direct communication with the participants.

The organizers would like to thank the participants and the staff of Electra Palace and Ourios Travel for their kind and professional contribution to the workshop success.

Agenda

Thursday 4th, 2014

Morning session: 20 min presentations and 20 min discussion

9h00-9h10
Welcome-registration

9h10-9h50
Sensors maintenance and calibration – Manolis Ntoumas (HCMR)

9h50-10h30
Common problems and solutions - Towards a harmonization through best practices – Manuel Bensi (OGS)
10h30-11h10
Anti-fouling techniques - Daniel Cano (IEO)

11h10-11h40
Coffee break

11h40-12h20
Deployment procedures - Miguel Charcos Llorens (NOC)

12h20-13h00
Data qualification – Laurent Coppola (CNRS)

13h00-14h00
Lunch

Afternoon session

14h00-14h40
"Providing observations in a standardized way - the Sensor Observation Service"- Christoph Stasch (52°North)

14h40-18h00
Open discussion of common practices and designation of best practices procedures

Friday 5th, 2014

Morning session

9h30
FIXO3 Best Practices handbook structure: agreement about chapters, appointment of leaders and deadlines
Presentation-Discussions
(All the presentations of the workshop can be found on Appendix B)

**Common problems and solutions -Towards harmonization through best practices**

**Manuel Bensi (OGS)** gave a presentation about the common problems and solutions adopted within the network in order to reach an optimal harmonization. The main objectives of these presentations were to stimulate a discussion on focal points about the best practices that the partners want to adopt within the FixO³ network and then present to (including but not limited to) the scientific community. The final goal is to decide and produce the necessary information to be included in the Best Practice Handbook.

The FixO³ network is quite big, with 23 observatories from 11 European countries and comprising of many multinational teams with high-level and multidisciplinary expertise. Some of the observatory sites were developed more than 30 years ago transmitting long term decadal data, but most of them were more recent and were deployed 5-10 years ago.

All the information about the architecture of the network is included in the deliverable report D.2.2 ("Review of the current marine fixed instrumentation"), which was delivered in August 2014. From that deliverable, some statistics can be extracted: in particular, 56% of the observatories are multiple arrays, while 30% are single arrays and 9% are cabled stations. Real time data transmission is a crucial point; so far only 50% of the observatories transmit in real time or near-real time. Therefore, within the WP3 and in light of the Best Practice Handbook due by Month 24 of the project, the minimum criteria required for the implementation of the real time data transmission were discussed.

From the summary of the information gathered through the web questionnaire on the FixO³ website (D.2.1: “On Line Knowledge-base For Infrastructure Characteristics”), common problems and possible solutions raised in the first year of the project were presented and discussed. Afterwards, the presentation focused on some general info about the mooring design, taking into account that the aim of the handbook is to provide important information to those approaching for the first time the deployment of a new observatory/mooring. The handbook will also cover questions such as: What are the basic considerations that the team has to take into account? What are basic components, type of the mooring, scientific purposes and location are some of them? Etc.

The mooring design at an open ocean fixed point observatory is a very important aspect because its configuration directly affects the success of the deployment. There are some tools that can help the observatory team to design a new mooring, one of these is the MDD (Mooring Design & Dynamics). Such tools offer the possibility to build a mooring line and test it under different environmental conditions before the deployment in order to check the tensions of the mooring line and the elongation that the cable can experience during its working period.

When the payload of the system is decided, or simply when an upgrade of the system is planned, changes in buoyancy must be taken into account in order to maintain the stability
of the mooring, and above all, to permit a correct recovery of the system during its “releasing phase”.

Another interesting tool that can help the observatory team to manage the data and the metadata in a standardized way is the Integrated Marine Observing System (IMOS) tool. It aims to provide an automated, easy to use interface for converting raw instrument data into IMOS compatible Quality Controlled NetCDF files. The toolbox is designed to process data, which are manually retrieved from long-term mooring sites.

In the final part of the presentation, Manuel Bensi gave some inputs for a discussion about problems found with particular instruments deployed at the OGS observatory (E2-M3A) during the last years. Indeed, the idea of a network should be to share data and technical information (expertise) that can help the community to optimize an observatory in the future. In order to investigate the presented problems and verify the reliability of the collected data, the OGS team has adopted and shared two good practices. The first one is to perform a CTD cast with some instruments attached on the rosette system, put them at a fixed depth for at least 40 minutes and check the data and the accuracies of the instruments. The second good, even more important, practice is to perform a CTD cast before the recovery and after the deployment in order to have the possibility to check the stability and the accuracy of the sensors, especially when and where the variability of the seawater properties is large. The presentation ended with an open discussion about the possibility to include a feedback of the users on each oceanographic instrument used within the network.

Sensors maintenance and calibration

Manolis Ntoumas (HCMR) gave a presentation about sensors maintenance techniques used in FIXO3 observatories. The methods and materials that can be used for maintaining different groups of sensors were presented using examples from HCMR’s Poseidon network of fixed stations. He also talked about sensor calibration procedures and recommendations based on the TNA calibration experiments and the Calibration Best Practices report from JERICO. He closed his talk with examples pointing to the necessity of monitoring the sensor behavior on the field after the maintenance and calibration procedures.

The main aspects of his presentation were:

- Sensors maintenance
  - Sensors maintenance facts for FixO³
- Maintenance and fouling affect – conductivity sensors example
- Fouling removal methods and materials
- Calibration Best Practices
  - Temperature and Conductivity calibration
    - On the lab
    - On the field
o Optical sensors (Fluorometer – Turbidity sensors) calibration
o Dissolved Oxygen calibration
  ▪ Dissolved Oxygen Protocols
o Chemicals sensor calibration
• Monitor sensor performance at the field

The key points of the discussion following the presentation included:

• Common problems that the observatory operators face during sensor maintenance
• The need for double checking the reference instruments of the calibration in specific time intervals; distinguish between well-established calibration standards and not well-established ones.
• Ways to check/validate the calibration results on the field prior to a new deployment
• The discussion highlighted the need for feedback on pH and CO2 sensors calibration and data analysis.
• The production of appropriate metadata for data traceability is a major task in FixO³. Data files should be self-described in terms of sensor operation, maintenance and calibration

Anti-fouling techniques

Daniel Cano (IEO) focused on the anti-fouling techniques used in open ocean fixed observatories. His presentation included an introduction about the fouling formation mechanisms and the affect on the sensors and different parts of an infrastructure using examples from his experience at the IEO station. He continued presenting the sensor groups that are most sensitive to fouling and the antifouling techniques already used within the FixO³ network, as well as some new ones that are under research.

Fouling Formation Biofouling is a common problem that arises in most of the marine platforms and observatories. Although the affectation varies in magnitude from observatory to observatory up to certain depth, it may be the main cause for major data loss.

Biofouling is simply the attachment of an organism or organisms to a surface in contact with water for a period of time. Despite its simple definition, the biofouling mechanism is not so simple and certain conditions (pH, nutrients, etc) have to be met.

Fouling Effects
None of the possible side effects of fouling formation on probes/structures are permanent. These side effects may:
- Increase the system weight, reducing then the buoyancy.
- Degrade coatings, exposing the whole system to corrosion.
- Change the normal behavior of the probes by covering sensor windows, blocking water intakes, and reducing wiper effectiveness, individually or all together.
- Problems on connectors and cables.
- Covering solar panels, not allowing batteries to charge and leading to a total failure.

Regarding the fouling effect on data all probes are exposed to biofouling, but the most sensitive ones are:

- pH
- Turbidity
- CO₂
- “Whatever dissolved” sensor
- Image/Video devices

**Anti Fouling Techniques**

Almost all of the stations share some instrument or set of instruments so this approach to antifouling is valid for all of them. This is a preventive approach and the success of this approach heavily depends on the geographical position and the depth of the structure. Maintenance frequency is also a key point.

1. First step is anti fouling coatings for structures where available
2. Next step is using sensors with anti fouling systems, such as.
   - Copper shutters
   - Chlorine production
   - Wipers
   - Bleach injection
3. Cleaning, as mentioned above, is a key point. The most frequent the maintenance and cleaning, the less the possibilities of being affected by fouling.

There are state of the art anti fouling techniques, not available yet but very promising, such as

- Bio mimetic coatings
- Electro-mechanical device
- Direct electrification
- UV radiation

Some comments about the most common techniques:

- Copper shutters are suitable for all optical sensors but can have an adverse effect on oxygen sensors.
- Chlorine injection is suitable for all sensors. May have some adverse effect on oxygen sensor, but it can be turned off if necessary.
- Wipers are suitable for optical sensors, but the soft material it is made of can tear.
- Bleach injections are suitable for every sensor, but may have an adverse effect if it is not flushed correctly.

Some details about the state of the art anti fouling techniques:

- Bio mimetic coatings are natural anti fouling coatings based on chemicals produced by animals.
- Electro mechanical devices vibrate in order to remove the fouling material from the probe surface.
- Direct electrification is deadly for lots of life forms surrounding the device, so it may only be used on closed circuits.
- UV radiation is effective but only works well near the UV light bulb.

The discussion following the presentation covered the issues below:

- Passive or active anti-fouling systems, when and where they can be used.
- Partners experiences from antifouling systems and techniques.
- Daily visual inspection of the data can reveal the fouling effect.
- Side effects of anti-fouling techniques on sensors and mooring lines.
- New anti-fouling techniques.
- Examples of sensors sensitive to fouling.

**Deployment procedures**

*Miguel Charcos Llorens (NOCS)* gave a presentation about the needs for the deployment of FixO³ observatories. The procedures presented in his talk were based on the experience with the PAP observatory. He pointed to the importance of documenting the procedures of the observatory from the data requirements, equipment test and calibration, the history of the sensors used in the observatory, as well as the post deployment experiences such as observatory tracking, deployment logs and lessons learned. He stressed the importance of the metadata at different steps of the deployment which could help with tracking the calibration and history of the sensors. Another main part of the discussion was the importance of real data and telemetry systems for long term observatories.

The presentation and discussion key points included:

- Plan ahead
  - Data requirements => Sensors => Frame & buoy
- Test/Calibrate equipment: lab and close to real environment
- Document Deployment: Plans, checklists and responsibilities.
- Make sure to correct data appropriately
  - CTD cast at deployment and recovery
  - Post-calibration of sensors
  - Clock drift
  - Change/maintain sensors "correctly"
  - Renew/maintain buoy, mooring (specially for long term deployments)
- Log deployment: pictures, comments, videos, etc.
- Survey evolution
  - Real data => check received data regularly
  - Two way telemetry system => configure observatory if needed
  - Gather engineering data: power, sensor, H&T, buoy position, etc
  - Regular maintenance
- Close cycle loop with feedback
  - Early post-processing of data
  - Check final data quality and compare to data requirements
  - Flag data
- Share lessons learned and results
  - Update metadata
  - Update reviews of sensors
  - Inform of issues and solutions

## Data qualification

**Laurent Coppola (CNRS).**

The objective was to present the most common data qualification methods used for physical and biogeochemical data acquired from autonomous sensors installed on fixed stations. These qualifications should be applied in post-deployment procedures (second level correction) in order to correct drifts and to qualify dataset. For physical data (pressure, temperature, conductivity and currents), a first review has been presented in 2005 with all Q/C procedures by Kartensen et al. 2005 (ANIMATE report). These procedures are still relevant and should be used as best practices for mooring sites.

In this session, we focused essentially on correction methods that should be applied for biogeochemical essential climate variables recently implemented in observing system as FixO³ (oxygen, nitrate, pH, pCO2). The advantage of fixed stations versus Argo floats and gliders is the opportunity to perform robust comparison with in situ samples collected near the moorings when recurrent ship visits are possible. If regular ship visits are not possible, the use of climatology dataset near the fixed stations is also possible under steady state conditions (e.g. deep waters, no mixing zone, and low concentration level).

Today, thanks to the Argo community efforts, oxygen qualification from optical sensors (optode) has improved especially due to the new calibration procedure performed by the
manufacturers (multi-points calibration and Stern-Volmer equation). However, it is still admitted by the scientific community that the optode deployment always presents an offset around 20 μmol/kg. To correct this offset, we recommend using the last method from Takeshita et al. (2013). This linear method allows us to determine the slope and offset coefficients estimated from in situ sampling (Winkler titration) or climatology dataset (World Ocean Atlas). In sensitive oceanic regions, where seasonal variability is significant, we recommend to use in situ sampling as reference measurements (before mooring deployment and collection).

Regarding the nitrate data obtained from optical sensors (ISUS, SUNA), we propose to use the Temperature Compensated Salinity Subtracted (TCSS) algorithm developed for the deconvolution of nitrate concentration from the observed spectrum, taking into account temperature dependence of bromide spectra (Sakamoto et al. 2009). To use the TCSS algorithm, the full UV spectrum is necessary (increasing the data flow rate). The correction needs also good temperature and salinity data. A pressure dependence of bromide spectra exists and an empirical additional correction is applied to the extinction coefficient of seawater (ESW). Long-term drift was determined from the slope of a linear regression of the nitrate concentration at depth (average value between 800m and 1000m-depth) and offsets were then corrected by comparison with the climatological dataset or in situ sampling in summer, (nitrate concentrations are generally nil in surface during summer period).

Finally, pH and pCO2 data from recent sensors (CONTROS, Aanderaa, Seafet, ...) are evoked but the quality control procedures are not ready to be proposed as best practices yet. So far, a calibration coefficients fitting seems to be the best way to correct the data drift but some work is still necessary. This should progress in FixO3 through the WP12 inter-comparison exercise.

Discussion points:

1. Data handling, post correction.
2. DOXY adjustment from optode. Accuracy requirements, achieved?
3. Parameters affecting the measurements of different variables and the compensation methods utilized.
5. Information missing from the pCO2 and pH measurements for computation of engineering units and calibration.
6. Summer school for FixO3 community on data calibration and validation.
Providing observations in a standardized way - the Sensor Observation Service

Christoph Stasch (52°North) gave a presentation about the Sensor Observation Service (SOS), which is a standardized web service for accessing sensor observations and sensor descriptions in the Web. At first, the general idea of the Sensor Web and standardization efforts were introduced. Then, the two data models and encodings which are used by the SOS were described, i.e. the Sensor Model Language (Sensor ML) and Observations & Measurements (O&M). The core of the presentation was an explanation of the SOS interface and the illustration of different deployment strategies. Finally, two example use cases from the EEA and IRCEL-CELINE were shown.

Discussion points:

- Usage of SensorML, O&M and SOS in FixO³; discussion of profiles, best practices
- Advantages of SOS: formalized metadata · provenance, sensor information
- SOS for low-level devices (UPC)
- O&M vs. NetCDF: are they the same or complementary?
- Role of SensorML in yellow pages and for sensor discovery in general

Linking to ESONET Yellow Pages

Ana Colaço (IMAR/DOP-UAc) gave a presentation about yellow pages. Her presentation included an introduction on what are the major goals of yellow pages and how to use the yellow pages. The presentation followed with the FixO³ expected deliverables and the major concerns. The discussion followed with several key points:

- How to deal with the old sensors that are still in use but not available in the market
- Do we need input from Jerico, Eurosite Carboocean Ocean site communities? If so, how can we integrate these inputs? Shall access be given to the sensors feed layout?
- How the contacts shall be done with the SME’s. here the partner SLR was suggested
- How can we introduce additional information concerning sensor performances?
Results/ Decisions

1. Support FixO³ webpage

All the presentations and the info pack of the workshop will be uploaded on the FixO³ webpage.

2. Update ESONET Yellow Pages

The first update will be based on the Deliverable D2.2: Review of the current marine fixed instrumentation.

The common sensors will be identified and if the company is not already in the yellow pages, contacts need to be made with the industry (including contact and collaboration with FixO³ partner SLR will be made).

One of the major concerns is how to give feedback regarding sensors performance, problems troubleshooting for the yellow pages users. A traffic light system was suggested (eg. Green = good performance or enough data to evaluate; orange = need improvements or more tests to be able to evaluate; Red = No data available from scientists). The final solution needs to be revised at the light of the results from the analyses of the D2.2 report and contact with the observatories end-users.

Regarding the infrastructures section of the yellow pages, as EurOCEAN has a good data base (http://www.eurocean.org/np4/9), it was suggested that a link could be created. However no final decision was made.

3. FixO³ Best Practices Handbook structure finalized

The main goal of the Athens workshop was to assess all the procedures used within the network of FixO³ observatories in order to provide valuable information for Task 3.2: Principles of “best practice”. The meeting answered this purpose and after the final discussion that took part on the second day of the workshop, the result was to have finalized the structure of the FixO³ Best Practices Handbook (Appendix C). Apart from the handbook structure it was decided the appointment of working group leaders and specific deadlines for each chapter of the Best Practice document. Future actions include the coordination between working groups to produce the final version of FixO³ Best Practices Handbook.
### Appendix A: Workshop participants list

**Participants: 24 persons – 14 Institutes**

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Appendix B: Workshop Presentations
(All the presentations of the workshop can be found in the link below)


Appendix C: FixO³ Best Practices handbook structure

1 Observatories
1.1 Introduction
For users, optimal way, experiences from inside, recommendations for outside
+ Add paragraph ESONET label

1.2 Platform types (CNR, IFREMER, INGV, IEO)
1.2.1 Mooring lines
1.2.2 Buoys
1.2.3 Seabed platforms
1.2.4 Cabled observatories
+ glossary

1.3 Design structure (OGS, GEOMAR, PLOCAN)
1.3.1 Observing purpose: Parameters to measure and sensors selection
1.3.1.1 Core Parameters
1.3.1.2 Other Parameters
1.3.2 FixO³ Geographical location
1.3.3 Mooring lines/Anchoring Systems
1.3.4 Data transmission/Storage
1.3.4.1 Underwater
1.3.4.2 Surface to shore/Positioning System
1.3.5 Energetic autonomy
1.3.5.1 Cabled
1.3.5.2 Autonomous

1.3.5.2.1 Energy Storage

1.3.5.2.2 Power generation

1.3.5.2.2.1 Solar Panels

1.3.5.2.2.2 Wind turbines

+ add matrix mooring design

2 Pre-Deployment Procedures (NOC, HCMR, CNRS, UPC)

2.1 Maintenance

2.1.1 Corrosion prevention

2.1.2 Biofouling prevention

2.2 Sensors Configuration/Installation (HCMR)

2.2.1.1 Meteorological payload

2.2.1.2 Oceanographic payload

2.2.1.3 Bottom observatories modules

2.2.2 Sampling Scheme

2.2.3 Sensors Validation/Calibration

2.2.3.1 On the lab

2.2.3.2 On the field

3 Deployment-Recovery (OGS, IFREMER, Univ. Aberdeen, UPC)

3.1 Means

3.1.1 R/V operations

3.1.2 ROV operations

3.1.3 Divers operations

3.2 Deployment-Recovery Procedures

3.2.1 Tests prior to deployment

3.2.2 Safety regulations
Environmental impact paragraph (noise, ...)

4 Post-Deployment Procedures (CNRS, IEO, CNR, INGV)

4.1 Data Transfer

4.1.1 Real time

4.1.2 Delayed mode

4.1.3 Data post processing

4.2 Emergency procedures

5. Data qualification/validation (CNRS, GEOMAR)

6. Future directions (Univ. Aberdeen, 52° North, UPC)