INGV

Deep Sea & Sub-Seafloor Frontier

Workshop Report

Workpackage 8

“Infrastructure and Synergies”

Workshops held at

Marseille, 15 December 2010, hosted by ESONET NoE General Assembly

Vienna, 6 April 2011, hosted by EGU 2011 General Assembly

Organisers:

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Introduction

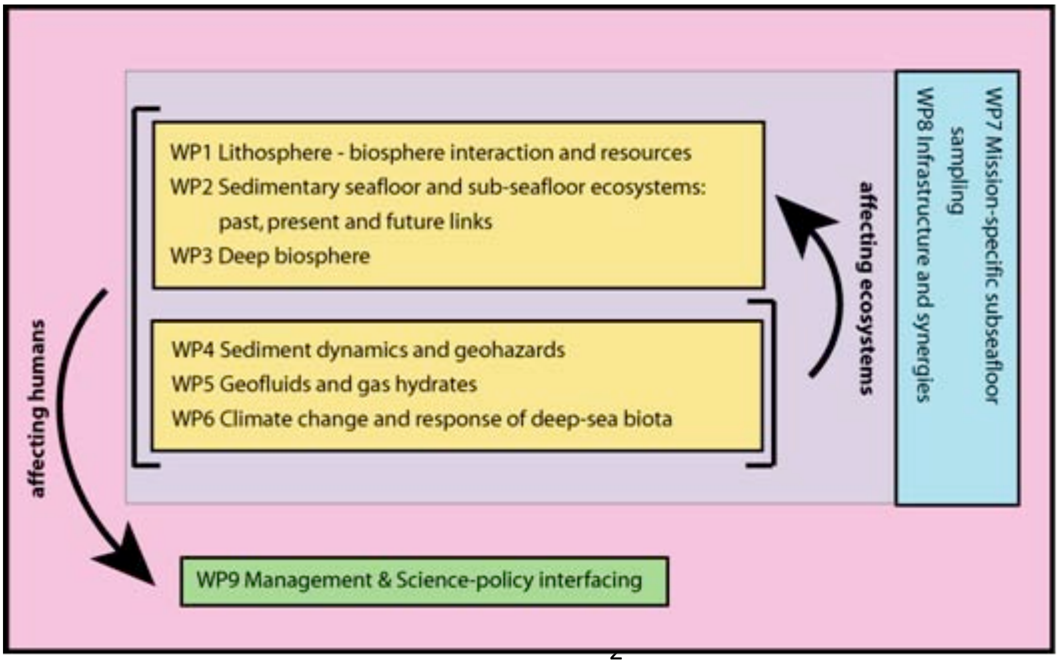
Deep sea monitoring and studies represent the new frontier of science. The project DS^3F provides a pathway towards sustainable management of oceanic resources on a European scale. It will develop sub-seafloor sampling strategies for enhanced understanding of deep-sea and sub-seafloor processes by connecting marine research in life and geosciences, climate and environmental change, with socioeconomic issues and policy building. The successful discovery and scientific achievements are strongly dependent on the availability, accessibility and novelty of the ocean technology and infrastructures and thus require the continuous innovation in marine engineering and knowledge transfer from a wide range of technical disciplines such as robotics, communications and energy to scientists, and then, in turn, to policymakers. The main objectives of DS^3F project are:

•Integrate the multi-disciplinary Deep-Sea Frontier community and experts in scientific drilling and sub-seafloor processes into a strategic partnership, in order to assess which targets are needed and how seabed sampling will contribute to emerging questions.

•Provide a link for various deep-sea, observatory & sub-seafloor frontier projects underway across Europe, create synergies and maximise the potential use of seagoing platforms, technology and scientific expertise.

•Produce a "white paper" and web portal for future research priorities in the deep-sea, seafloor and sub-seafloor frontiers that are required to underpin Europe's emerging Marine Strategy and Maritime Policy.

•Document areas where academia, and explicitly the international drilling initiatives and sub-seafloor sampling programs, have overlap with industry, and how synergy is gained when combining the two.



Taking into account the above points, two workshops were organized as part of DS^3F Work Package 8 *"Infrastructures and Synergy"* activity

- in Marseille (15/12/2010) during the ESONET NoE General Assembly
- in Vienna (6/4/2011) during the EGU 2011 General Assembly

This report summarises the discussions and ideas solicited in these workshops.

The primary goal of the workshops was to identify the needs to achieve the coordination of those ESFRI research infrastructures addressing marine monitoring and studies, FP7 projects and initiatives, and a distributed drilling European infrastructure that will allow the scientific communities to cooperate and share their resources and equipment.

Among the ESFRI infrastructure projects, the main participants are involved in EMSO- European Multidisciplinary Seafloor Observatories and KM3NET-Kilometer-Cube NEutrino Telescope. Both EMSO and KM3NET are in their Preparatory Phases which are aimed at the study, selection and establishment of the most appropriate governance and management structures. The studies also includ the analysis of costs relating to maintenance and upgrade of these research infrastructures. FP7 ESONET NoE (2007-2011) helped the networking of research institutions and companies for the integration of scientific and technological approaches in support of EMSO.

Further EC initiatives such as EuroFleets allows research vessels, large exchangeable equipment and ship time to be managed between members for optimal use. There is also the possibility to extend their access to non-member countries. Another project called EuroSites, is focused on establishing fixed observatories for water column processes monitoring and studies. It is fundamental to be aware of all these initiatives so that important observatory components and logistic supports may become available to a larger group of scientists if organised as RIs on the ESFRI list.

The WP8 workshops were intended to encourage discussion and brain-storming to identify scientific and technological topics and themes related with Research Infrastructures and European initiatives around which deep-seafloor and drilling communities can develop joint actions for a beneficial synergy.

Section 1: General information

WP8 Workshop in Marseille *Date*: 15 Dec. 2010

Location: Marseille (France)

Organiser(s): A. De Santis, L. Beranzoli (INGV, Italy)

Local host: ESONET NoE General Assembly , Jean Francois Rolin (IFREMER, France)

WP8 Workshop in Vienna *Date*: 6 Apr. 2011

Location: Vienna (Austria)

Organiser(s): A. De Santis, L. Beranzoli (INGV, Italy)

Local host: EGU 2011

Section 2: Logistics

Marseille WP8 WS

List of participants:

Angelo De Santis, (leader WP8) INGV (Italy)

Laura Beranzoli, INGV (Italy)

Paolo Favali (Guest: EMSO coordinator), INGV (Italy);

Fiona Grant (in replacement of Michael Gillooly), IMI (Ireland);

Christoph Waldmann, MARUM/Uni. Bremen (Germany);

Vasilis Lykousis, HCMR (Greece);

Nevio Zitellini, CNR-ISMAR (Italy);

Jean Francois Rolin (ESONET coordinator), IFREMER (France)

Vienna WP8 WS

List of participants:

Angelo De Santis, Laura Beranzoli, Enkelejda Qamili, INGV (Italy);

Fiona Grant (in replacement of Michael Gillooly), IMI (Ireland);

Christoph Waldmann, MARUM/Uni. Bremen (Germany);

Catherine Mével, IPGP (France) and WP7 Leader

WS Marseille Agenda:

The ESONET NoE General Assembly has been considered a profitable occasion for the WS meeting of the members of the WP8 working group contacted in the previous months.

The meeting agenda was conceived in two parts:

- (1) Give an overview of DS^3F
- (2) Provide the basis for an effective contribution of the members of WP8 working group to help the preparation of the 'DS^3F white paper'

with the following details:

Part 1)

- General Overview of DS^3F project: DS^3F at a glance
- More details of DS^3F project (e.g. Partnership/WPs)
- Meetings envisaged by the project

Part 2)

- WP8 objectives and what to do
- WG8 composition
- Scheme of working and tentative ToC of document
- Next WG8 Meeting

WS Vienna Agenda

1. Status on the DS^3F project and of WP8 and next deadline for reporting
2. Contribution of WP8 to Workshop report and mid-project report to the Commission
3. WP8 Document on guidelines (White Paper) and other amendment of DoW
4. Next WG8 meetings

Section 3: Scientific wrap-up

Abstract:

Work package 8 addressed “Infrastructure and synergies” within DS^3F and, more generally, the deep sea during two workshops at Marseille and Vienna in 2010 and 2011, respectively.
The European scientific community for long-term observation and state-of-the-art deep-sea technology has been involved in several important initiatives in FP6 and also during FP7. Development of European seafloor observatories with multi-disciplinary capabilities has been pioneered under the EC-funded GEOSTAR project, whereas later major technical advances have been made in the EC projects ASSEM and ORION-GEOSTAR-3 (a deep-sea geophysical, oceanographic and environmental network) and EXOCET/D. Experience in underwater cable connection by submersibles and ROVs has been gained by the deployment of neutrino arrays in the Mediterranean, such as NESTOR (Ionian Sea SW of Peloponnesus, Greece), ANTARES (Ligurian Sea, off Toulon, France), and NEMO (Ionian Sea, East of Sicily, Italy). Larger European projects have addressed, or still address, deep seafloor observatory networks, presently represented by the FP6/FP7 NoE ESONET and FP7 EMSO projects. ESONET NoE helps the networking and integration of scientific and technological approaches to establishing multidisciplinary deep-water cabled or autonomous observatories appropriate to monitor specific deep sea phenomena at various temporal and spatial scales around Europe from the Arctic Sea to the Black Sea. In parallel with ESONET, the EMSO-PP project (European Multidisciplinary Seafloor Observatory - Preparatory Phase) will study, select and establish the governance and the management structure, and will analyse the cost of developing and maintenance of the EMSO European Research Infrastructure, listed in the ESFRI roadmap.
The WP8 workshops were intended to initiate discussion and brain-storming to identify scientific and technological topics and themes related with Research Infrastructures and European initiatives around which deep-seafloor and drilling communities can develop joint actions for a beneficial synergy. Among the main themes identified during the two workshops, are i) facilities, ii) in situ measurements, and iii) data and models.

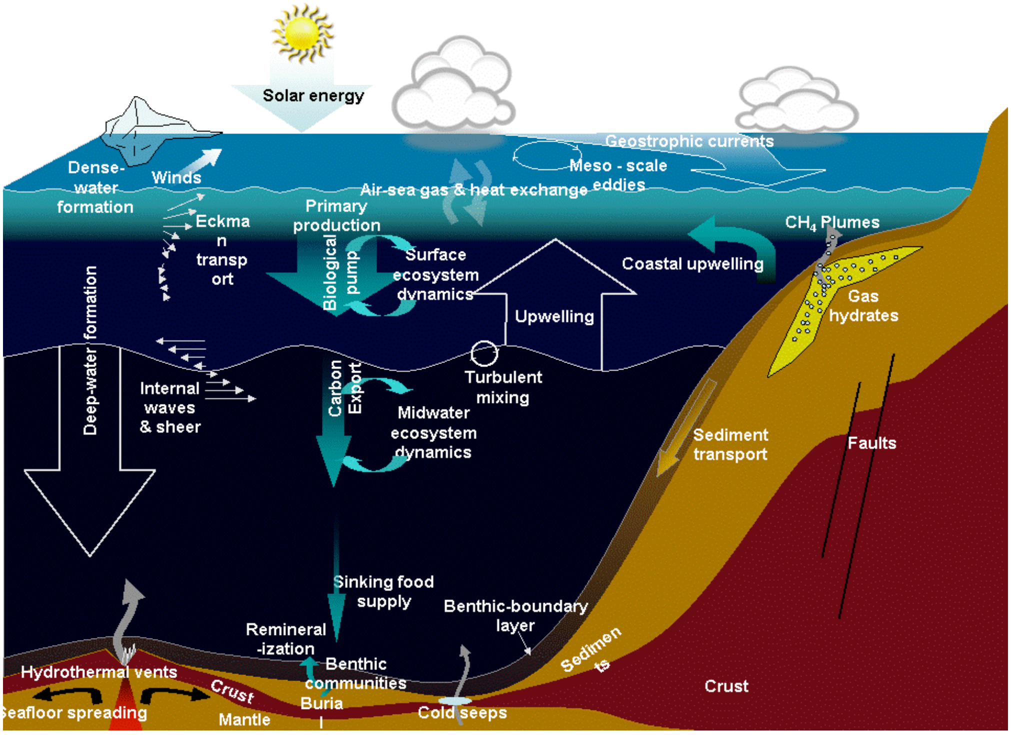


Figure 1: *Unravelling the complexity: interactions between atmosphere, ocean, Earth processes (Ruhl et al., 2011a)*

Background and Objectives:

Understanding the complex coupling of oceans with solid earth and atmosphere represents one of the greatest challenges of the new millennium (Ruhl et al., 2011a,b). The deep seafloor is our main source to discover and reconstruct the climate change history and its effects on the ecosystems.

Within the great ocean conveyor belt, involving a global interaction among upper, deep and bottom ocean waters, the latter colder waters store huge quantities of greenhouse gasses for at least a thousand of years: its monitoring is fundamental to understand how the oceanic part of the planet responds to global warming. At the UN Copenhagen Climate Conference in December 2009, all nations unanimously agreed to curb global warming not to exceed 2°C. Since human-induced global greenhouse warming will soon cross the 1°C mark and approach 2°C (IPCC, 2007), the next decades will be crucial for monitoring climate change. As the ocean is one of the most important factors in governing the worldwide warming process and climate variability, they must be closely observed (You, 2010).

Most tectonic margins are covered by oceans, and their better understanding in space distribution and time evolution is compulsory to give us real chances to mitigate potential future disasters caused by earthquakes, volcanic eruptions and tsunamis.

Marine technology has strongly evolved over the past decades and has been offering science new tools to achieve significant advances. As example, deep-sea vehicles (ROVs, AUVs, crawlers, etc.) are now key tools for the exploration of the deep ocean realms as well as drill ships (see WP7 report), which can provide long records into the past. With DV *Chikyu*, the scientific community has a platform of industry-standard, which is capable of riser coring and which hosts various biological and geochemical ultra-clean laboratories (www.jamstec.go.jp/chikyu/eng/index.html).
Since developments in industry run in parallel, the science community has benefited from a mature industrial supplier base and has been able to progress towards greater depth and higher reliability

regarding new sensor systems for physical, chemical and oceanographic *in situ* measurements. In this regard, the recent development of long-term, multi-parameter seafloor observatories has replied to a major challenge - the acquisition of long-tem time series in deep waters – which, in essence, represents the fourth dimension, i.e. temporal variability, to what academic research had established as a 3D understanding of the biosphere and geosphere. The fourth temporal dimension is critical for many processes affecting ecosystems and life on Earth, for instance the episodicity of fluid flow, rates of active tectonics, recurrence intervals of seismic hazards and landslides, and ecosystem life cycles. And with regard to the temporal dimension, long-term multidisciplinary sub-seafloor measurements are still very infrequent while the assessment of exchanges in the ground-water interface is essential to complete the observational frame and develop comprehensive models.

The European scientists' skills

The European scientific community for long-term observation and state-of-the-art deep-sea technology has been involved in several important initiatives in FP6 and also under FP7, which will be founding and continuous support of the development of DS^3F project. European seafloor observatories with multi-disciplinary capabilities have been pioneered under the EC-funded GEOSTAR project. Recent major technical advances have been made in the EC projects ASSEM and ORION-GEOSTAR-3 (a deep-sea geophysical, oceanographic and environmental network) and EXOCET/D. Experience in underwater cable connection by submersibles and ROVs has been gained by the deployment of neutrino arrays in the Mediterranean, such as NESTOR (Ionian Sea SW of Peloponnesus, Greece), ANTARES (Ligurian Sea, off Toulon, France), and NEMO (Ionian Sea, East of Sicily, Italy). Larger European projects addressed deep seafloor observatory networks, such as, for instance, FP6/FP7 NoE ESONET and FP7 EMSO projects. ESONET NoE has improved the networking and integration of scientific and technological approaches to establishing multidisciplinary deep-water cabled observatories at various temporal and spatial scales around Europe from the Arctic Sea to the Black Sea. EMSO project (European Multidisciplinary Seafloor Observatory) will study, select and establish the most appropriate governance and the better management structure, and will analyse the costs of developing and maintenance of the EMSO European Research Infrastructure. From these bases, DS^3F will follow the fundamental steps to contribute to the roadmap of the future deep sea research in Europe, together with the necessary infrastructures and trans-disciplinary expertise.

Since important international research programmes already exist in North America (NEPTUNE cabled network) and Japan (DONET cabled network), strict collaboration with these programmes has been already established to allow cross-fertilisation of ideas and technological approaches and strengthen and coordinate the role of European experts in this field.

Discussion and conclusions

On the basis of the presentation of the project as given by WP8 leader and Laura Beranzoli (INGV) to all WS participants, it was decided that there was a clear need to set up a tentative Table of

Content (ToC) as a constructive contribution to the "DS^3F white paper". This will help discussion within WG8 around main issues together with the assignment of part of the document to individual members of WG8 and inputs form other DS^3F WP leaders, to produce refinements/modifications/additions to the issues and ToC according to an "iterative approach".

Also the list of the invited people to participate to the WP8 was presented.

The following provisional Table of Content (ToC) was agreed as a frame of work:

1. Scientific objectives/needs addressed by seafloor and sub-seafloor observations (optional, expected contributions from the other WP leaders)
2. Synopsis (what is feasible nowadays)
   - *Seafloor and sub-seafloor monitoring*
   - *Infrastructures for in-situ measurements:*
     seafloor observatories, boreholes, moorings.
   - *Logistics for:*
     seafloor observatories
     seafloor sampling
     drilling and borehole instrumentation

   ……..others

   …….others
   - *Conclusions*
3. State of the art in Europe: present operating infrastructures for in situ measurements
   - *Monitoring infrastructures*
   - *Ships*
   - *ROV, AUV, etc.*
   - *Major stakeholders and scientific communities*
   - *Conclusions*
4. Requirements for optimal cooperation and synergy of the major Infrastructure Stakeholders and Deep Seafloor Scientific Community
   - *Requirements for optimal use*
   - *Requirements for infrastructure access*
   - *Requirements for future developments*
   - …
5. List of suggestions for agreement/MoU…

Although not apparently pertinent to the workshop, it is worth noting that during the discussion various comments had arisen on the difficulties to establish a single collaborative frame of the "drilling community" and "seafloor and water column communities", because of their different approaches, tools, and needs of financial support. This view was shared by many participants: it is widely understood that the inclusion of the "drilling community" within the FPs, would enrich the present "seafloor and water column" community by a wider scientific and technological perspective. However there is a substantial risk that it would also introduce an unbalance in the financial distribution. A recommendation with this respect was communicated by WP8 coordinator during the Vienna (April, 2011) Steering Committee meeting, and will be an important aspect in upcoming workshops and, most likely, the “DS^{3}F white paper” during the second half of the Coordination Action.

Figure 2:

1) GEOSTAR observatory during the ESONET-LIDO demo mission; 2a, 2b) Seafloor installation during the ESONET-MODOO demo mission; 3) junction box of MEUST cabled observatory; 4) POSEIDON experiment; 5) ESONET-Marmara demo mission.

Section 4: Link to WP7

Technological requirements for sub-seafloor sampling and measurements identified:

WP7 and WP8 will cooperate to ensure maximum efficiency in the use of equipment and infrastructures on a broader scale. This will provide a link between processes related to geology and biology in the sub-seafloor to its effects at ecosystems on the seafloor and the overlying water column.

Collection of sub-seafloor measurements however needs special attention with respect to installation of monitoring systems. For instance, some systems have to be effectively insulated from the seafloor environmental effects (e.g., seismometer installations in borehole: Webb, 1998; Stephen et al., 2003; Shioara et al. 2006), otherwise no reliable results can be obtained. Also the possibility to harnessing submarine telecommunication cables should be given proper consideration (You, 2010).

Delayed–time data retrieval at interval of the order of 1-2 months, when real time is not practicable, has to be the minimum requirement for data availability and assimilation. Conversely, for measurements related to geo-hazards, data transmission in real-time is the basic requirement to be fulfilled. The homogenisation of the data quality control and the data format, in compliance with the most popular standards used in Earth Sciences, has to be fundamental for data sharing and measurements comparison achieved. In this respect ESONET NoE has produced reference documentation (www.esonet-emso.org) whereas running FP7 projects can provide reference frames for the different data management issues (e.g., GENESI-DEC, 2010-2012, ENVRI, 2011-2014) .

Emerging infrastructure needs identified

A major integration among the present infrastructures and consortia is required. EuroFleets (Consortium of Research vessels), EuroSites and EMSO will be the emerging core of inter-connections and inter-relations supervising and providing the necessary technological supports to future scientific objectives. Also SIOS (Svalbard Integrated Arctic Earth Observing System; www.sios-svalbard.org) will be attracting and connecting most European research activities in Arctic seas, where its marine component is quite extensive and also overlapping with EMSO Arctic nodes.

It will be also stringent a greater integrated data/metadata/info management, in terms of : open access; quality control (QC) data/metadata; interchangeable formats and interoperability. These issues will take advantage of the previous and present initiatives at European (and global) level, such as GEO (Group on Earth Observation), EurOcean, SeaDataNet; INSPIRE, GOOS (Global Ocean Observing System), OceanSITES, MyOcean, etcetera.

Is it finally expected that any Deep Sea/ Subseafloor Research Infrastructure that can mature from DS^3F experience must have full integration in GEOSS (the Global Earth Observation System of Systems).

Synergies with industries

Many industries have direct interest on deep-sea, especially Oil and Gas industries and all those involved in mineral extraction and processing, Among many, an important issue will be the collaboration between deepsea scientists and industry to guarantee and assess the sustainability of the exploitation and use of sub-seafloor resources.

On a world wide scale, contacts with international organisations and authorities will be of valuable importance. Among these organisations, we recall: WOC (World Ocean Council; www.oceancouncil.org), ITU (International Telecommunication Union; www.itu.int) EMF (European Metalworker Federation; www.emf-fem.org).

A present European example of industry involvement with Research and Academic Institutions for deep-sea and sub-seafloor investigation, exploitation and possible drilling is the Marsili Project, a National project funded by the Italian Ministry for Economical Development. The main objective of this project is to understand whether this submarine volcano, which is the biggest European seamount (located in Southern Tyrrhenian Sea) can be a possible geothermal resource.

Scientific and technological themes for collaborations

Together with the known sea and deep sea infrastructures a point was made about the importance of cooperation and integration with existing and/or the next established on-land infrastructures (e.g. EPOS). Additional infrastructure projects, although not specifically addressed to deep-sea research can provide a pathway for the integration of the marine and the land based observations for hazard mitigation aims. An example of a currently running infrastructure project is represented by NERA EC (2010-2014) that integrates key research infrastructures in Europe for monitoring earthquakes and assessing their hazard and risk.

Strategies for future interactions and synergies

The experience, the methodological approaches, the tools and sensors that the deep seafloor observatory scientists have acquired and regularly use can be complementary to the deep seafloor drilling scientists. In turn, deep seafloor observations can largely benefit drilling for sub-seafloor long-term in-situ monitoring. The integration of systems and procedures used in these different priorities has to be supported by adaptation, tuning and coordination of technical and management issues.

The following technological and infrastructure needs and key-issues could be a starting point for this integration.

- Theme 1 - Facilities:

Facilities for deep-sea research are expensive and far from accessible for many scientists. The possibility to share logistics, infrastructures and ship-time of marine operations should be included in scientific programs and projects. In particular the following issues are essential:

- Extend access to surface support ships, vehicles and research equipment;

  this is partly realised by efforts such as EuroFleets or the Data exchange of days and personnel onboard research vessels, however, could be extended to geophysical gear (OBSs, streamers, etc.), seagoing equipment and vehicles (ROVs, AUVs, lander systems, etc.) and in situ probes (piezometers, fluid-samplers, CPT, etc.).

- Extend access to drilling facilities for a variety of scientific tasks, including borehole monitoring;

this is a topic to be further explored in WP7, however, it can be established here that a coordinated effort for the seafloor drills (BGS, MARUM, CEREGE) or piston coring devices under the umbrella of an EU Research Infrastructure (i.e. something recognisable on the ESFRI Roadmap) would be absolutely vital.

- Extend access to advanced sampling technologies for rocks, sediments, fluids, fauna and microbiota;

  this is subject of WP7 and will not explored further within WP8.

- Theme 2 - *In situ* measurements

Instrumented boreholes integrate the seafloor observation systems and experiences were gained especially in Western Pacific. In Europe, this kind of measurements is not available in key sites, although episodic campaigns were performed as pilot experiments (see for example Montagner et al., 1994) with borehole seismometers. The latter showed that the background noise level for oceanic borehole instruments with optimal installation is less than most of their counterparts on land (e.g., Stephen et al., 1999). In particular the following requirements are considered basic, but nonetheless essential:

- acquisition of oceanographic, geological and biogeochemical key parameters;
- continuous acquisition of measurements, and event-triggered sampling and analyses;
- long-term monitoring, including repeated high-resolution surveys.

Theme 3 – Data basis and models:

The integration of seafloor and sub-seafloor data acquisition and observations is necessary to understand the Earth processes in the deep sea, the exchange within the Benthic Boundary Layer and possibly feedback models, and prediction/mitigation techniques originating from the above. Deep-sea exploration experiments can provide important additional information to complete the geologic picture before any sampling/drilling campaign and in situ measurements acquisition can take place. Accordingly,

- integrated databases for *in situ* measurements and sample archives;
- improved high resolution mapping and seabed imaging / sub-surface profilers (including 3D seismic reflection); and
- improved analytical and modelling techniques based on the former

are urgently needed and represent subjects for collaborative, well-coordinated efforts.

In essence, it is apparent the need for the strong and durable coordination of the increment European infrastructures in the of DS³F initiative. While ship time is handled relatively efficiently, many other avenues within the field of marine / seagoing equipment, associated data acquired, models developed, etc. show severe shortcomings.

WP8 will address these shortcomings in the overarching workshops, which are planned for the second phase of DS³F. This will be done together with WP7 (in case of the drilling / sub-seafloor sampling tools, which require a coordinated effort across intra-European borders), and existing projects such as ESONET-NoE and EMSO-PP (in case of observatories and time-series data acquisition), and based on the goals DS³F has set for a sustainable research approach in the deep sea for the next decade(s).

Section 5: Preliminary Conclusions

The close collaboration of the diverse scientific and technological communities of the deep-sea realm as well as associated fields (shallow water, coastal zones, continental drilling programs, to name just a few) is necessary to fulfill a comprehensive vision of the phenomena in this challenging field. The sharing of technologies for deep-sea investigations and drilling is timely to increase European scientific competitiveness, and in fact the only affordable way to justify such investments. Europe's role in deep marine infrastructure is not unambiguous: Europe is in the lead with respect to e.g. seafloor drills, long piston coring, and also certain scientific fields related to deep processes (e.g. deep biosphere; see WP1, WP2 and WP3 reports above), but at the same time, is in need of improvements to compete on a global level (e.g. DONET Japan has 20 functional seafloor / sub-seafloor observatories in place, and NEPTUNE Canada uses IODP borehole observatories for sub-seafloor real-time monitoring for a while).

In order to identify and close gaps in advancement of knowledge in some of these fields, projects such as DS³F are an ideal mechanism established by the European Commission. The strategy by the WP8 group to minimise the abovementioned gap and enhance European infrastructural achievements is two-fold:

- bundle scientific approaches, and hence investments, in a couple of key locations where hot research topics (from WP1 through -6 can be addressed), and
- link EU efforts to those from countries outside Europe.

This latter point can turn out to be extremely efficient in case joint standards for observatory technology or data could be achieved. The interoperability of sensors or instruments on a global scale would, in an ideal world, cumulate in a plug-and-play approach in terms of identical power supply, identical data formats, etc. Likewise, intra-European support to establish such technology would be affordable since the diversity in Europe and commingled funds via Brussels represent a strategic advantage over entities such as the USA or Japan.

Primary themes of collaboration and funneled refinement of infrastructures are related to

- Facilities access and their optimal and cost-effective utilisation,
- The establishment of systems for *in situ* borehole measurements properly designed to obtain high quality data for many physical processes there occurring (ideally to compete with IODP CORK systems; see WP7 report),
- Data quality suitable for integration to seafloor and water column available data, and for feeding models.

A profitable forum of discussion on such themes can be represented by ESONET –Vi (ESONET-Vision), formerly ESONET-VISO, one of the outcomes of ESONET NoE, which aims at defining a perennial integration at European level of scientists of the numerous laboratories using data collected by deep-sea observatories of infrastructures such as EMSO and SIOS.

Along another line, data acquired prior, during or after (i.e. with monitoring approaches) sub-seafloor campaigns in the deep sea have to be stored and maintained in a way that ensures their future use for decades. Europe has established *state-of-the-art* means to manage data, and some of those databases and data management systems (e.g. WDC-Mare / Pangaea) receive highest demand from programs outside Europe (e.g. IODP). WP8 is trying to underpin that these strengths of European researchers will be recognized in the future and represent a vital element in enhanced deep-sea and sub-seafloor projects within Europe and on a global scale.

References

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ANNEX 1

Poster by WP8 Working Group to the recent 2011 EGU Session “Deep Sea Frontier – A European Challenge”