

EXtreme ecosystem studies in the deep OCEan: Technological Developments

EXOCET/D FP6-GOCE-CT-2003-505342

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ABSTRACT

The general objective of EXOCET/D is to develop, implement and test specific instruments aimed at exploring, describing, quantifying and monitoring biodiversity in deep-sea fragmented habitats as well as at identifying links between community structure and environmental dynamics. Inboard experimental devices will complement the approach, enabling experiments on species physiology. The EXOCET/D working fields include: video and acoustic imagery, *in situ* analysis of physico-chemical factors, quantitative sampling of macro- and micro-organisms, *in vivo* experiments, integration of multidisciplinary data, implementation on European deep-submersibles and a final phase of technical and scientific validation.

KEYWORDS

Deep sea; ecosystem; imagery; *in situ* analysis; faunal sampling; submersibles; observatory.

INTRODUCTION

The use of deep-sea submersibles during the last decades brought new insights into deep-sea environments with the discovery of unusual biologically rich areas on continental and plate margins. The acquisition of deep underwater vehicles by several European countries brings our scientific community at the leading edge of the studies of remote ecosystems. Moreover, the increasing anthropic pressure on the deep-sea (offshore exploitation, wrecks, waste disposal) and the requirements of the Convention on Biological Diversity, reinforce the strategic importance of our ability to observe, sample, measure and experiment in deep environments through the development of non-invasive approaches that will help minimizing threats to their fragile biodiversity.

The general objective of EXOCET/D is to develop, implement and test specific instruments aimed at exploring, describing and quantifying biodiversity in deep-sea fragmented habitats as well as at identifying links between community structure and environmental dynamics.

Inboard experimental devices will complement the approach, enabling experiments on species physiology. The targeted ecosystems are related to the emission of reduced fluids (cold seeps, hydrothermal vents), peculiar topographic structures (seamounts, deep corals), massive organic inputs (sunken woods) or to unpredictable events (pollution, earthquakes). Beside their insularity in the abyssal plain, these ecosystems are characterised by patchy faunal distributions, unusual biological productivity, steep chemical and/or physical gradients, high perturbation levels and strong organism/habitat interactions at infra-metric scales. Their reduced size and unique biological composition and functioning make them difficult to study with conventional instrumentations deployed from surface vessels. Their study requires the use of submersibles able to work at reduced scales on the seafloor as well as the development of autonomous instruments for long-term monitoring (seafloor observatories e.g. EU projects ASSEM and ESONET).

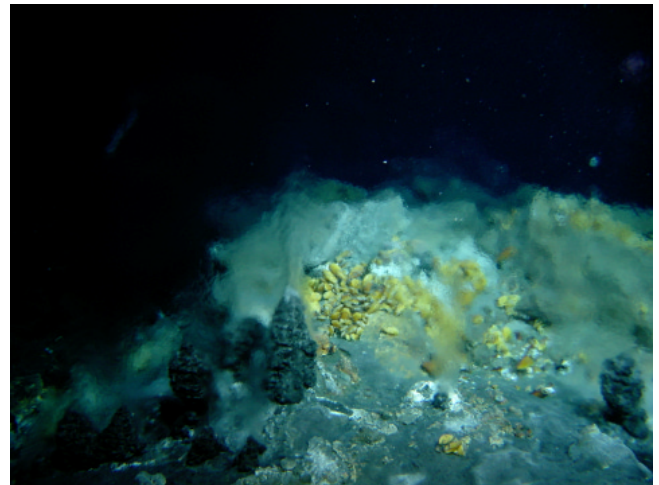


Fig. 1: Mussels assemblage on Menez Gwen hydrothermal vent (MAR)

EXOCET/D will be a major support for the development of the capacity of EU Nations to observe, monitor and survey extreme marine ecosystems in natural and disturbed conditions. Recent investigations of the "Prestige" tanker wreck, off European coasts sunk by 3500 metres depth, showed the difficulties of EU countries to operate at oceanic depths, even with available submersibles. This intervention capacity is crucial to evaluate the impact of future catastrophic events on the biodiversity of the European Exclusive Economic Zone. Contracting nations to the United Nations Convention of the Law of the Sea (UNCLOS) and the Convention on Biological Diversity (CBD) have the obligation to protect and preserve the diversity of marine ecosystems. The discovery of highly productive fragmented ecosystems at great depths (cold-seeps, deep carbonate mounds, hydrothermal vents), living away from solar energy, is one of the most important findings of the last century in ocean sciences. The increasing anthropic pressure on these poorly known deep-sea ecosystems emphasizes the need for a rapid development of technologies dedicated to their investigation. Several European countries are now purchasing or developing deep-sea underwater vehicles but their acquisition alone is not sufficient to realize effective integrated deep-sea studies. International co-operation between EU nations is a strong requisite to overcome the technological challenges needed for exploring, observing and monitoring extreme deep-sea ecosystems. There is an urgent need for fast but long term stable multi-sensor instrumentation that can be either connected to autonomous sea floor observatories or deployed on underwater vehicles.

ORGANISATION

EXOCET/D is a three-year project starting in 2004 and funded by the European Commission (STREP, FP6-GOCE-CT-2003-505342). It involves partners from ten research institutions and three SME's. It is organised in seven workpackages (WP) and follows different thematic areas :

- video and acoustic imagery;
- *in situ* analyses of habitat chemical and physical components;
- quantitative sampling of macro- and microorganisms, *in vivo* experiments;
- integration of multidisciplinary data;
- instrumentation implementation on deep-submersibles;
- scientific validation during demonstration actions.

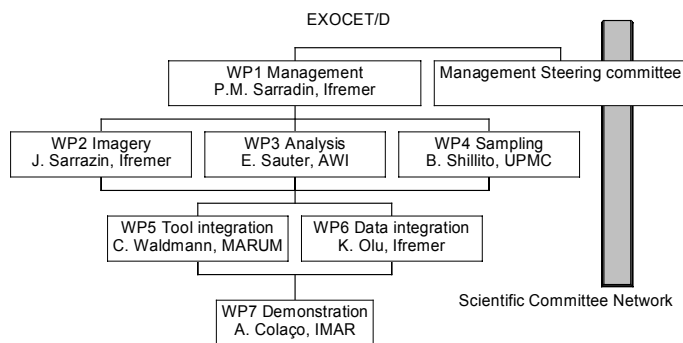


Fig 2 : EXOCET/D organization

A large emphasis has been put on imagery (WP2) because this tool is of central importance for deep-sea biological studies. Access to quantitative biological samples is limited and non invasive approaches

are needed to avoid ecosystem perturbations. The integration and management of multidisciplinary data, obtained on similar small spatial scales, will be possible through the development of different software and approaches. Particular attention will be paid to the final implementation of the developed instrumentation, software and tools on submersibles or benthic observatories.

WP2 – QUANTITATIVE IMAGING

WP2.1 Assessing Spatial Variability at Small Scales

Ecology has to consider scale issues because organisms and habitats are rarely homogeneous and heterogeneity makes ecological variables and processes scale-dependent (Legendre et al. 1997). This is particularly true in deep sea chemosynthetic habitats (hydrothermal vents, whale bones, seeps) that exhibit high spatial variability of both species distribution and abiotic factors at relatively small-spatial scales. Imaging tools permit the non-destructive, cost effective acquisition of ecological information at different spatial scales in the marine environment. Photo and video imagery have been used in a variety of marine applications, including estimating animal abundance, density, percent cover (reviewed by Norris *et al.* 1997, Berkelmans 1992, Miller & Muller 1999) and growth rates (Done 1981, Christie 1983, Fisher et al. 1997). Both photo and video imagery often serve as the primary source of information and have been used for manual mapping, microcartographic reconstruction and image mosaicking to document faunal distribution (Juniper et al. 1998, Sarrazin & Juniper 1999, Sibuet & Olu-Le Roy 2002). Resultant maps can be used to identify relationships between faunal assemblage distribution patterns and habitat features. The effects of small food-falls on motile fauna have also been described by means of imagery and sonar data (Klages et al. 2001, Premke et al. 2003).

There are still some important limitations to the use of video imagery. Thickness of faunal cover is not taken into account, leading to underestimation of faunal density, smaller organisms are often underestimated and finally, estimation of surface area from 2D images results in errors in estimation of surface-dependant ecological descriptors (Norris et al. 1997, Sarrazin & Juniper 1998). Manual mapping and image mosaicking have been used with some success to analyse organism distribution at scales larger than what can be seen through submersible view ports or camera lenses. Image mosaicking is less subjective than mapping by hand, but the present state of the art requires precise control of camera distance and viewing angle to avoid spatial distortion as images are adjusted and fitted into the mosaic (Grehan & Juniper 1996). The quality of a mosaic is dependent upon the accuracy of the juxtaposition between successive video images but the reality of deploying cameras or submersibles over uneven seafloor terrains does not always permit collection of imagery ideally suited to mosaicking. Recent studies based on robust motion estimation within video sequences, fused with dead reckoning and positioning techniques, have been realized on large scale areas with the MATISSE® software (Vincent et al. 2003). Trials have been conducted with the VICTOR6000 ROV, on the Hakkon Mosby mud volcano during the summer 2003 (see <http://www.polarstern-victor.de/index-e.html>) and video data were merged with produced MNT. Problems concerning lightning correction and 3D projections have been addressed but the integration of mosaics in large-scale maps remains still problematic.

The major objective of this WP is to set-up a complete methodology to make a projective reconstruction of small-scale scenes from underwater video imagery. It will allow 3D reconstruction through stereo-video technique and stereo-photo methods, including warping of local 3D patches on high density Digital Model of Terrain (DTM). The

development will focus on the following items :

Improve image mosaicking - Problems arising from the use of several successive video images can be solved directly by computing image motion through feature trackers or optical flow methods or through computerised transformation that minimises the discrepancy between the current mosaic and the warped image. Artificial lighting conditions restrict mosaicking and 3D reconstruction processes. Correcting adverse lighting effects should improve mosaic quality (Borgetto et al. 2003). Two methods of correction, based on radiometric correction and reflectance-illumination modelling, will be investigated.

Extract features from imagery - Extracting robust features is a necessary step of image processing but is limited by particular characteristics of benthic habitats (complex geometrical forms, high noise, weak knowledge of the environment). The implementation of a point detector, based on multi-scale images, will be investigated and should permit the classification of distinct features. A software for preliminary data processing will be developed and should allow the use of advanced computer vision techniques for benthic habitat imagery.

Self-calibration techniques for quantitative measurement and 3D reconstruction - In order to quantitatively exploit images in different optical conditions, tools for rapid automated camera calibration, without external means, are required. Methods for calibrating an underwater vehicle camera will be developed. The intrinsic and extrinsic parameters of the vehicle camera will be used to develop point matching algorithms. The integration of a typical 3D grid from laser site scanning data will strengthen the calculated model to obtain a high density, small spatial scale, 3D Digital Terrain Model. Finally, wrapping techniques, allowing mapping of 2D mosaics into 3D DTM, will be developed using either the laser range finder or a pencil beam sonar or stereo vision methods. Feature- and texture-based techniques will be used to improve the registration of 2D video mosaics on 3D DTM.

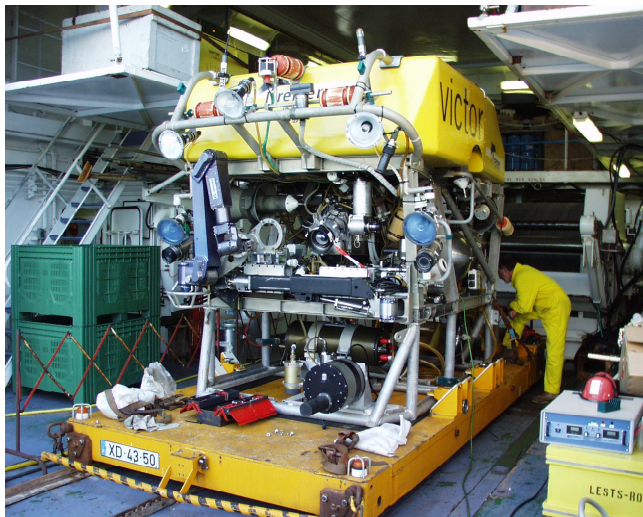


Fig. 3 : Front view of the French ROV Victor with multibeam sounders and optical devices

Overall, the development of stereovideography techniques will permit the reconstruction of 3D maps of species distribution and environmental variability, at scales ranging from 0.5 to 2 meters and to link visual biological data to chemical and physical measurements. The visual 3D information of habitat and community structure are complementary to the geochemical 3D environmental characterization that will be obtained in WP3. Collection of high resolution data is a

crucial step forward to the understanding of factors influencing marine community structure and functioning at small spatial scales. It will extend our knowledge of microhabitats exhibiting high spatial heterogeneity and will allow quantitative analysis of deep-sea ecosystems. The techniques developed will have applications in a variety of other research fields such as the study of shallow and deep-water coral reefs, coastal biotope studies, surveillance of marine protected areas or fish stock studies.

WP2.2 Time-series studies in marine ecosystems

There is world-wide recognition for the need of long term *in situ* monitoring of the marine environment. While the intertidal zone and coral reefs have retained much attention because of their accessibility (Estes & Peterson 2000), technological limitations have delayed observational studies in the deep ocean. Only recently are we beginning to understand some of the dynamics of deep-sea communities. Even more important, most of the traditional techniques used to evaluate the influence of biological interactions are not yet applicable in deep-sea habitats. As a result, our knowledge of the influence of biotic and abiotic factors in these ecosystems is extremely limited compared to shallower environments. Particularly lacking in the study of abyssal benthic communities are time-series data. Time-series studies provide a means of studying organism growth, faunal succession, biological interactions and the response of species and communities to natural environmental changes (Sarrazin et al. 1997). Understanding community dynamics is also an important prerequisite for management, conservation and protection of natural ecosystems. Long-term studies in abyssal ecosystems will give fundamental insights about the reaction of the benthos to different environmental events -flow changes, food falls, catastrophic disturbances- as well as on the role of biological interactions on community dynamics (Flach 2002). Short-term video recordings can also be used to describe and document faunal behaviour, including territorial interactions (Morineaux et al. 2002) and predation (Rocha et al. 2002). A great effort is now being invested by the international scientific community into developing new ways to study the temporal aspect of both environmental and biotic factors in abyssal zones (e.g. NEPTUNE, ESONET, MoMAR). The development of new autonomous scientific tools, suited for long-term deployment, is an essential step to insure the success of these future observatories.

A major goal of this WP is to design a long-term imaging module equipped with a deep-sea autonomous video camera, adequate lighting and sufficient energy storage. The main features of the module will include :

Light weight and small size - Important progress in photonics, electronics and computing has led to the manufacturing of small, powerful and low power devices that allow significant reduction of camera size. This will give the imaging module the ability to positioned not only on flat bottom but also on rough and rocky areas, very close to target faunal communities and will facilitate submersible operations.

Innovative lighting - While a few years ago, the brightest LEDs could generate only 1 or 2 lumen per emitter, actual Light Emitting Diodes (LED) can produce a luminous flux up to 120 lm and a wide range of colours. This new technology will allow the design of a new underwater power light source (up to 50W) presenting several advantages over usual sources, especially in terms of reliability, life time, and spectral characteristics.

Autonomous operation up to several months - The module autonomy will depend on several factors including image acquisition, time-frame, environmental conditions and power cells. To increase the autonomy length, the electronic control subsystem will have power management functions and, both camera and light, will be low energy consumers. Solutions to reduce the effect of fouling on camera port and lighting

sources will be studied. The imaging module will be tested during several days on a small spatial scale (1 m) at the bottom of the ocean and first high quality data will be collected. In parallel to the development of the video module, the technology will be used to develop a macrophotography module, equipped with *in situ* setting controls and designed to be manipulated with a ROV.

WP2.3 Integration of acoustic and optic imagery at intermediate spatial scales

Acoustic imaging techniques are finding new applications in benthic habitat mapping. However, in spite of tremendous progress done in the field, much work remains to be done to fully explore the complementarity of optic and vision imagery to classify seabed communities and assess their spatial extent, and to generate accurate digital terrain maps.

Classification of bottom types and benthic communities: Backscatter signals from single and multi-beam sonars can be used for automated, swath mapping of habitat over large areas of seafloor, at scales that go well beyond what can be practicably achieved with optical imagery (Durand et al. 2002). Whereas the return time of an acoustic signal to its source provides distance information for depth mapping, the scattering of acoustic energy by the seafloor provides information on substratum or community characteristics. In addition to not being hampered by lighting and visibility problems, acoustic methods permit the 3D reconstruction of habitats on the seafloor through the integration of bathymetric and backscatter information. The extraction of habitat and community composition information from backscatter data still requires the development of new processing algorithms (Clarke & Hamilton 2001, Legendre et al. 2002) and ground truthing using optical imagery and traditional sampling (Durand et al. 2002). Results of a previous study at a deep-sea hydrothermal vent indicate that sonar backscatter analysis has considerable potential for mapping habitat distribution in large, flat, hydrothermal vent fields or seep environments with extensive coverage of faunal assemblages. However, it is not obvious how to distinguish smaller organisms from the surrounding basaltic substratum (Durand et al. 2002). Applications to more complex terrains, such as hydrothermal edifices, will be more difficult because of possible confounding effects of the relief on the backscatter signal.

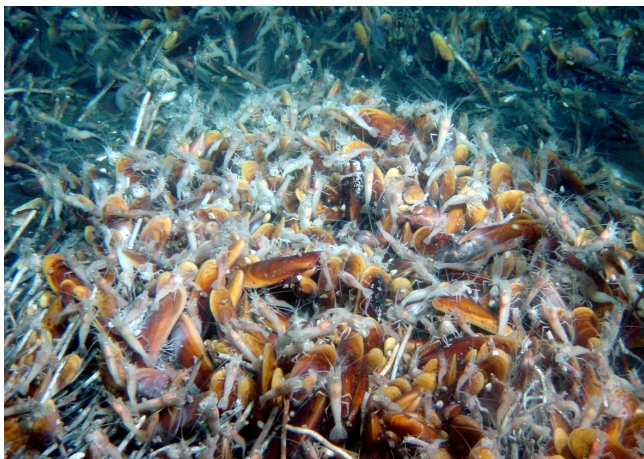


Fig. 4 : Cold seep mussel faunal assemblage REGAB, Gabon margin

The goal of this project is to evaluate the potential of using sonar data to study deep-sea community changes and to explore their complementarity with video imagery. Instead of processing only the first backscatter, which produces a 3D distance map, the first

backscatter cluster and its tail will be analysed to extract depth information, as well as flora and fauna characteristics. This work will build on previous research efforts on the analysis and classification of subbottom sediment layers using bottom-penetrating sonar (Loke & du Buf 2002).

Generation of Digital Terrain Maps: There is currently great interest in the development of techniques and instrumentation to automate marine habitat mapping processes. The underlying mapping methodologies resort to a “decreasing scale, increasing resolution” strategy: the ocean floor is first surveyed on a large scale using acoustic sensors (e.g. sidescan and low frequency profilers), the resolution and quantitative refinement increases as observations are made at closer ranges by using high frequency acoustics and vision. The problem of overlaying the different data sets (for example, sidescan, profiler and vision data) to generate composites of benthic ecosystem and bottom types can be resolved by resorting to advanced sensor fusion techniques. Resulting information can be made available to scientists using Geographic Information Systems (GIS).

Currently, there are well established methods to obtain digital terrain maps of large areas of the seabed using acoustic sensors. The equipment used is standard and can be installed on small autonomous vehicles (Oliveira et al. 1998). Automatic bathymetry operations are by now routine (ASIMOV 2000, Pascoal et al. 2002). However, these methods do not yield the type of resolution and accuracy required to study the spatial distribution of benthic communities. For this purpose, disparate, yet complementary data from a wide range of sources (acoustic sensors, video images, navigation data) positioned closer to the seabed have to be merged. This WP aims at developing and demonstrating selected techniques for accurate digital terrain mapping. Algorithms to fuse sonar profiler data with sidescan data, resorting to wrapping techniques will represent the first step to produce acoustic mosaics, with increased detail, known as micro-bathymetric maps (Singh et al. 2000).

In order to evaluate the ability of the sonar to distinguish between different bottom types and benthic communities, a series of ground truthing experiments combining the acquisition of acoustic and visual data will be conducted both in controlled and simulated environments and at sea during a series of field tests in the Azores. Final algorithms will be developed to fuse vision and acoustic data and to produce detailed digital terrain maps (DTM).

WP3 – IN SITU SENSING, ANALYSIS AND WATER SAMPLING

This WP will focus on the integration and modification of different existing underwater instrumentation. Cost efficient and reliable solutions will be found to make these instruments suitable for long term deployments on stationary deep-sea observatories or used as payload systems on moving underwater vehicles (ROVs, AUVs, and submersibles).

Peculiar deep-sea ecosystems such as vents are characterised by limited spatial scales, steep biogeochemical and physical gradients and by the coexistence of chemically reactive species (hydrogen sulphide, reduced metals) and dissolved gases (oxygen, methane) (Johnson et al. 1988, Sarradin et al. 1998, Le Bris et al. 2003). This extreme spatio-temporal variability of environmental factors influences species distribution (Sarradin et al. 1999, Luther et al. 2001) and has to be resolved by using appropriate instrumentation. In order to circumvent sample artefacts and alterations caused by de-pressurisation and temperature effects, *in situ* analyses are preferable when possible. Our approach foresees to adapt and optimise existing *in situ* analysers and sensors. A small volume multi water sampler will also be designed. It will provide samples for analysis of additional parameters (geochemical species)

and allow reference measurements to be carried out subsequently in the laboratory. The data obtained through instrumentation development within WP3 will be complementary to visual and acoustic seafloor observations gathered within WP2.

WP3.1 In-situ flow analysis

Beside chemical sensors, flow analysis offers a great potential for underwater analyses (Sakamoto-Arnold et al. 1986). Several analysers allowing *in situ* calibration with standard solutions to overcome signal drifts as well as temperature or pressure artefacts have been developed (Sakamoto-Arnold et al. 1986, Le Bris et al. 2000, Chapin et al. 2002). One objective of this WP is to build a second generation *in situ* chemical analyser, based on flow analysis and colorimetric detection, taking advantage of the expertise gained by Ifremer during the development and scientific use of the Alchemist (chemical analyser for *in situ* measurements, Le Bris et al. 2000) and the collaboration of Systea srl. The design will be based on microfluidic and miniaturised photometric detection systems. Measurement reliability and the frequency of analysis will be increased in order to respond to strong gradients. Special emphasis will be made on minimization of power and reagent consumption and solutions to inhibit fouling processes within flow-through parts of the system will be investigated. Efficiency and reliability of the autonomous analyser will be tested in the field by implementation on ROVs as well as on a long-term benthic station.

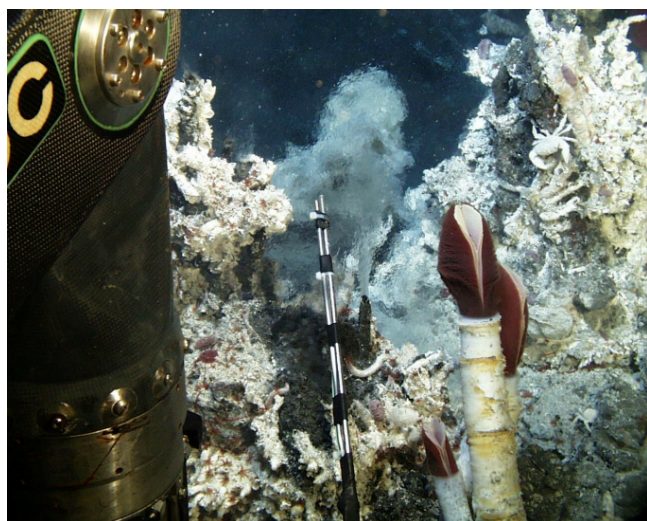


Fig. 5: *In situ* analysis using the Alchemist (13°N, EPR)

WP3.2 Small volume multi water sampler

A small volume multi water sampler will be developed in this WP. It will combine a high number of water samples within a concise and small instrument. The device will be designed to take water samples at certain way points of an underwater vehicle's course or at programmed time periods during a stationary deployment. The sampler will provide samples for analyses that can not be carried out *in situ* as well as for *in situ* sensor calibration and validation. It will offer the opportunity to complement the range of geochemical species covered by *in situ* sensors and also to perform reference measurements from water samples as regular *in situ* calibration ("ground truthing").

WP3.3 In situ sensors

A variety of geochemical sensors allowing investigation of nutrients, dissolved oxygen and other solutes in sea water already exist. Anyhow, energy consumption, size, response time and memory need to be

improved. This is the case for the *in situ* methane sensor developed by Capsum GmBh to survey marine methane sources like eutrophic gassy sediments, mud volcanoes and gas hydrate deposits as well as methane discharged from leaking gas pipelines, oil fields and fish farms (Christodoulou et al. 2003). The methane sensor performance will be increased through miniaturisation of the sensor's head to lower diffusion times and the development of a special flow-through chamber to maintain constant flow at the sensor membrane. The sensor signal will be processed and filtered to quantify its dynamics and error sources. The methane sensor will be adapted to moving underwater platforms.

The second sensor to be improved is an *in situ* hot film flow-meter. Ecosystems associated to cold seeps or hydrothermal vents are strongly dependent upon the emission of reduced compounds. Flow rate appears to be an essential abiotic factor in these ecosystems and the quantification of fluid flow velocities is crucial to understand community structure and dynamics in these habitats (Sarrazin et al. 1999). A hot film flow sensor developed at Cardiff University (Schultz et al. 1996) will be better adapted to the constraints of the studied environments. An autonomous version will be developed and it will be implemented on an underwater vehicle.

WP4 – QUANTITATIVE SAMPLING OF MACRO- AND MICROORGANISMS, *IN VIVO* EXPERIMENTS

This WP will provide technological means for studying the organisms inhabiting extreme ecosystems. These means will allow the investigation, through experiments on live organisms, of the physico-chemical limits suitable for life. In addition to improve our understanding of organism/environment relationships, these experiments will help gathering crucial information on native biological characteristics of these organisms (thermotolerance, adaptation to anoxic conditions). Two approaches are proposed : the first one is to collect and recover live macrofauna in good physiological state, in order to carry out *in vivo* experimentations in controlled environmental conditions; the second is to monitor *in situ* environmental conditions associated to the development of microorganisms inside experimental colonisation devices (Takai et al. 2003).

Live organism studies are very valuable to understanding the biology of deep-sea fauna. For instance, in the case of hydrothermal vent fauna, which flourish under extreme environmental conditions, relevant biological features such as thermotolerance, reproduction, or primary production have been determined using *in vivo* experimentation at native pressure (Pradillon et al. 2001, Shillito et al. 2001, Ravaux et al. 2003). Nevertheless, a pre-requisite to successful *in vivo* pressure experiments is that the collected organisms survive throughout their recovery from the deep sea. Vertebrates (fish) in general are very sensitive to decompression, and if some invertebrates tolerate well decompression events (crustaceans), many do not survive them. Furthermore, most chemosynthetic life, from anaerobic microorganisms to high pressure and/or high temperature-adapted organisms are very sensitive to sampling procedures and have rarely been kept alive or cultured, hence current research in these remote habitats is largely restricted by the lack of observational and *in situ* sampling and experimentation technologies. Finally, isobaric collection cells for macrofauna are not available at the European level, whereas a Japanese team has recently developed such a tool, designed for collection at 2000 m depths.

WP4.1 PERISCOP

PERISCOP - Projet d'Enceinte de Récupération Isobare au Service de

la Collecte d'Organismes Profonds- will consist of a container allowing the collection and recovery of deep-sea organisms at their natural pressure (isobaric collection), from depths up to 3000 m. It will give biologists access to live animals or bacteria, by avoiding the traumatic, and often lethal, decompression. This device will be composed of a sample container of about 5 litre volume, and a pressure control unit. Upon recovery on ship deck, PERISCOP will allow :

- transfer towards appropriate experimental pressure vessels (i.e. the IPOCAMP or DESEARES systems) for *in vivo* experimentation;
- direct conditioning of organisms, after controlled decompression, giving access to native biological characteristics by limiting physiological modifications due to decompression stress.

WP4.2 DESEARES

Since the discovery of deep-sea hydrothermal vents, few labs have developed instruments to study, under pressure, the physiological processes developed by these amazing organisms. Some years ago, Jim Childress's lab from UCSB built deep-sea respirometers coupled with a chemical regulation device for the well-known vent worm *Riftia pachyptila*. However, despite a great interest for the European scientific community, such instruments yet remain to be developed in Europe. The objective of this WP is to build a small DEep-SEA RESpirometer (DESEARES). This instrument will allow us to understand, with a high level of resolution and using an ecophysiological approach, the physiological mechanisms, responsible for the life and evolution of the key organisms colonizing extreme marine habitats.

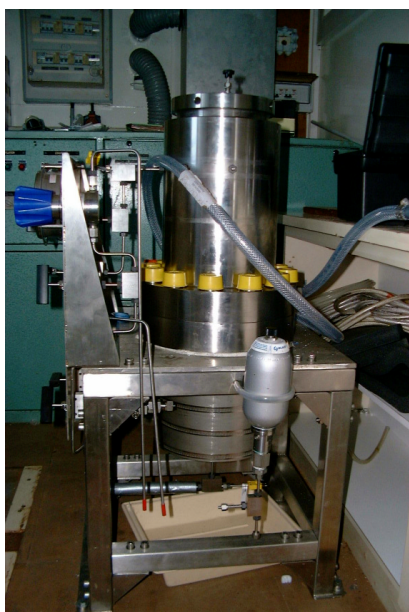


Fig. 6 : The IPOCAMP pressure vessel, VENTOX EVK3-1999-00003

WP4.3 AISICS

Microorganisms play crucial roles in all biogeochemical processes that sustain the biosphere, especially in organic material remineralisation and element recycling. Recent estimates, based on molecular biological methods, suggest that less than 5% of marine microbial species have been identified. Furthermore, most of the dominant microorganisms of the different functional groups in sedimentary systems have not been obtained in culture. Thus, a variety of biochemical pathways and key enzymes remain to be discovered. This enormous diversity of catalytic capabilities is still incompletely explored and appears to continuously expand as new organisms are discovered. New biochemical pathways

mediated by not-yet-cultured microorganisms and symbiotic associations with benthic invertebrates add further aspects to future scientific interest. In the past, important discoveries were made using new *in situ* technologies and methodologies for sampling and detecting microbial organisms. Accessing to the microbial diversity of extreme environments requires proper sampling equipment adapted to manned submersibles or ROV. Direct sampling of rocks, chimney structures, hydrothermal vent or cold seep animals and sediment with grab sampler is of wide use. However, in most cases, it is almost impossible to link the samples to the physico-chemical conditions prevailing *in situ* at the cm-scale. This is detrimental to further microbiological work since it remains difficult to select the appropriate physico-chemical conditions for enrichment cultures and strain isolation. In order to circumvent this major limitation, an Autonomous *In Situ* Instrumented Colonisation System (AISICS) will be developed. This system will allow *in situ* colonisation of a specific substratum by indigenous microorganisms and will simultaneously provide information on temperatures and fluid composition inside the colonisation system. The main components of AISICS will be :

- a titanium pipe with many small holes able to contain various types of porous substrates. This pipe will be "plugged" into vents, seeps or sediments and will insure limited fluid circulation inside.
- a cap sealing the top of the pipe and allowing the setting of a thermal-resistant temperature probe as well as fluid sampling tube(s); their extremity will be located inside the titanium pipe.

Temperature probe and sampling tube(s) will be connected to the autonomous devices that will record data and store small water samples in sterile flask for further analyses on board e.g. chemistry and microbiology.

WP5 – INSTRUMENTATION INTEGRATION AND COMPATIBILITY

The basic aim of this WP is to find strategies and technical solutions to bridge the gap between : (i) individual sensors and sampling tools, including interfacing and power requirements and (ii) different observation platforms (long-term module or AUV/ROV system).

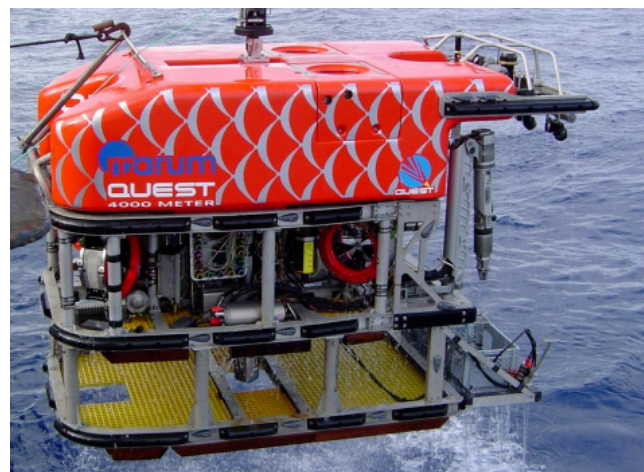


Fig 7 : The ROV Quest (courtesy of C. Waldmann)

From instrument specifications, principles can be derived on how to make interchangeability between the different instrument carriers or deployment methods. Generally, instrument manufacturers or individual designers are seeking simple solutions for interconnecting their instruments, for instance, to cable lowered sensor packages. However, this approach often leads to insular solutions. For example,

while power is generally not a big concern, it becomes crucial on autonomous vehicles and systems such as AUVs. A standard interface like CAN-BUS or alternatively, intermediate devices that translate between different interfaces may be recommended. An evaluation of the trade-off between the different approaches will be done. In addition to hardware interfacing, the integration of individual data stream into the entire set of scientific data has to be accomplished. Closely related to this issue is the problem of data quality. Procedures have to be defined to evaluate data quality, particularly during the acquisition processes.

Compatibility with future observational systems like cabled benthic observatories will also be investigated. Since no common standard exists, this WP will greatly contribute to ongoing initiatives in the EU and at the international level. The organisation of an international workshop will help defining interface specifications and tool sharing procedures for ROVs, AUVs, manned submersibles, and benthic observatories. The second step of this WP will be the integration of the EXOCET/D instrumentation into prototype structures (e.g. ASSEM node) as well as on ROV/AUV systems.

WP 6 – DATA MANAGEMENT TOOL: SUBMETRIC SCALE DATA VISUALISATION

The objective of this WP is to develop a data management tool for integration and visualisation of different types of data collected at small scale (from cm to a few m) in a 3D GIS project. Spatially referenced data will include 3D reconstructed images from stereo videogrammetry, faunal patches drawn from 3D imagery, biological data from sampling as well as physico-chemical data from *in situ* measurements or samples. Data from several dives (day-scale) or cruises (year-scale) as well as time-series data will be included.

Mapping of these complementary data will help estimating surfaces covered by each species or species association, visualising sampling points, describing species habitat, highlighting spatial structures and factor co-variations and understanding community and habitat dynamics. ArcGIS has been chosen as it is a reference software, used by several research laboratories. Subsequent data processing may include geostatistical analysis to interpolate faunal or physico-chemical data in a 3D small scale map.

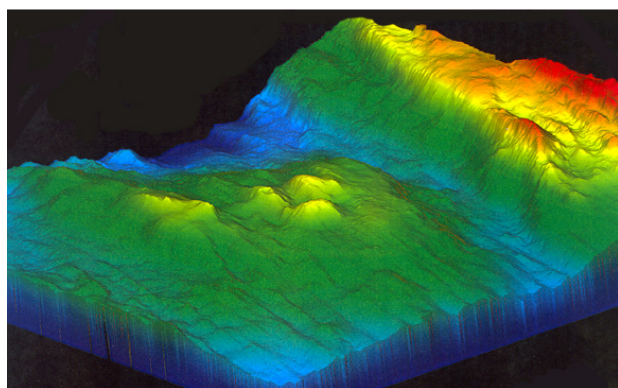


Fig. 8: The Lucky Strike hydrothermal field, MAR (©Ifremer DRO/GM)

WP7 – DEMONSTRATION ACTION

WP7 will focus on testing individual technological components developed in EXOCET/D. Demonstration actions will help validate the technology at different developmental phases of the project (lab and at-

sea trial).

The final instrument testing and validation should be performed in 2006 during the MoMARETO cruise. The main objective of this cruise aboard the NO Pourquoi pas ? and working with the ROV Victor 6000 (Sarradin et al. 2002, Michel et al. 2003) will be to study the spatial and temporal dynamics of hydrothermal communities colonizing the MoMAR zone, located on the Azores Triple Junction. The first leg of the cruise will be dedicated to the implementation and test of the instrumentation developed during EXOCET/D while the second leg will be entirely focused on realizing the scientific objectives and on deploying a first ecological long-term observatory on the Lucky Strike hydrothermal field (MoMAR area), using mobile and fixed complementary platforms.

ACKNOWLEDGEMENTS

Photos are copyright Ifremer (from HOPE, BIOZAIRE and ATOS cruises).

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- ESONET - European Seafloor Observatories Network, <http://www.ifremer.fr/esonet/>
- EXOCET/D : <http://www.ifremer.fr/exocetd>
- MoMAR : Monitoring the Mid Atlantic Ridge <http://www.ipgp.jussieu.fr/rech/Igm/MOMAR>
- Neptune : <http://www.neptune.washington.edu>