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Preface

Following the previous two International Workshops on Research in Shallow Marine and Freshwater Systems, which were held in 2009 in Freiberg, Germany and in 2010 in Milazzo, Italy, the third edition also aims to promote research in shallow water with the aid of scuba diving. This workshop covers scientific, technical and legal aspects of scuba diving as a means of scientific work. The importance of this type of research is often overlooked. More attention is generally paid to the seemingly more impressive research endeavors in deep water with the aid of large ocean going research vessels, submarines and autonomous underwater vehicles. However, the shallow, near shore regions of the oceans are the breeding and hatching grounds for many, if not most marine animals and thus being the starting point of marine food chains. Chemical and biological processes occurring here should have an influence well beyond their geographic location, affecting both the open ocean and the coastal waters. For example, the chemical composition of seawater in coastal areas is controlled through a combination of natural and anthropogenic processes. In areas of volcanic activity and/or high heat flow the discharge of fluids from shallow-marine hydrothermal systems may have a considerable impact.

The continued dialogue between Diving Associations, Universities, Insurance Companies and other Institutions is a necessity to establish a platform and the legal framework to foster scientific progress for this important line of research. Unfortunately, this process is often hampered by special interest, be it of institutional or commercial nature. In this context over and over the question arises, what is a scientific diver and is specific training needed? A variety of courses are being offered for the training of scientific divers, which are organized by purely economic institutions, such as the Professional Association of Diving Instructors (PADI), while others are offered by educational institutions without any commercial interest. Several additional arrangements are found as well. To make diving, as a means of data and sample collection, more accessible to a wider range of young scientists, we need clearly defined minimum requirements for scientific diving.

Working underwater happens in a variety of environments with conditions ranging from clear visibility and 30 °C water temperature to practically no visibility and water temperatures below 0 °C. Practical depths may vary from 3 m to more than 100 m, using mixed gas. The underwater activities may involve different techniques such as underwater photography, underwater video documentation, transporting equipment, and more. For some research projects all of the above are needed, while others consist of the simple collection of sediment samples. In lieu of the variety of conditions and techniques it becomes clear that there can be no uniform training requirement for a scientific diver. Should a Bachelor Student who wants to collect a few shells in the Caribbean for his thesis be trained to the same level as a PhD Student who plans to dive under pack ice? It does not make sense to train a scientist for all eventualities of scientific diving. The attempt to do this generates an unnecessarily high barrier for many interested students. Each scientific project and discipline has its own specific set of requirements. Though, there is one requirement all have in common – the individual carrying out scientific work with the aid of scuba diving should be a SAFE DIVER.

The Organizing Committee would like to acknowledge the help of effort provided by Ms. Gisela Haack, the Verband Deutscher Sporttaucher (VDST) and the Department of Geosciences, University Bremen.

Workshop Program: Talks

DAY 1 - 14. February 2013

Session 1 - Biological and Ecological Research

8:45 Opening Remarks

9:00 On the effects of coastal protection structures on the fish community in shallow water coastal habitats.

Philipp Fischer, Stephanie Wehkamp

9:20 Diver surveys of rocky reefs facilitate habitat mapping of the West Solent recommended marine conservation zone, UK

Martin, L.E.C., Collins, K., Jensen, A.C .

9:40 Monitoring biodiversity on hard substrate: experience from the implementation of the NaGISA project in Greece

Georgios Chatzigeorgiou, Thanos Dailianis, Sarah Faulwetter, Wanda Plaiti, Elena Sarropoulou, Panagiotis Vavilis, Christos Arvanitidis

10:00 Engaging citizen-scientists for the assessment of marine biodiversity: experience from the ongoing COMBER project

Thanos Dailianis, Sarah Faulwetter, George Chatzigeorgiou, Wanda Plaiti, Nancy Prentiss, Costas Dounas, Yolanda Koulouri, Stavroula Artemiou, Athina Vlasiou, Giacomo Pinsoglio, Christos Arvanitidis

10:20 **COFFEE BREAK**

10:40 Investigating benthic assemblages on northern Adriatic concrete artificial reefs: methodological comparison

Massimo Ponti, Rossella Angela Perlini, Federica Fava

11:00 Human Impact on Gorgonian Corals

Georgios Tsounis, Lucia Martinez, Lorenzo Bramanti, Nuria Viladrich, Josep-Maria Gili, Angela Martinez, Artemis Atsalaki, Mariyianna Kotta, Sergi Rossi

11:20 Surveying benthic communities in marine caves of the Aegean Sea

Vasilis Gerovasileiou , Vasilis Trygonis, Maria Sini, Drosos Koutsoubas, Eleni Voultsiadou

11:40 Controlled light-emission by fish eyes and its function as a novel detection system

Nils Anthes, Nico K. Michiels

12:00 **LUNCH BREAK**

13:20 Impact of CO_2 gas seeps on the seagrass Posidonia Oceanica

Miriam Weber, Matthias Schneider, Christian Lott, Stefanie Grünke, Boris Unger, Antje Boetius

13:40 Research of Lithophyllum algal rims in the central Adriatic - what have we learned so far

Tatjana Bakran-Petricioli, Sanja Faivre, Donat Petricioli

14:00 A comparison between particle associated bacteria in Marine and Limnic systems

Mina Bižić-Ionescu, Michael Zeder, John Marshall, Sandi Orlic, Rudolf Amann, Bernhard M. Fuchs, Hans-Peter Grossart

14:20 Springs of Life in a Dead Sea - Investigating a newly discovered shallow freshwater spring system in the Dead Sea

Stefan Häusler, Christian Siebert, Thorsten Dittmar, Lubos Polerecky, Yaniv Y. Munwes, Christian Lott, Miriam Weber, Mina Bižić-Ionescu, Christian Quast, Aharon Oren, Stefan Geyer, Jonathan B. Laronne, Dirk de Beer, Danny Ionescu

14:40 Foraminifera as Ecosystem Engineers in Shallow-Water Reef Habitats from the Zanzibar Archipelago (Tanzania)

Jens M. Thissen, Martin R. Langer

15:00 **COFFEE BREAK**

Session 2 - Geological Research

15:20 Calcification in EPS-rich hypersaline lakes, a model from the atoll Kiritimati

Danny Ionescu, Svenja Spitzer, Dominik Schneider, Stefan Sprin, Barbara Zippel, Nicole Brinkmann, Dirk De Beer, Joachim Reitner, Gernot Arp

15:40 Geo-Bio interactions in shallow hydrothermal vents and their impact on trace metals

Charlotte Kleint, Andrea Koschinsky

16:00 Poleward Range Extension of Foraminifera (Protista): Species Distribution Models of Current and Predicted Future Ranges

Martin R. Langer, Anna E. Weinmann

16:20 Geochemical-mineralogical investigation of degassing structures caused by recent volcanic hydrothermalism - La Calcara, Panarea (Italy)

Andreas Prautsch, Richard Stanulla, Thomas Pohl, Broder Merkel

16:40 Long term monitoring of gas discharge at large submarine fumaroles of Pararea, Italy

Katrin Bauer, Matthias Hertwig, Marco Ponepal, Gerald Barth

17:00 Gas sampling of submarine fumaroles

Mandy Schipek, Nadja Schmidt, Robert Sieland, Nicolai-Alexeji Kummer, Broder Merkel

17:20 **POSTERS & BEER (open end)**

DAY 2 - 15. February 2013

Session 3 - Education, Techniques and Legal Aspects

9:00 DOBB: Water sampling device for SCUBA divers to obtain also in situ data

Franz Brümmer, Gisela B. Fritz, Martin Pfannkuchen

9:20 Efficiency and reliability of eCC Rebreathers for the underwater scientific research beneath the pack-ice

Roberto Palozzi

9:40 Teaching Shallow-water Research

Christian Lott, Boris Unger, Miriam Weber

10:00 **COFFEE BREAK**

10:20 The concept of education and training at the Scientific Diving Center of TU Bergakademie Freiberg

Broder Merkel, Thomas Pohl, Gerald Barth, Mandy Schipek

10:40 Multi-disciplinary diving-based science: recent research supported by the UK National Facility for Scientific Diving

Martin Sayer

11:00 Project and development of instruments for flora metabolism and radiation absorption measurements in seawater

G. Fasano, A. Materassi, C. Conese

11:20 Legal aspects and issues of scientific diving in Croatia

Donat Petricioli and Tatjana Bakran-Petricioli

11:40 **POSTERS & LUNCH (2h)**

14:00 **Panel Discussion**

Scientific Diving in Europe - Where are we heading?

Introductory presentations by Martin Sayer (Toward a European Scientific Diving Network), Philipp Fischer (Das Rechtssystem des Forschungstauchens in Deutschland) and Thomas Pichler (What is Scientific Diving?)

16:00 Concluding Remarks (End of Workshop)

Workshop Program: Posters

Number	Title
1	An underwater survey for the study and conservation of marine biodiversity in an Aegean island (Agios Efstratios, North Aegean Sea) *Elena Akritopoulou, Vasilis Gerovasileiou, Maria Sini, Drosos Koutsoubas*
2	Long term monitoring of gas discharges at submarine fumaroles of Panarea, Italy *Katrin Bauer, Matthias Hertwi1, Marco Ponepal, Gerald Barth*
3	Geothermal investigations of the submarine caldera of Panarea with respect to energy utilization *Wolfram Canzler, Gerald Barth, Thomas Grab und Broder Merkel*
4	A Status of the Diversity and Composition of coral Communities within the Fringing Reef Eco-Systems of the southern Egyptian Red Sea *Constanze Conrad, Kerri Dobson*
5	Teflon optical protection for solar radiation sensors in seawater *Gianni Fasano, Alessandro Materassi, Matteo De Vincenzi, Ilaria Conese*
6	Extreme habitats, extreme organisms: sulfur bacteria in a meromictic lake *Gisela B. Fritz, Martin Pfannkuchen, Ulrich Struck, Franz Brümmer*
7	A rapid method for 3D mapping and visualization of marine cave topography *Vasilis Gerovasileiou, Vasilis Trygonis, Maria Sini, Drosos Koutsoubas, Eleni Voultsiadou*
8	CEDIP Underwater Nature Guide – between scientific education and environmental protection *Martin Heß*
9	Diving as a tool for environmental education *Timo Kaminski, Gerd Meurs-Scher, Marén Bökamp, Nicole Pekruhl*
10	Bioactive substances in a benthic prosobranch gastropod (Vermetidae, Mollusca) of the sublittoral *Anne Klöppel, Franz Brümmer, Denise Schwabe, Gertrud Morlock*
11	Underwater visual stimulation and videography of bivalve behavior *Florian Kretzler & Martin Heß*
12	Environment-Driven Trends in Shallow-Water Foraminiferal Assemblages from Fetovaia Bay (Elba Island, Mediterranean Sea) *Gloria H. Mouanga, Martin R. Langer*
13	Georeferenced UW-video taken by divers *Gerd Niedzwiedz, Dirk Schories*
14	Monitoring of the invasive American bullfrog Lithobates catesbeianus (Shaw, 1802) in small shallow water bodies in Germany *Ralph O. Schill, Chantal Göttler, Elena Kromidas, Daniela Maichl, Benjamin Morgner, Andreas Müller, Lisa Wolf, Gisela B. Fritz, Franz Brümmer*
15	Forschungstauchen als Methode am Institut für Ostseeforschung *Ingo Schuffenhausen*

Session 1

Biological and Ecological Reasearch

On the effects of coastal protection structures on the fish community in shallow water coastal habitats

Philipp Fischer and Stephanie Wehkamp

Center for Scientific Diving, Biological Institute Helgoland/ Alfred Wegener Institute for Polar and Marine Research (AWI) Helgoland, Germany

Abstract. Artificial defense structures protecting shorelines against storm and flood driven erosion significantly increase in number and spatial extension world wide. However, until now, the ecological impacts of such structures, especially in hard-bottom shallow coastal areas, are hardly understood. In an ongoing project we study the effects of experimentally introduced tetrapods (4-footed concrete structures used for coastal protection measures world wide) in the southern North Sea off Helgoland. We specifically investigate the impact of such artificial structures on the demersal fish and macro-crustacean community. Using SCUBA line transect assessments in combination with state-of-the-art remote underwater observatory technology, we investigate the seasonal and spatial effects of tetrapods fields in 5 and in 10 m water depth. We specifically focus on both, the immediate vicinity of the structures and the farer surrounding. The results from 2009 to 2012 clearly show that such artificial structures have a significant effect on the fish abundance whereas no clear effects could be observed for the macro-crustacean community. Fish abundance significantly increased in the immediate vicinity of the structures while the average fish abundance significantly decreased in the surrounding area. This indicates an overall shift of fish towards the potentially limited (artificial) resource with an expected increase in inter- and intraspecific competition. In contrast, no distinct spatial effect was observed for the macrocrustacean community but there, a significant decrease in the overall abundance occurred in the entire area where the tetrapods were installed. Together with an ongoing sampling program of hydrographic and biological variables using permanent mounted online probes (CTD, ADCP, the a fish and jellyfish tracker RemOs2), the project will provide a deeper insight in the underlying mechanisms of temporal and spatial changes in the sublittoral community associated with artificial defense structures in coastal ecosystems.

Diver surveys of rocky reefs facilitate habitat mapping of the West Solent recommended marine conservation zone, UK

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Abstract. A national and regional stakeholder consultation exercise has produced 127 recommended Marine Conservation Zones (rMCZ) for England, which are currently being assessed for the quantity and quality of the ecological evidence as to their conservation value. One such area is the West Solent which has recently been surveyed by Channel Coast Observatory (CCO) high resolution multi-beam sonar which was interpreted as physical substrates at biotope level three of the European Nature Information Service (EUNIS) classification. Ground-truthing this acoustic data by dredge and grab is possible for sediments but not for the rocky reefs, a common feature for the designation of rMCZs; providing a hard substrate for a rich diversity of marine life. We describe scientific surveys of West Solent reefs by SCUBA diving techniques. Here strong tidal currents make work challenging, requiring a team of experienced divers and careful dive planning for a short tidal slack. The restricted bottom time required rapid data collection, thus high resolution seabed photography was employed to enable species' assemblage comparisons relative to the substrates. To complement this, first hand descriptions, only attainable with specialist diver knowledge of seabed geology and species identification, were used to cross-validate photographic interpretations. A handheld geographic position service device was time-synchronized to dive computers and cameras and attached to a towed surface marker buoy providing co-ordinates for the submerged diver's observations and photographs. Incorporation of the geo-referenced species assemblage data into the acoustically interpreted habitat map will advance it to EUNIS levels four of five. This sophistication has not yet been achieved from the CCO sonar. Placing emphasis on the use of non-destructive methods in conservation areas, we explain the habitat map construction from analysis of sonar imagery to diver collected data. Scuba diving techniques are further described addressing the merits associated with habitat mapping in sensitive areas. Finally, the results thus far are explained and, from these, the conservation value of West Solent rMCZ is considered.

KEY WORDS: habitat mapping, multibeam sonar, photography, SCUBA diving, EUNIS.

Monitoring biodiversity on hard substrate: experience from the implementation of the NaGISA project in Greece

Georgios Chatzigeorgiou[1], Thanos Dailianis[1], Sarah Faulwetter[1], Wanda Plaiti[1], Elena Sarropoulou[1], Panagiotis Vavilis[1] & Christos Arvanitidis[1]

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Abstract. The experience from the implementation of the European node of the CoML project NaGISA (Natural Geography in Shore Areas) in the Aegean Sea by HCMR is presented. NaGISA aims at the long-term monitoring of coastal areas, focusing on the intertidal and sub tidal area down to 20 m, including assessment, non-destructive and destructive sampling. Preliminary results after six years of implementation are presented, along with the development of sampling devices designed and utilized by HCMR for the purpose of the project.

The NaGISA project worldwide: overview

The Natural Geography in Shore Areas (NaGISA) is a Census of Marine Life (CoML) Ocean Realm Field Project, focusing on long-term monitoring of coastal biodiversity. The acronym is a Japanese word for the area where the ocean meets the shore. Sometimes translated as coast or beach, the word *nagisa* refers to the whole ecosystem. The NaGISA project is attempting to get a complete picture of the coastal area from high tide down to 20 m depth. Until now 8 regional offices and currently over 240 sampling sites along the shores of over 28 countries have been established; over the years more countries are joining the project. Using global standards to answer local questions, NaGISA members (researchers, managers and students) are producing the world's first near shore habitat-specific global census. This is now possible because simple, cost-efficient and intentionally low-tech sampling protocols allow NaGISA to draw on the participation of international researchers and community groups. Five European countries are participating to the project with 8 sites totally, half of those located in the Mediterranean Sea. The Hellenic Center for Marine Research (HCMR) is responsible for the sites located at the south Aegean Sea.

For each rocky site selected, two study transects are surveyed, each with five replicate samples to be collected at each designated tidal depth: high, mid and low intertidal, 1, 5, and 10 m subtidal depth. Additional sampling occurs in the Cretan sites at 15 and 20 m depth. The NaGISA protocol is standardized and includes assessment, as well as non-destructive and destructive sampling. Some of the techniques used are those that allow an estimate of percent surface cover within quadrats, careful removal of organisms from small quadrants, measurements of surface and bottom seawater temperature and a visual classification of substrata.

Selection of sites in Crete

The NaGISA program works with low-tech standardized protocols that can be easily replicated by members or interested parties. The protocols are basic steps to assessing biodiversity in specific habitats and standardization allows comparisons to be made on local, regional and global scales. Two sampling sites located in the Island of Crete have been established, one in a center part of island and the other in the eastern part. Both areas are characterized by a continuous hard bottom habitat with dense algal coverage (*Cystoseira* spp., *Sargassum* sp., *Corallinales* spp.) and a moderate wave exposure. The bed slope is significantly steeper at the first sampling site. Both sites are located far from any detectable anthropogenic impact.

Sampling techniques and research focus

Samples were obtained following the NaGISA protocol by means of scuba diving for the subtidal samples. A plexiglass frame (25 x 25 cm) with a net of 0.5 mm mesh size mounted on its top side was attached to the rock with its base side. The framed surface of the substrate was scraped and sucked into a collecting net bag by means of a specifically designed suction device, using an extra air tank to create and maintain the suction current. Apart from this limited destructive sampling, a non-destructive sampling takes place as well, consisting of photography and observational techniques, estimates of percent cover of colonial invertebrates and rhizoidal macroalgae, and counts of algal stripes and solitary fauna within quadrats (1 x 1 m and 50 x 50 cm size).

Results

The robustness of the NaGISA protocol was a front line issue. To answering this, two hypotheses were tested, based on the Syllidae data set (the most abundant family in the NaGISA samples) from four Mediterranean hard substrate sites. The first hypothesis was the representativeness of the NaGISA syllid biodiversity for the entire Mediterranean region and the second was the randomness of the syllid taxo-community in relation to the polychaete assemblages to which they form part of. The results from those two hypotheses show that the observed syllid biodiversity of the NaGISA sites can be considered as a representative for the Mediterranean region only under certain assumptions and that this example should be expanded to the entire polychaete assemblages. The randomization test used for the later hypothesis shows that local species lists and their phylogenetic relationship are random subsets only at small observational scales. Therefore, it can be assumed that local processes are overlapping the historical-evolutionary processes and influence the shaping of the assemblages in a greater way.

Outlook

Facing difficulties with the handling of the suction device (due the manipulation the necessary bulky air cylinder), the design of a new suction device, without the need for pressurized air, emerged as a need. A manually operated suction device was subsequently created by the replacement of air tank with two one-way valves. These valves are placed on the suction device in such a way so that one end of the suction pipe is able to suck the sample in, while the other end can pump it out and store the sample inside a removable net. This suction device has been operationally tested and its sampling efficiency will be experimentally evaluated in the forthcoming sampling season. The results will then be compared with the previous sampling gear.

NaGISA is a long-term biodiversity monitoring project based on voluntary effort. Thus, it will result in the creation of a large database incorporating species records and distribution values, globally, with extremely low cost. This database could make it possible to detect biodiversity changes in local, regional, and global scale over time. Even for early warning signals would be possible to be recorded, while extensive biodiversity extinctions and massive habitat losses could be potentially prevented. Another fundamental aspect of the project is the student and citizen involvement and participation, as well as their environmental education. The latter will result in an increase of the environmental awareness of those vital parts of the community.

References

Chatzigeorgiou G, Faulwetter S, López E, Sardá R, Arvanitidis C (2012) Can coastal biodiversity measured in four Mediterranean sites be representative of the region? A test for the robustness of the NaGISA protocol by using the hard substrate syllid (Annelida, Polychaeta) taxo-communities as a surrogate. Hydrobiologia (in press)

Engaging citizen-scientists for the assessment of marine biodiversity: experience from the ongoing COMBER project

Thanos Dailianis[1], Sarah Faulwetter[1], George Chatzigeorgiou[1], Wanda Plaiti[1], Nancy Prentiss[2], Costas Dounas[1], Yolanda Koulouri[1], Stavroula Artemiou[3], Athina Vlasiou[3], Giacomo Pinsoglio[4], & Christos Arvanitidis[1]

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Abstract. COMBER project was designed by the HCMR as part of the EU ViBRANT project, based on the citizen science concept. Its goal is to demonstrate the potential for production of scientifically useful data through the engagement of a broader, non-scientific audience. It is currently based on fish identification and abundance monitoring in the Greek seas, with the option to expand in the Mediterranean. It is targeting recreational scuba divers and snorkelers, through collaboration with diving and sailing clubs. The methodology behind the project and the experience from a 2-year pilot implementation is presented and discussed.

Background

The COMBER project (Citizens' Network for the Observation of Marine BiodivERsity) was initiated by HCMR in 2011 as part of the EU ViBRANT e-infrastructure, aimed at supporting virtual research communities in biodiversity science. COMBER was designed to engage citizen scientists –that is, all persons interested in nature– in a coastal marine biodiversity observation network (Arvanitidis et al. 2011). The idea of 'citizen science' has been much discussed during the past decade, especially within the field of biological systematics, as the shrinkage of the population of professional taxonomists renders the mobilization of citizen scientists a key element to the success of the information and data collection process (see Hand 2010). Nevertheless, the implementation of citizen science in the marine environment currently faces two limitations: (a) only the tidal zone can be approached by all citizens, and (b) the maximal depth commonly reachable by recreational scuba divers is 40 m. In the above sense, COMBER is designed as a pilot effort to engage recreational divers and snorkelers to the monitoring of marine life at the extent of those limitations.

Approach

Fish were chosen as a target taxon for the implementation of the pilot project, since they are commonly observed at most diving sites and most frequently attract the attention and interest of a wide audience. The species observation and data collection is facilitated by usage of the commercial BIOwatch™ underwater guide (http://www.bio-watch.com). This species identification card (Dounas 2009; Dounas and Koulouri 2011) includes the forty most common fish species of the Mediterranean coastal environment and divides them on basis of morphological characteristics, color pattern, and habitat. During the dive, each participant is equipped with a fish card which he/she uses to both identify species and directly note down observations during the dive. Four abundance classes are assigned to facilitate recording, following a geometric scale: (a) absence, indicated by a blank field; (b) 1-3 individuals, marked by a single bar; (c) 4-10 individuals, marked by two bars; (d) more than ten individuals, marked by three bars. A web site (www.comber.hcmr.gr) has been developed to serve as a dedicated data upload platform, and as the main communication and promotion vehicle of the network. Collected data are automatically channeled to large data aggregators (e.g. GBIF - Global Biodiversity Information Facility) and publication media (e.g. PENSOFT).

Training of participants on data collection and entry is provided as a briefing, delivered at the diving clubs and schools by marine scientists or trained divemasters. The courses are divided into three parts: (a) pre-dive: participants follow an introduction on the data collection protocol, including how to identify target fish species using the underwater fish card and correctly record the observations; (b) during the dive: participants are initially accompanied by the supervisor (scientist or divemaster) to continue training in fish identification and data recording, and are consequently encouraged to continue the data collection by themselves, while the supervisor is still available for help; (c) post-dive: debriefing and discuss the possible questions follows, and participants are introduced to the project's website, create an account, complete their user profile, log dive information and register the observed species. Users can log into the site with their Facebook™ account, a feature employed to facilitate the registration process on the site. Registered users can continue to contribute data after participation in the seminars, use the diving log to keep track of their dives and species observations, upload original photos of fish species, and discuss various topics in the relevant fora. A competitive element is introduced by a five-star ranking system indicating the activity level of the user – the more dives with fish observations are contributed to the system, the higher the user ranks in a 'top contributors' list, thus providing a playful incentive to contribute.

Additionally to the scuba divers, COMBER is also addressed to snorkelers, via either the diving clubs or sailing excursions. Moreover, a course addressed to visitors of Cretaquarium (a commercial aquarium facility operated by HCMR in Crete) was introduced in summer 2012; this course gives participants the opportunity to learn to identify fish aided by the BIOwatch™ card while visiting the aquarium route. They are then encouraged to continue their observations in the field, either on their own or by visiting a collaborating partner.

Users of the COMBER project are rewarded for their involvement by: (a) a personal membership and certification card, establishing their participation and training; (b) the association of their name with the information and data from the moment they submit them, ensuring full credits for their contribution in any upcoming publication which makes use of them; (c) a complimentary BIOwatch™ identification card; (d) discounts applying to Cretaquarium or collaborating diving clubs and schools.

Results so far

An overview of preliminary results after 2 years of pilot implementation of COMBER can be summarized as usage statistics. During the first year of implementation, covering a two-month span (July to August) in summer 2011, 48 users participated in the project. Twenty of the users contributed data from more than one dive or snorkeling trip, thus expanding the sampling area to several other locations. In total, 1,879 species observations were recorded during 95 scuba dives and 39 snorkeling trips. During the second year, in summer 2012, 45 participants (20 out of which contributed more than once) made 1,834 species observations through 126 dives (of which 99 were scuba and 27 snorkeling).

Regarding the users' perception of the project, as derived from questionnaires completed after participation during the first year of the project, showed a generally positive attitude towards both the idea and the implementation: On a scale from 1 to 5, 96% of the users rated both the project idea and its implementation to be good or very good. However, the implementation part was not always scored with full marks and participants provided valuable suggestions for improvement, most of them asking the organizers to: (a) offer more detailed introductory seminars about marine biodiversity and to make identification underwater easier; (b) provide additional material online (presentations, photos, videos, quizzes) and (c) include more fish species and other taxa (e.g. marine invertebrates). Interestingly, the majority (84%) claimed they would continue contributing data on future dives, while a minority stated that they were not interested, or they would like to but would probably lack motivation without instructors' help (16%). Moreover, the project had a strong impact on the participants' perception of biodiversity: 84% declared that they now see the underwater world with different eyes, while only 16% claimed that the participation left no impression on them. This is reflected in the answers to the free-text questions concerning what participants liked most or what left an impression on them: 72% stated that they appreciated learning more about the marine life, and that being able to differentiate species (and thus appreciate the greater diversity) made diving a richer experience. The actual diversity of life that they were not aware of before their participation left a strong impression on many participants, but there was also a positive perception of experience of citizen science: divers were impressed by the difficulties of identifying species and data collection –and thus the difficulties of conducting science– and they felt a personal reward through their contribution to data collection.

Evaluation and outlook

The biggest challenge faced during the implementation of the pilot project, similarly to other attempts towards citizen science, was to actually engage the broader audience to the study of marine biodiversity. A trade-off between the scientific goal and the needs of both society and economy is considered necessary, aiming to the sustainability of the activity at both ends. The latter is needed in order to ensure production of reliable datasets, both regarding the number of observations and the duration of the initiative through time. This way the produced data can actually serve the purpose of the assessment, monitoring, and conservation of marine biodiversity.

Taking into account the results so far, the future expansion of the project should be channeled into two different directions, aiming at two major target groups: (a) experienced recreational divers, offering an established diving specialty certification (e.g. “marine biodiversity diver”) through more comprehensive and detailed seminars, and (b) nature clubs and associations, encouraging motivated people with relevant interests engage themselves in marine biodiversity conservation.

Another option that is being currently considered is the shift from structured observations (i.e. those based on a specific identification card), to “open” submissions from the users. In this way, the value of produced data could be greatly increased, as the diversity of observations would be multiplied. It would also allow the recording of significant observations, such as the reporting of new invasions. However, this is approach would also increase complexity, meaning that on the one hand it would demand more experienced and enthusiastic users, while on the other hand the rate of errors in the submitted data would expectedly be higher.

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Investigating benthic assemblages on northern Adriatic concrete artificial reefs: methodological comparison

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Abstract. Benthic assemblages colonising 16 concrete artificial reefs in the northern Adriatic Sea, at 13-14 m in depth, were investigated by both destructive and not destructive sampling techniques. Sessile species were removed by scraping off using hammer and chisel within a 20x20 cm frame, the removed materials were collected in tissue bags. Image samples were obtained by a digital camera equipped with strobe and a 21x28 cm frame. For each reef, 4 random scraped samples and 6 random pictures were analysed. The scraped samples, analysed under a dissecting microscope, provided densities of 106 taxa, which include small sessile species (e.g. the zoantharian Epizoanthus spp., the polychaetes Spirobranchus triqueter and Sabellaria spinulosa, and the bivalve Anomia ephippium) as well as several vagile organism (e.g. the amphipod Monocorophium acherusicum) inhabiting deposited sediments. Pictures, analysed superimposing a 100 cells grid, provided percent cover data of only 26 taxa. Despite the obvious different taxonomic resolution, both methods were enough informative to allow to discriminate between typologies and ages of the submerged structures. For management purposes, photographic sampling may be preferred because it is faster and not destructive, allowing higher replication in space and time.

Human Impact on Gorgonian Corals

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Abstract. In order to better understand the sources, patterns and consequences of human impact on populations of the gorgonian *Paramuricea clavata*, we studied populations along the Costa Brava at the Mediterranean coast of Spain. Distinguishing anthropogenic disturbance types such as recreational cast fishing, commercial lobster pots, gill nets, and SCUBA diving tourists, was possible due to intimate familiarity with the study area, -a result of two years of monthly diving surveys and collaboration with local divers. These impact types have in common that they inflict tissue damage to gorgonians, and a comparison showed that 10 – 33 % of the colonies in unprotected populations were partially colonized by epibionts, most likely following tissue injury, while only 4 – 10 % of the populations in a marine protected area were affected. We studied the physiological response of injured corals and found that colonies with about 30 – 35 % of epibiont coverage showed significantly lower fertility. Furthermore, analysis of carbohydrate and protein concentrations in branches of various locations revealed changing distribution of food within injured gorgonians, which represents a preference of apical growth in recovering colonies in an attempt to accelerate recovery. In this workshop we take the opportunity to present our results, while describing the SCUBA related methods in greater detail than commonly possible.

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Surveying benthic communities in marine caves of the Aegean Sea

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Abstract. Over the last century, the exploration of marine caves has brought to light rich communities of great scientific interest. Cave geomorphological complexity generates abiotic gradients which are reflected on biological zonation. Relevant quantitative descriptions exist only for a small number of caves mainly from the northern Mediterranean coasts. In this study preliminary results from a broader research concerning the biodiversity of Aegean marine caves are presented. Two submerged caves were surveyed with SCUBA diving and non-destructive methods (photo-quadrats). Percentage cover of 12 taxonomic groups was calculated for the walls and ceiling of different cave zones. Algal and sponge coverage differed among the corresponding zones of the two caves in relation to topographic factors (e.g. depth, cave opening) which determine the level of illumination. Semi-dark zones were dominated by sponges, the dark interior was mainly covered by serpulids while ceilings were prevailed by scleractinian corals. The observed distribution patterns among and within the surveyed caves highlight the individuality of each cavernicolous ecosystem.

This research has been co-financed (01/2011 up to date) by the European Union (European Social Fund) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework - Research Funding Program: Heracleitus II. Investing in knowledge society through the European Social Fund. The first author also benefited from "Alexander S. Onassis Public Benefit Foundation" fellowship for postgraduate studies (10/2009-12/2010).

Controlled light-emission by fish eyes and its function as a novel detection system

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Abstract. In 2007 we discovered that some marine fishes (mainly Fam. Gobiidae and Fam. Tripterygiidae) possess anatomical adaptations to passively modify and re-emit the incoming environmental light. They do so through fluorescence (a shift in spectrum), focusing of incoming light (increase in light intensity) or redirection (light guidance, reflection) in or close to the pupil. This arrangement of light emission close or in line with the viewing direction is ideally suited to detect the reflection of eyes or other organisms in the environment. Our measurements and experiments suggest that these systems are used to detect otherwise cryptic prey and predators. We discuss the implications of these findings for the co-evolution of eye function between the detecting observer and the detected target organisms.

Impact of CO_2 gas seeps on the seagrass *Posidonia oceanica*

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Abstract. Impact studies of CO_2 on the marine environment are needed for a better understanding of the changes induced by ocean acidification either by global climate change or by local potential hazards such as leakages from sub-seafloor storage of carbon dioxide (CCS = Carbon capture and storage). This study presents preliminary data about the impact of CO_2 on the endemic seagrass *Posidonia oceanica* in the Mediterranean Sea. The aim was to determine the effect of enhanced CO_2 on the function and community structure of micro- and macro-epibionts, and of the plant itself.

To assess long-term effects of CO_2 on marine benthic organisms and their habitats we chose a natural gas seep site in the shallow waters around the island of Panarea (Aeolian Islands, Italy). The natural gas seeps in the East of Basiluzzo islet had a continuous seepage activity and no measurable temperature anomaly. The gas composition analysis revealed 97% CO_2, 2.5% N_2 and traces of methane, carbon monoxide and helium. Sulphide was detected to be less than 1ppm. The data confirmed earlier analyses of Calanchi and colleagues in 1995.

The endemic seagrass *Posidonia oceanica* is the most important Mediterranean macrophyte and due to its mat-forming growth is creating the most diverse coastal habitat. The seagrass leaves perform the primary production of the plant and provide a solid substrate for organisms to settle. We investigated the impact of CO_2 on the productivity of *Posidonia oceanica* and the seagrass epibionts.

First we recorded a video and photo transect to visually assess the seagrass epiboints along a gradient from a CO_2-impacted site to a non-impacted site. Along the transect the divers also visually estimated the intensity of the gas seepage and took water samples for the analysis of pH as a measure of CO_2 influence. The field observation revealed an obvious differentiation of the cover of calcareous red algae along the transect. Furthermore one bryozoan and one hydrozoan species were more abundant at the impacted site.

For a more detailed study of the epibionts two sites impacted by CO_2 gas and one non-impacted site were chosen. At each site three replicate areas of 0.25 meter square were selected randomly (Piazzi et al 2004). First the shoots were counted *in situ* to be able to calculate the Leaf Area Index (leaf surface per area seafloor) later on. Then ten shoots with leaves were sampled from each replicate area. All leaves were scanned on both sides with a resolution of 1200 dpi and fixed in formaldehyde for further analysis. The top part of the leaves were analysed for epibiont diversity, abundance and cover in the laboratory using the samples and scans. The epibionts were classified as calcareous and non-calcareous algae, four types of bryozoans, hydrozoans and the rest as „unidentified" (Pardi et al 2006).

The photosynthetic potential of the *Posidonia* plant was investigated by using a diver operated microsensor system for *in situ* oxygen measurements on a seagrass leaf on the CO_2-impacted and the non-impacted site. The sensor was positioned on a seagrass leaf and oxygen concentration was measured along a profile away from the leaf surface to asses the net photosynthesis. Shading the plant while doing continuous oxygen measurements on the leaf surface allowed for the calculations of the gross photosynthesis later on (Polerecky et al 2008). More oxygen measurements will be conducted during the next field campaign in June 2013 so that the data presented here are mainly used to optimise the design of the *in situ* investigations.

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Research of *Lithophyllum* algal rims in the central Adriatic – what have we learned so far

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Abstract. Biogenic littoral rims built by the coralline rhodophyte *Lithophyllum lichenoides* can be found on particularly exposed sites on rocky coasts of the Central Adriatic islands in Croatia. The thick and well-developed *Lithophyllum* rim is considered to be a precise (±10 cm) sea-level indicator. Up to now we have studied five locations on which biogenic rims were mapped, measured and sampled for ^{14}C dating. The researched algal structures have two dominant levels: the upper one, with a maximal extension up to 150 cm, and the lower one with a maximal extension of ~40 cm. The surface of the lower level is ~60 cm below the recent one. Today, living talli of *Lithophyllum lichenoides* were found only in small patches at the highest position of the rim and along its upper limit, what could clearly be connected to the recent acceleration of sea-level rise. Based on these biological indicators a new sea-level reconstruction was made which showed that large algal rims grew during near-stable sea-level conditions that occurred during two relatively colder periods in the past 1500 years. The presentation will focus on issues that we encountered during the field sampling and measurement of biogenic rims; that is: measuring the position of the rim in relation to recent biological mean sea level (BMSL), the relation of the BMSL and the hydrographic MSL and the position of the sample according to the BMSL and hydrographic MSL. Our research emphasizes the importance of precise measurement during sampling accompanied by precise drawing and taking notes.

A comparison between particle-associated bacteria in marine and limnic systems

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Abstract. Particles play a crucial role for organic matter cycling and sedimentation in both limnic and marine ecosystems. As hotspots for microbial activity they harbor microorganisms that otherwise may not be found in the water column. Moreover, particles may have a significant role in the transfer of bacteria from within and outside of an ecosystem. In this study, we compare particle-associated microbial communities in limnic and marine environments to identify similarities and differences between both systems. CARD-FISH was used to compare the particle-associated and free living bacterial communities. Further, to increase phylogenetic resolution, we performed pyrosequencing for the 16S rRNA gene of representative samples of limnic systems chosen based on DGGE profiles. We compared oligo-/ mesotrophic Lake Stechlin (Germany; monthly in 2009), 2 distinct compartments of the experimentally divided Lake Grosse Fuchskuhle: South-West (SW)-acidic, humic matter rich and North-East (NE) - almost neutral, eutrophic compartment (Germany; monthly in 2009), the mesotrophic North Sea (Helgoland Kabeltonne; autumn 2009 and spring 2011) and the eutrophic North Adriatic Sea (Croatia, Po River delta-Rovinj transect; July 2011). The semi-automated analyses of 3000 particles showed that in stratified systems particles above the thermocline are larger, but particles in limnic and marine system do not systematically differ in size. However, bacterial cell number (DAPI) was stronger correlated with particle size in limnic than in marine systems. This suggests that colonization of particles, especially in marine systems, is determined by additional factors than solely availability of space. Both marine and limnic ecosystems encompass groups that are found exclusively as free living. These include the marine and freshwater members of the SAR11 and SAR86 clades as well as the marine SAR92, SAR324 clades. Individual particles vary significantly in their bacterial communities, thus often encountering in one sample a range between 0 to 100 percent colonization by a respective taxa. This suggests that multiple factors such as particle type, bacterial source community and bacterial succession significantly determine microbial communities on particles. The latter is supported by seasonal and spatial shifts in particle colonizing communities within an ecosystem. Limnic particles were predominantly found in spring. In all limnic systems studied, particle-associated bacterial communities were dominated by Alphaproteobacteria, Betaprotebacteria and Bacteroidetes. Actinobacteria that are often found as free living in limnic systems were occasionally, and for short periods, found as attached in large numbers in Lake Grosse Fuchskuhle. Similarly, the Gammaproteobacteria group which is often a minor component in limnic systems was periodically found both as attached and as free living bacteria in Lake Grosse Fuchskuhle. Pyrosequencing data revealed that bacterial communities associated with limnic particles were diverse and greatly varied in time and with space.

Our results indicate that bacterial communities on particles in both systems are diverse and greatly differ from each other, whereby similar ecological niches seem to be filled with different taxa. The high variability in bacterial community composition on individual particles do not allow for general conclusions on systematic differences in bacterial colonization on limnic vs. marine particles.

Springs of Life in a Dead Sea - Investigating a newly discovered shallow freshwater spring system in the Dead Sea

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Abstract. The Dead Sea is a terminal desert lake. Due to reduced freshwater input, high evaporation rate and export of water to evaporation ponds the water level drops on average 1 m yr^{-1}. The increased salinity (347 g l^{-1} total dissolved salts) and high concentration of divalent ions (~2 M Mg and ~0.5 M Ca) make the Dead Sea one of the most hostile habitats on earth. Though microbial life exists in the Dead Sea, it is by far less abundant than in other aquatic environments, with densities in the range of 10^3 cells ml^{-1}.

A recently discovered system of underwater, freshwater springs forms an oasis of microbial life within the Dead Sea. The spring water originates in the Judea Group Aquifer, its chemistry indicating that it reaches the Dead Sea through a diverse net of channels with different levels of mineral interaction. Gene community analysis (16S rRNA) suggests that microbial activity is abundant with sulfate reduction and sulfide oxidation often being the dominant processes. The spring-water microbial community is fueled by highly abundant organic matter. As shown by high resolution fingerprinting (FT-IRMS), the dissolved organic matter contains both microbially and thermally modified components and has the characteristics of fossil organic matter.

In the Dead Sea, the springs allow the formation of large biofilms covering the sea floor and several rocky formations. Location dependant, these biofilms consist mainly of diatoms, sulfide oxidizing and sulfate reducing bacteria. Using *in-situ* microsensor measurements as well as radiolabel experiments we have shown oxygenic photosynthesis and both sulfide oxidation and sulfate reduction to occur in these mats, suggesting the presence of an internal sulfur cycle. Stable isotope labeling has shown that both autotrophy and heterotrophy pathways occur; however, the latter is the preferred pathway.

In several locations cobbles are covered in thick, green, microbial mats mainly consisting of green sulfur bacteria and cyanobacteria. Oxygenic photosynthesis could not be detected in these mats neither *in* or *ex-situ.* Interestingly, we found a light-dependent oxygen consumption which could be measured in both cases.

Microbial community fingerprinting analysis demonstrates the spring sediment and biofilms community to originate from the resident Dead Sea sediment-community. This suggests that the spring water provides the community with missing nutrients and organic matter. Additionally, using a novel salinity microsensor it is apparent that the springs form a less saline microenvironment. All these conditions allow the formation of a dense microbial community previously undescribed in the Dead Sea. This studied spring system is one of many such systems on the west and east coasts of the lake, suggesting the Dead Sea harbors and supports a larger diversity of microorganisms and biogeochemical pathways than previously assumed.

Foraminifera as Ecosystem Engineers in Shallow-Water Reef Habitats from the Zanzibar Archipelago (Tanzania)

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Abstract. Foraminifera are prolific producers of calcium carbonate and contribute significantly to the stabilization of reefal frameworks worldwide. We have conducted underwater research in reefal and lagoonal habitats around three islands of the Zanzibar Archipelago (Zanzibar, Mafia and Pemba) to study the spatial distribution, diversity, composition of assemblages and significance of foraminifera as ecosystem engineers. Our results suggest that foraminiferal ecosystem engineers modify the physical habitat and affect abundances, diversity and species richness in reefal and lagoonal ecosystems.

Introduction

Benthic foraminifera are important producers of calcium carbonate ($CaCO_3$) because they contribute substantially to the world's reefs (Langer 2008; Langer et al. 1997). Due to their abundance and high production rate, benthic foraminifera have substrate modifying capabilities and add to the fortification of reefal structures. The most prolific and abundant taxa in reefal ecosystems (e.g. *Amphistegina* spp.) were therefore considered to be ecosystem engineers (Langer et al. 2012). Because carbonate production is propelled by zooxanthellate endosymbionts (Hallock 1985), larger symbiont-bearing benthic foraminifera (LBF) constitute ubiquitous and prominent components in virtually all marine tropical ecosystems. We have examined the distribution, diversity and composition of recent benthic foraminiferal assemblages in shallow-water reefal and lagoonal habitats around the three major islands of the Zanzibar Archipelago (Zanzibar, Mafia and Pemba), to 1.) identify foraminiferal ecosystem engineers in east African tropical reef settings, 2.) document their abundances and habitat preferences, and 3.) assess their impact on species richness and structure of foraminiferal communities.

East African reefs constitute a valuable resource for millions of people along the East African coast but are increasingly threatened by local and global pressures. The most immediate threats impacting reefal carbonate production include coastal development, large-scale expansions of tourist facilities, eutrophication and pollution. The identification of reef ecosystem engineers is thus of immediate interest for reef and conservation management.

Large-scale studies on modern foraminifera from the coast of eastern Africa are lacking. The most extensive studies of foraminifera from eastern African localities were conducted by Heron-Allen and Earland (1915), Braga (1961), Pereira (1979), Banner and Pereira (1981), Pignatti et al. (2012), and Langer et al. (2013). This study presents the first examination of foraminiferal assemblages from the islands of the Zanzibar Archipelago.

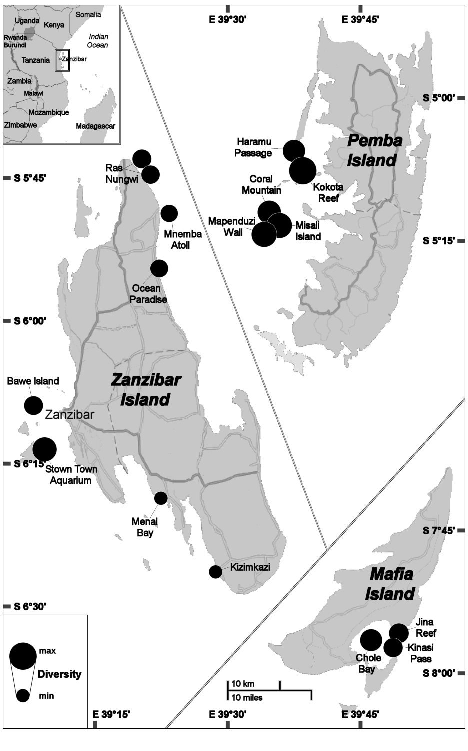

Fig.1. Map illustrating the foraminiferal diversity around Zanzibar, Pemba and Mafia.Island

Material & Methods

Sediment samples for foraminiferal analyses were taken by SCUBA diving and snorkeling in March 2005 (Zanzibar and Pemba Island) and March 2012 (Mafia). A total of 27 samples from 16 sites (Fig.1) were recovered from reefal, lagoonal and nearshore habitats. All samples were washed over 63-μm mesh sieves and dried, and the foraminifera were then picked from each. The foraminifera picked from the samples, were identified to species level and counted. Between 450 and 825 specimens were picked from each sample. Benthic foraminiferal species were identified and documented via Scanning Electron Microscopy (SEM). To illustrate the structure of the foraminiferal data set obtained, a cluster analysis was conducted. This technique grouped together samples with similar faunal assemblages found in similar habitats (Fig.2). The foraminiferal diversity was determined by using the Fisher α index, which evaluates the relationship between the number of species and the number of individuals (Fisher et al. 1943; Fig.1).

Results

A total of 16,804 foraminiferal specimens were picked from the samples. They were assigned to 72 porcelaneous, 79 hyaline-perforate and 18 agglutinated species of benthic foraminifera. These species belong to 93 genera. Species of the three most abundant genera *Amphistegina*, *Neorotalia* and *Quinqueloculina* make up almost 50 % of the total number of specimens counted. Larger benthic foraminifera constitute 51 % of the total number of individuals.

Cluster analysis: Q-mode cluster analysis revealed four cluster groups that mirror major macrohabitats (Fig.2). Cluster A contains reef sites from Mafia Island and the fringing-reefs off NE Zanzibar. Cluster B comprises patch-reef sites from Pemba and from the western side of Zanzibar. Samples from Mnemba Island and from Kizimkazi Beach form Cluster C. Cluster D is composed of shallow-water nearshore sites from Menai Bay and Ocean Paradise.

Occurrences: Quantitative analyses of foraminiferal assemblages reveal distinct differences between taxa and assemblages and illustrate their distribution patterns. Figure 3 shows the occurrence and abundance of the most prominent foraminifera from the Zanzibar Archipelago. Amphisteginids are the most abundant foraminifera. Specimens of *Amphistegina* are rare to common in shallow waters (1.19-12.61 %) and frequent to dominant at reef sites (19.37-48.79 %; Fig.3A). *Neorotalia calcar* is the second most abundant taxon and dominates the assemblages at Kizimkazi Beach (48.16 %) and Mnemba Atoll (65.3 %). This species also constitutes a noticeable amount of foraminifera in the eastern fringing reefs (2.49-20.24 %). It is common at the Ocean Paradise site (4.17 %) and rarely present at most of the western reefs (0-1.83 %) as well as at Menai Bay (0.42 %; Fig.3B). *Quinqueloculina* is the third most abundant genus and makes up between 1.94 % (Coral Mountain) and 12.49 % (Jina Reef) of foraminiferal individuals at reef sites, and between 12.43 % (Kizimkazi Beach) and 26.7 % (Menai Bay) in shallow waters (Fig.3C). *Ammonia convexa* dominates the assemblages at Menai Bay (31.57 %) and is common in the other shallow water samples (3.85-4.96 %) but absent or extremely rare at reef sites (maximum 0.94 %; Fig.3D).

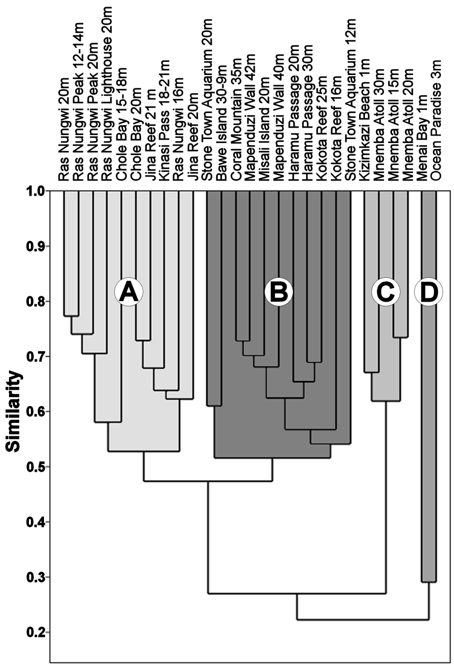

Fig.2. Q-mode cluster dendrogram

Diversity: The number of species discovered at each site ranges from 35 (Menai Bay) to 127 (Kokota Reef). This equals Fisher α indices between 8.73 and 35.12. The diversity is higher at reef sites (63-127 species, Fisher α indices 15.94-35.12) than in shallow waters (35-54 species, Fisher α indices 8.73-15.33; Fig.1). The Mnemba Atoll represents an intermediate stage (71 species, Fisher α index 14.44). At reef sites, the average diversity in the ocean-facing fringing reefs is lower (77 species, Fisher α index 18.41) than in the more protected western patch reefs (98 species, Fisher α index 27.17).

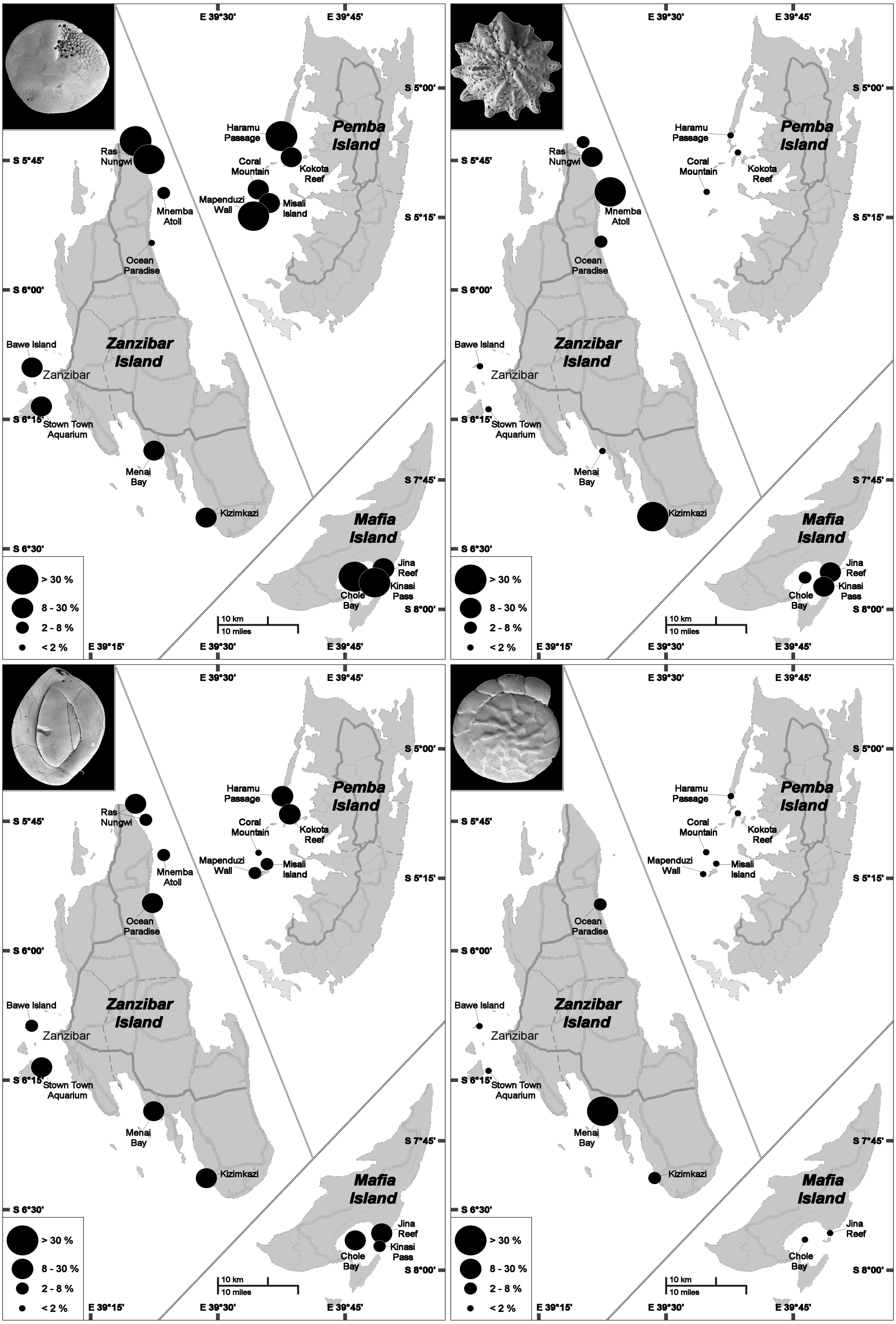

Fig.3. Occurrence and abundance maps of the most important taxa.
A) *Amphistegina* spp. B) *Neorotalia calcar*. C) *Quinqueloculina* spp. D) *Ammonia convexa*.

Discussion & Conclusion

Amphisteginid foraminifera are among the most abundant and prolific producers of calcium carbonate in modern ocean reefs. The genus has a circumtropical distribution and tolerates variable environmental conditions (Hohenegger 2011; Murray 2006). *Amphistegina* is the most abundant genus around the islands of the Zanzibar Archipelago and appears in virtually all environments. It is most abundant in the high energy eastern fringing reefs and constitutes up to 50 % of all foraminiferal specimens. *Amphistegina* spp. in addition to other LBF contribute significantly to the stability of the carbonate reefs and are therefore considered true ecosystem engineers. *Neorotalia calcar* was found to be the second most abundant taxon around the Zanzibar Archipelago. This species, however, occupies a narrow environmental niche, and is adapted to particularly warm and shallow carbonate settings. The species was found to be most abundant in shallow-water tide pools where temperatures are as high as 40°C (see also Hohenegger, 2011; Murray, 2006). Species of the genus *Quinqueloculina* are by far the most common taxa of the miliolid forms. They appear in variable amounts in all habitats but are most common at a depth above 20 m and most diverse within the lagoonal site at Ocean Paradise. The most eutrophicated shallow water sites are occupied by *Ammonia convexa*. *Ammonia* is an opportunistic taxon, known to dominate extreme environments with highly variable conditions (Murray 2006).

The species richness computed to date resembles the diverse assemblages from the Bazaruto Archipelago (Langer et al. 2013; 158 species). However, the total number of species recorded so far is significantly lower than reported by Heron-Allen and Earland (1915; 465 species), Braga (1961; 270 species), Banner and Pereira (1981; 206 species) and Pignatti et al. (2012; 256 species).

Examination of foraminiferal assemblages from the Zanzibar Archipelago indicates, that four genera of benthic foraminifera dominate the shallow-water reefal and lagoonal habitats. The taxa are prominent contributors to reefal carbonates and their abundance and ubiquity impacts the diversity and species richness of associated assemblages. These results also suggest that dominant taxa modify the physical habitat and affect the sedimentary composition of reefal and lagoonal sediments.

Acknowledgements

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Session 2

Geological Research

Calcification in EPS-rich hypersaline lakes, a model from the atoll Kiritimati

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Abstract. Microbial carbonate precipitation results from an increase in the ion activity product of Ca^{2+} and CO_3^{2-} and heterogeneous nucleation, for example at acidic exopolymers. Processes increasing the Ca^{2+} x CO_3^{2-} ion activity product include, for example autotrophic carbon fixation (photo- and chemoautotrophy, anaerobic methane oxidation and ammonification. Microbial processes that lead to carbonate dissolution include heterotrophic respiration, aerobic sulfide oxidation and ammonia oxidation. Extracellular polymeric substances (EPS) greatly affect the precipitation of $CaCO_3$ due to their Ca^{2+} binding properties. This in turn depends on microbial activity which by altering the pH or consuming the polymeric substances can increase or decrease Ca^{2+} binding. We analyzed two hypersaline lakes on the atoll Kiritimati (Republic of Kiribati), with thick (lake 21) and thin (lake 2) EPS layers respectively. Photosynthesis, pH and Ca^{2+} precipitation were evaluated in-situ using microsensors. Despite the high oxygenic photosynthesis, hardly any microbial precipitates were observed in the oxic region. Interestingly, microprofiles showed a light dependent Ca^{2+} release in these layers of the mat. Photosynthesis results in an increase in pH and a deprotonation of the EPS matrix leading normally to an increase in Ca^{2+}-binding. Therefore we suggest the release of Ca^{2+} from the matrix towards the deeper layers is the result of aerobic heterotrophy. In the absence of light, oxygen is rapidly consumed and the anaerobic release of Ca^{2+} is significantly reduced. A sharp decrease in Ca^{2+} concentration was measured at the transition to the anoxic zone and was found as well to be light dependent. This matches the observation of a first layer of gypsum and aragonite precipitates in this transitional zone and suggests that may be anoxygenic phototrophs are mainly responsible for their deposit. This also corresponds with a previous analysis which found the microbialites depleted in light carbon suggesting a strong influence of autotrophy. A termination of the EPS-binding inhibitory effects may have a role as well in the formation of this layer. Pyrosequencing of the 16S rRNA gene from the different layers showed purple sulfur bacteria to be specifically located at the transition zone. Measurements in microbial mats of Lake 2 showed a similar light dependent increase in Ca2+ concentration in the upper layer however precipitation of carbonates was observed only in deeper layers and only in the dark. The composition of the EPS was analyzed using lectin staining and was found to be highly complex with >60 positive bindings, as compared to <30 from other analyzed microbial mats. Further analysis of the EPS revealed large autofluorescent microbialites in the deeper layers of the mats suggesting buried, EPS-trapped, unicellular cyanobacteria serve as nucleation sites for carbonate precipitation. Based on these results we suggest a model for calcification in EPS rich hypersaline environments to explain the existence of microbial precipitates only in the deeper layers. Calcium ions are trapped from the water in the upper EPS layers and are being transported downwards by EPS degradation by aerobic heterotrophs. Anoxygenic photosynthesis leads to a first layer precipitate. Further precipitation occurs deeper in the layer via a yet unknown mechanism.

Geo-Bio interactions in shallow water hydrothermal vents and their impact on trace metals

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Abstract. Life at shallow- and deep-sea hydrothermal vents is exposed to high concentrations of different metals in the venting fluids. Some are biologically essential, while others react toxic at even low quantities (e.g. Copper), whereas the chemical speciation determines the metal toxicity rather than the total concentration of an element.

There is evidence that not only organic molecules constitute ligands that are able to form strong complexes with Cu to reduce its toxicity, but also, that these ligands are produced by bacteria in response to increasing Cu concentrations (*Klevenz et al.*, 2012). Hydrothermal vents at the sea floor release large volumes of these metal rich fluids into the ocean. Therefore, due to the binding of organic compounds to metals, the trace metal flux into the ocean is expected to be higher than assumed until recently (*Sander and Koschinsky*, 2011).

In this study, we want to examine the total dissolved copper concentrations and responding ligand concentrations at shallow water hydrothermal vent fields by a voltammetric ligand titration, using adsorptive stripping voltammetry. Samples were taken during a sampling campaign on Milos, Greece in May 2012.

Copper-complexing ligand concentrations are determined using an indirect method of competing ligand equilibration, whereas a well-characterized ligand (Salicylaldoxime) is added to the sample. Salicylaldoxime was chosen as the competing ligand because its complexation parameters with Cu in seawater are well studied, and its sensitivity allows the detection of even the lowest ligand and copper concentrations (*Campos and van den Berg*, 1994). Despite of a buffer, increasing concentrations of a copper standard and Salicylaldoxime are given to the sample in different, increasing amounts, depending on the expected ligand concentration an the titration window, respectively. This study will give insight into the geo-bio interactions at shallow hydrothermal vents which are influenced by photosynthetic and chemosynthetic processes, in contrast to deep-sea hydrothermal systems which are only chemosynthetic affected.

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Environmental-Driven Trends in Shallow-Water Foraminiferal Assemblages from Fetovaia Bay (Elba Island, Mediterranean Sea)

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Abstract. A representative set of sediment samples from the Bay of Fetovaia (Elba Island) was analyzed to study the distribution, diversity and habitat preferences of shallow-water benthic foraminifera. Faunal analysis indicates that the distribution of foraminiferal indicator taxa, patterns of species richness and diversity, and the assemblages mirror the major macrohabitats. Species and communities of foraminifera thus retain information regarding the original community structure and preserve environmental information useful in paleoecological studies.

Introduction

Benthic foraminifera have widely been used to reconstruct environmental settings and attempts have been made to develop quantitative proxies or to detect index markers for shallow-water macrohabitats, water depths and paleoproductivity. The analysis is commonly based on the relationships between individual species or assemblages of foraminifera and their environment and has become an important tool for understanding and managing marine communities (Murray 1991; Langer and Lipps 2003). These studies rely on a qualitative or semi-quantitative interpretation of the faunas, since the relationship between the environmental situation and the corresponding fauna seems to be extremely complex and bears a non-linear nature. In this study, surface sediments from across the Bay of Fetovaia were analyzed to assess the relationship between environmental attributes and the distribution of benthic foraminiferal taxa. We have analyzed community structures of benthic foraminiferal assemblages from various macrohabitats in the Bay of Fetovaia (Elba Island, Mediterranean Sea) to identify potential indicator taxa, patterns of diversity and habitat specific assemblages that may be useful in paleoecological and paleoenvironmental studies. This study tests the environmental controls on the distribution, diversity and composition of benthic foraminiferal assemblages in surface sediments as a means of characterizing typical Mediterranean macrohabitats. The computed relationship between biota and environment can be applied to interpret environmental and ecosystem change through time.

Material & Methods

Surface sediment samples were collected in August 2011 by SCUBA diving at 19 sites in the Bay of Fetovaia (Elba Island) in the western Mediterranean Sea (Fig. 1). Samples were collected in four different shallow-water habitats: seagrass meadows of *Posidonia oceanica*, fine to coarse-grained nearshore siliciclasitc sediments, rocky shore hard substrates with algal cover, and coarse detrital carbonaceous sediments. Q-mode hierarchical cluster analysis reveals that habitat-specific foraminiferal assemblages can be distinguished. For each assemblage faunal composition and distribution, diversity indices and dominance are assessed. The material was wet-sieved to the 63μm size fraction and split into aliquots, each containing at least 300 specimens of benthic foraminifera. The foraminifera were identified to species level using a blight microscope and referencing the taxonomic studies of Cimerman and Langer (1991), Langer and Schmidt-Sinns (2005), and Goldbeck et al., (2005).

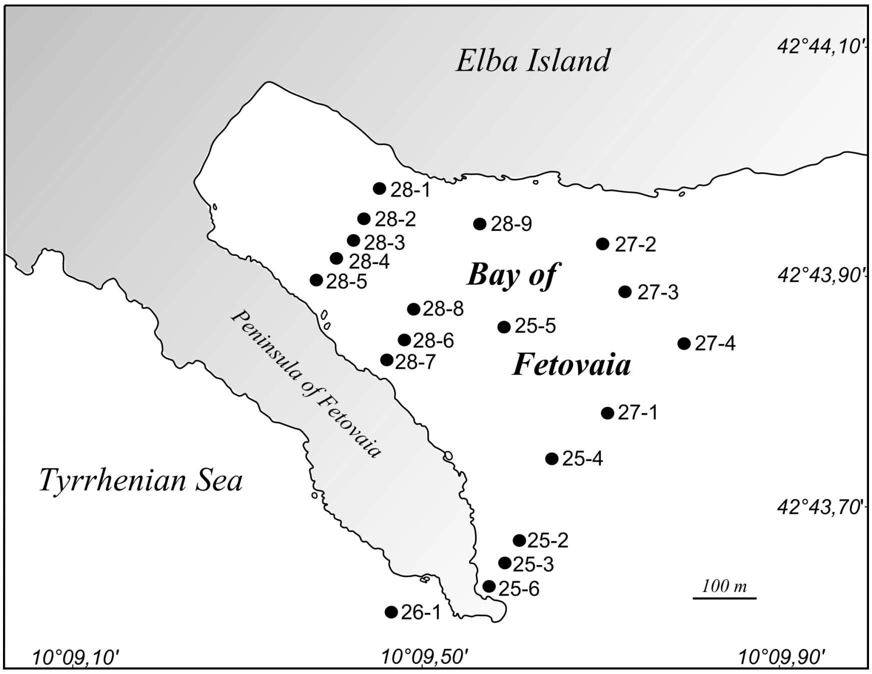

Fig.1. Location of sample sites in the Bay of Fetovaia (Elba Island, Mediterranean Sea).

Results

A total of 5677 were recovered from all sampling sites. The foraminiferal assemblages contained a total of 78 species and belong to 42 genera. Almost two thirds of all individuals counted are members of the porcellaneous miliolids (62.8 %). Perforate taxa make 29.5 % and agglutinated foraminifera represent 7.7 % of all specimens.

Cluster and faunal analyses indicate that individual macrohabitats (Fig. 2) are characterized by groups of assemblages and indicator taxa (Plate 1). Hierarchical Q-mode cluster analysis reveals the presence of three cluster sets (A, B, C) that represent shallow, intermediate, and deeper water settings. Cluster A represents shallow siliciclastic sample sites in wave and energy dominated nearshore environments. It is characterized by abundant occurrences of *Ammonia*. Epiphytic foraminifera and smaller miliolids appear abundantly in Cluster B. Abundant occurrences of agglutinated taxa characterize Cluster C.

Quantitative faunal analysis shows that there is an overall trend of increasing species diversity (Fig. 3) from the nearshore siliciclasitic habitats (0-9 m), to carbonate dominated environments (9-15m), and finally to high-diverse settings in deeper water seagrass meadows (15-44 m). Within the seagrass environment, an imbrication of several microhabitats occurs (infauna, epifauna, epiphytes), commonly resulting in increased species richness and sample sites displaying higher Fisher α diversity indices.

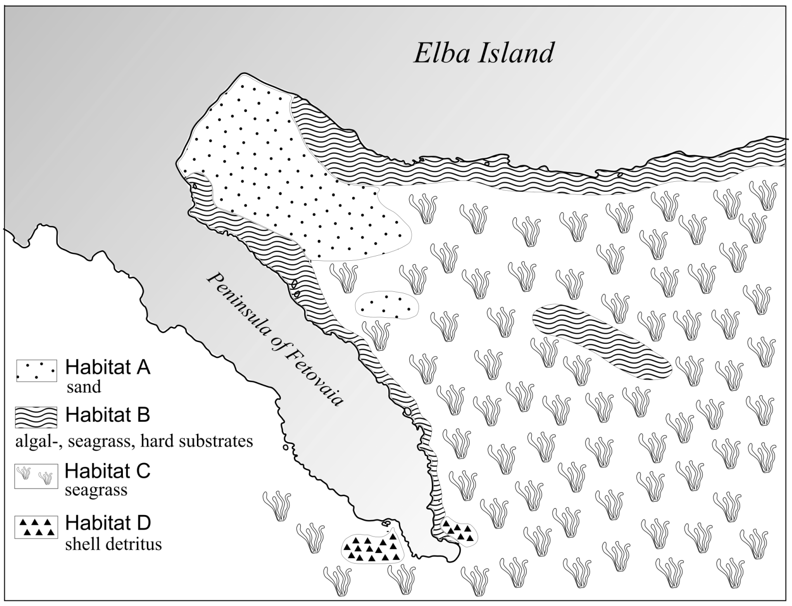

Fig. 2. Distribution of major habitat types across the Bay of Fetovaia.

Fisher α diversity values recorded within Fetovaia Bay range between 8,0 and 18,3. Highest values were obtained from deeper water seagrass sites, where epiphytic, infaunal and epifaunal taxa co-occurr within the same habitat.

Seagrass meadows are dominated by taxa adapted to the flat surfaces of leaves and rhizomes (e.g., *Planorbulina, Miniacina, Cyclocibicides*). Rocky shores and hard substrates along the coastlines are marked by abundant occurrences of *Asterigerinata* and other taxa. Morphotype analyses shows that foraminifera with trochspiral test forms have maximum abundances in high-energy shallow water settings, while fragile or unilocular morphotypes are more frequent in deeper waters. Robust agglutinated test have maximum occurrence records within the nearshore siliciclastic sediments at depth between 3 and 10 meters.

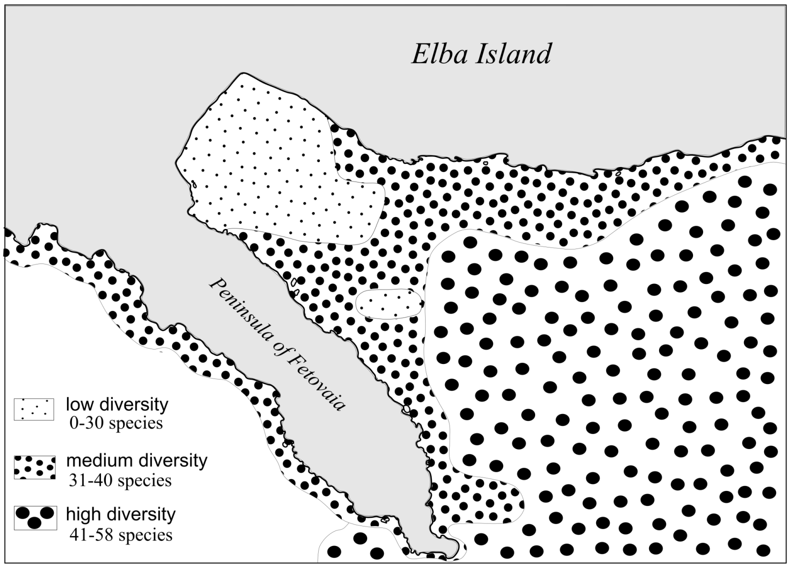

Fig. 3. Species richness map of benthic foraminifera in the Bay of Fetovaia illustrating the general increase of taxa with water depth. Maximum values (> 41 species) are commonly observed at depth between 20 and 45 m.

Discussion and Conclusion

Benthic foraminifera are ubiquitous components of shallow-water ecosystems and the distribution of individual species is constrained by their environmental preferences. Across the study sites at Fetovaia, the distribution of benthic foraminiferal assemblages is strongly correlated to changes in water depth, grain size, phytal coverage and substrate types present in macrohabitats. Each habitat is characterized by a specific set of foraminiferal index markers and percent abundances of selected taxa. Each faunal group contains a number of numerically abundant indicator species that do not occur in other faunal clusters. This implies low horizontal transport rates within Fetovaia Bay and signifies that faunal mixing among the cluster groups is limited. Foraminiferal death assemblages may thus be autochthonous and retain information regarding the original community structure (see also Langer and Lipps 2003). They may also preserve environmental information useful in paleoecological studies and they are good ecological indicators of shallow-water Mediterranean habitats. The findings of 1.) specific indicator taxa characterizing individual macrohabitats and 2.) patterns of diversity and assemblage configurations can contribute to our general understanding of fossilized ecosystems and have important implications regarding the consequences of environmental management. Indicator taxa of benthic foraminifera produce a strong correlation to the environmental variables, indicating their potential to provide a detailed assessment of fossil habitat and ecosystem types.

Acknowledgements

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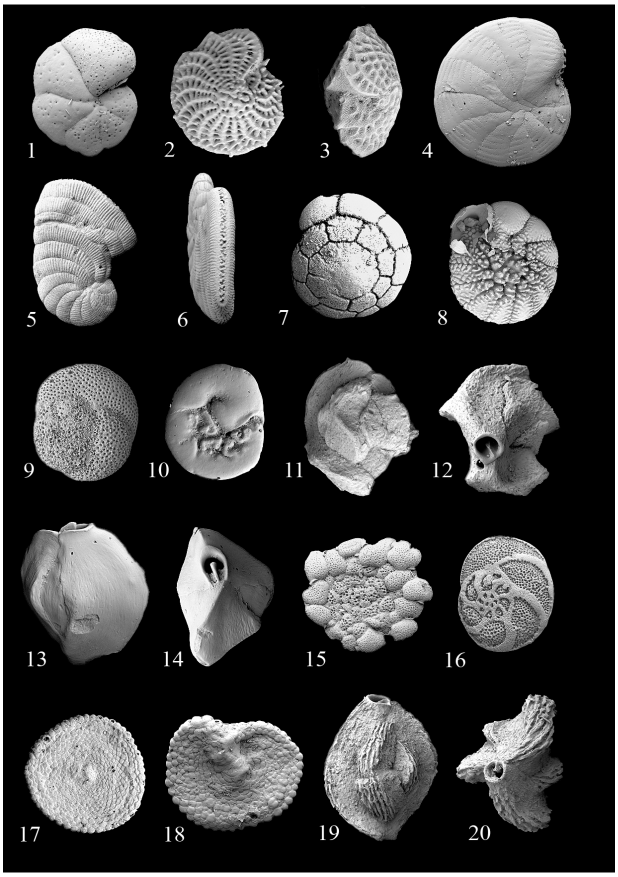

Plate 1. Scanning electron micrographs showing the most common benthic foraminifera from the Bay of Fetovaia. 1. 1) *Lobatula lobatula* (Walker and Jacob, 1798) umbilical side, x30; 2) *Elphidium aculeatum* (d`Orbigny, 1846) side view, x60; 3) apertural view, x60; 4) *Peneroplis pertusus* (Forskål, 1775) side view, x33; 5) *Peneroplis planatus* (Fichtel and Moll, 1798) apertural view, x30; 6) side view, x28; 7) *Ammonia beccarii* (Linnaeus, 1758) spiral view, x35, 8) umbilical view, x35; 9) *Rosalina bradyi* (Cushman, 1915) spiral side, x55; 10) umbilical side, x60; 11) *Quinqueloculina berthelotiana* (d`Orbigny, 1839); side view, x30; 12) apertural view, x33; 13) *Quinqueloculina vulgaris* **(**d`Orbigny, 1826) side view, x20; 14) side view; 15) *Planorbulina mediterranensis* (d`Orbigny 1826) unattached side, x22; 16) *Rosalina macropora* (Hofker, 1951) spiral side, x50; 17) *Sorites orbiculus* Ehrenberg, 1839; side view; 18) side view, x18; 19) *Quinqueloculina disparilis* d`Orbigny, 1826; side view, x35 29) apertural view, x38.

Geochemical-mineralogical investigation of degassing structures caused by recent volcanic hydrothermalism - Case study: La Calcara, Isle of Panarea (Italy)

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Abstract. Mineralogical and geochemical analysis of hydrothermal degassing tubes from Octopus Rock (La Calcara, Panarea, Italy) yielded a hydrothermal influenced dacitic to andesitic volcanic material, building up characteristic sedimentary structures. Marcasite mineralization is a common feature, which developed during periods of higher thermal activity and thus hydrothermal influence in the past. A batch wise genesis of the tubes was proven.

Introduction

The recent active shallow marine hydrothermal system of Panarea, Italy, is characterized by various types of active hydrothermal venting what causes prominent sedimentary structures. These degassing tubes, especially from the diving location La Calcara, are addressed by our investigations. The tubes were sampled during fieldcampaigns of the Scientific Diving Centre at TU Bergakademie Freiberg in 2011 and 2012.

Methods

Geochemical and mineralogical investigations of the degassing tubes were accomplished on macro-scale as well as on microscopic features using optical microscopy (transmitted, polarized and reflected light; Fig. 1) and SEM-EDS measurements. Point counting at stitched thin-section-images was used to evaluate mineral contributions dependant on the relative distance from the tubes centre. Additional information was gained from volcanic glasses by differential thermo analysis (DTA). The volcanic glasses were separated using a stereomicroscope with crossed polarized light and read-out utensils. XRD-analysis of sampled soft-rock material beside Octopus Rock in La Calcara was accomplished.

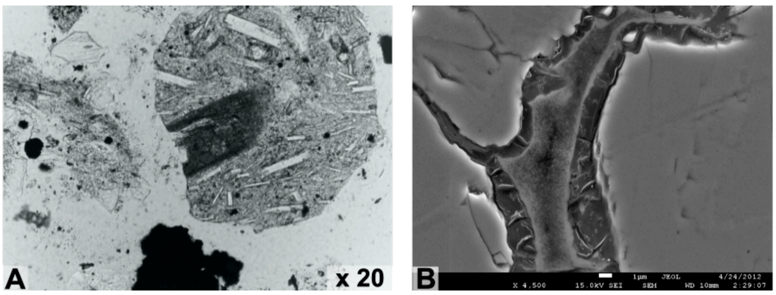

Fig. 1: A: Transmitted light capture of a decomposed mineral (hydrothermal alteration) with a magnification of 20. This outer shape of the minerals is common in the sample material. **B:** FeS_2-mineral with small interstices which contain small (?fecal) pellets (scale: 1 μm).

Sampling and preparation of the softrock material next to Octopus Rock was challenging because of semi-preservable and unstable material (Fig. 2). The relatively hard specimen (mineral precipitates) were collected into PVC cases (4.2L; Fig. 2-A). Alternatively, sampling was realized using a transparent plastic cylinder. It was inserted vertically into the softrock material over a degassing tube (Fig. 2-B). The aim was to get better knowledge of the structural setting of the tubes and the genetical processes during their formation at the soft sediment environment at La Calcara ("Octopus Rock").

Results

Macro scaled documentation of the degassing tubes revealed mainly appr. 1.5 cm wide and 70° to 110° inclined tube openings. Thin section analysis shows that the main composition of the tubes varies between the volcanites dacite (quartz, alkali feldspars) and andesite (plagioclase, nepheline). The occurrence of decomposed minerals is abundant. The influence of hydrothermal alteration is clearly witnessed and mineral precipitates of various types are a common feature. Smectite and Alunite (occurs in form of Svanberigite) were proven through XRD-analysis and confirm the occurrence of basaltic original material, which was transformed into a softrock material: smectite can be an alteration product of basaltic ash (RÖSLER, 1980). Decomposed feldspar accumulations have a specific element contribution. In outer areas of the accumulations, the composition is similar to an alkali-feldspar and in inner area plagioclase-like. This might be a result of alteration processes, which affected at first outer areas of the feldspar accumulations causing a depletion of Ca and an enrichment of K in the minerals.

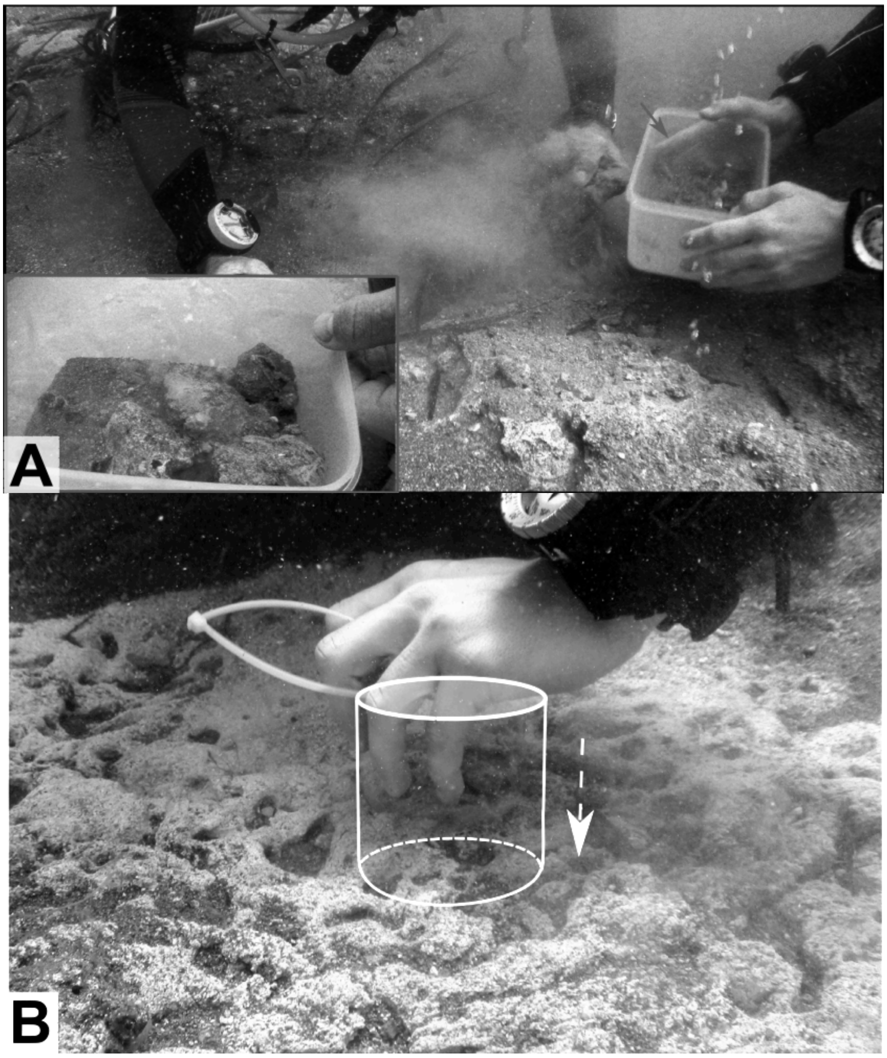

Fig. 2: Two tested sampling methods in La Calcara. **A:** Sampling of softrock material with a PVC-Box (4.2 L). The material decomposed under air pressure. Degassing structures stay stable under water (small picture in frame).**B:** A transparent cylinder was vertically inserted into the softrock underground to sample degassing structures (redrawn schematically with white lines). After sampling the opening was covered with a small board.

Sulphide ore minerals could be identified as marcasite (FeS_2), being common in La Calcara. Pyrite was not proven. The marcasite minerals are overgrown with other mineral phases like feldspar, biotite or pyroxene. Most of the marcasite minerals have a brown seam probably due to alteration processes. A batch wise genesis of marcasite minerals took place (cf. STANULLA et al., 2012). This can be explained by a sudden event with higher thermal activity accompanied by higher occurrence of gas bubbles and water flow. This causes the development of a degassing tube during a sudden temperature and degassing high (Fig. 3).

Measurement of volcanic glasses from Area 26 with DTA showed two different environment conditions: juvenile glasses and altered glasses. This enforces the thesis of batch-wise genetical processes.

Near Octopus Rock two different types of altered basaltic tuffs (Figure 4, A and B) were investigated. The first material (A) has a dark grey to grey color and a grain size from medium clay to silt. The tubes in this material are mainly small but relatively good preserved. The second material (B) is made up of clay to silt with a bright gray color and mainly good preserved degassing tubes. Octopus Rock itself is a small elevation made up of a consistent dacitic rock. The measured temperatures (Fig. 4) at Octopus Rock are shown in the detailed map.

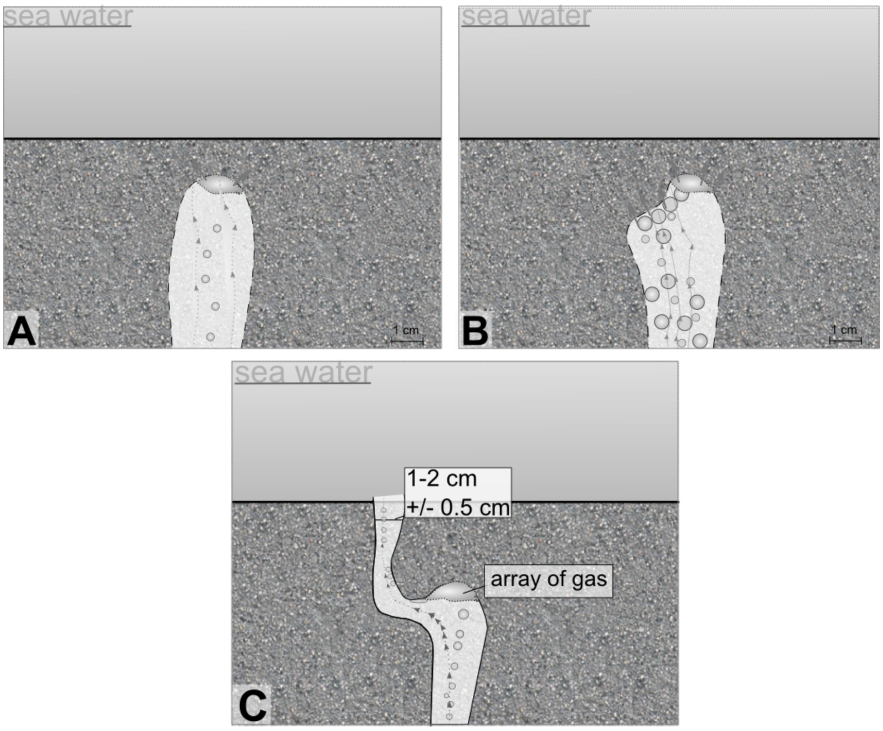

Fig. 3: Model of the systematic step by step evolution of the degassing structures at Octopus Rock (La Calcara). Grey bubbles mark hydrothermal gas emission. Arrows in the tube mark water emanation (cf. STANULLA, 2012). In picture C) a tube is shown as being documented here.

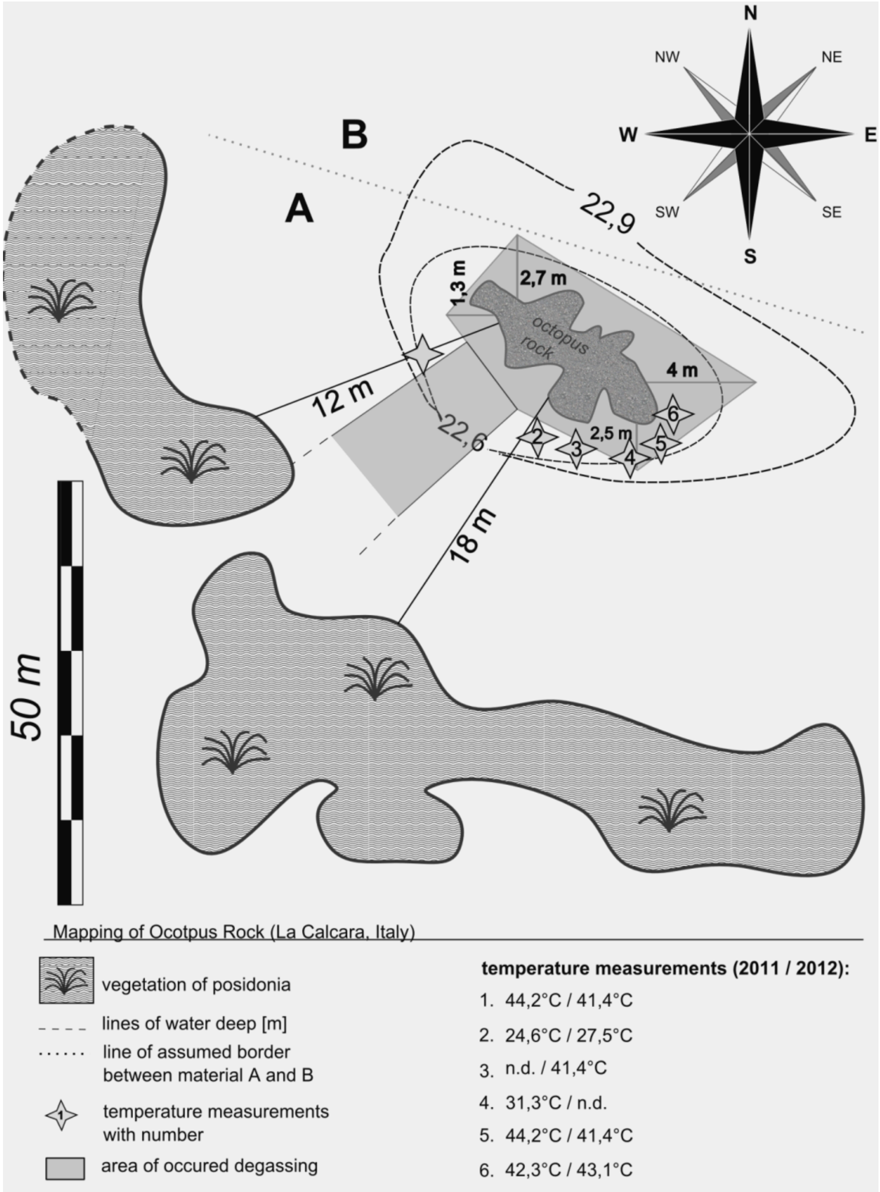

Fig. 4: Map of Octopus Rock with the morphological shape of Octopus Rock, the recognized softrock materials A and B, the temperature measurements, the distance to the posidonia vegetation, lines of water depth and the area where degassing occurred. The dark grey lines mark the distance between Octopus Rock and vegetation of posidonia. At Octopus Rock itself no active degassing was documented.

Compared to other diving locations in Panarea such as Bottaro West, Hot Lake, Point 21, Area 26, Black Point or Basiluzzo, La Calcara has different types of degassing structures. They are genetically influenced by gas- and water discharge and connected constructive processes. Unconsolidated cones and partly consolidated tubes are common. Mineral precipitates of sulfur-, iron- and other, still unidentified, compounds and substances occur (cf. STANULLA, 2012) in an altered softrock material.

In the future, the continuation of sampling in Area 26 (large area lateral sampling of volcanic glasses) and in La Calcara especially at Octopus Rock (improvement of sampling methods of softrock material) should be completed.

A detailed investigation with a microprobe of polished thin sections which contain a radial cut through a degassing tube should be targeted. Gaining information about oxidizing or reducing genetical conditions should be one main point of interest to evaluate the influences of microorganisms in hydrothermal systems with respect to sedimentary degassing structures.

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Long term monitoring of gas discharges at submarine fumaroles of Panarea, Italy

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Abstract. Against the background of predicting volcanic and tectonic activity, respectively, one possibility for prediction can be the monitoring of submarine volcanic gas emissions. Their intensity and composition is assumed to be an indicator for volcanic activities.

It is our goal to develop a device, suitable for long term measurements of the flow rate of submarine gas discharges. In recent years, several concepts have been tested by our research group, all with drawbacks. The main problems are the harsh conditions at the observation site such as low pH-values leading to strong corrosion and bacterial agglomerations at the test section.

So far, gas has been collected by a funnel and guided through a test section (Fig. 1 (a)) where the flow rate is measured. The whole device is called FSVG (**F**low Meter for **S**ubmarine **V**olcanic **G**as emissions). The flow rate is captured by two independent mechanisms. Firstly, by counting the revolutions of an impeller and second by measuring the thermal loss of the gas passing the test section. The longest measuring duration was about 3 months. The goal is to gain data for at least one year and furthermore to increase the measuring range, especially for lower flow rates at smaller fumaroles.

A new measuring principle will be presented, here, which will be suitable to measure smaller gas flow rates. It is based on the buoyancy which the discharged gas causes in a collecting container (Fig. 1 (b)). The lifting force is measured by a load scale and linear dependent on the flow rate. The gas finally leaves the container through slits whose size is adapted according to the strength of the fumarole. This way, smaller flow rates can be captured.

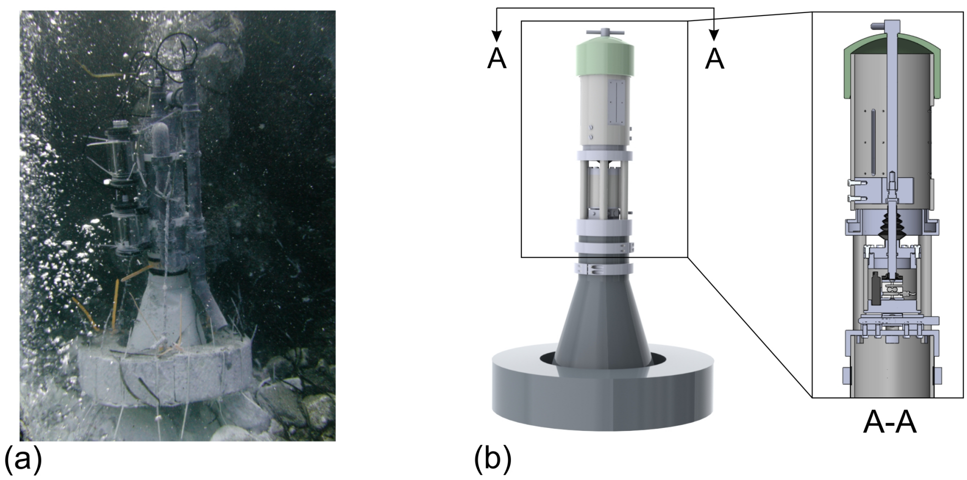

Fig. 1. (a) Recent FSVG mounted on top of a fumarole at Point 21, Panarea, Italy, (b) schematic of new FSVG.

Gas sampling of submarine fumaroles

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Abstract. Geochemical investigations of volcanic gases depend on the availability of complete and accurate analyses of volcanic exhalations. Sampling submarine fumaroles is much more complicated than sampling subaerial exhalations due to the surrounding water and the possible contamination by seawater, limited time etc. but offers some advantages as well. Three different sampling methods (air displacement in gas sampling tubes, Giggenbach bottles, sampling by large gas bags) were applied at submarine fumaroles of Panarea, Italy. Some results are presented.

Introduction

Volcanic gases are important indicators for magma beneath volcanoes. The release may be continuous or related to eruptions. On the first glance gas sampling under water appears to be more complicated and less favorable. But, certain advantages have to be seen as well: small volume gas discharge into ambient air is less likely to be detected than small gas volumes that discharge to a water body. Even massive gas discharge to ambient air is not easy to quantify; on contrary this is possible when gas discharge is submarine. However, disadvantages are that gas will dissolve physically into water and that working under water is a challenge intrinsically.

The Aeolian Archipelago, located in the Southeastern Tyrrhenian Sea north of Sicily, consists of seven main islands and several seamounts. The origin of the 460 km² large region is mainly volcanic (Capaccioni et al. 2007). The active subduction of the African continental plate under the Eurasian plate led to the formation of the Aeolian Archipelago and is responsible for the volcanic activity in this region (Dekov and Savelli 2004).

One of the volcanic islands is Panarea; together with several small islets it represents the remnants of a former crater rim (Esposito et al. 2006, Gabbianelli et al. 1990). Panarea’s hydrothermal system appears at the sea floor in form of numerous gas exhalation sites, hot water vents, and strongly elevated temperatures.

Field work has been organized by the scientific diving center (SDC) of TU Bergakademie Freiberg every year since 2006. Various spots with water depths between 8 and 30 m were investigated for geological and geothermal properties together with aspects of water chemistry and microbiology.

In the following selected results of different gas sampling campaigns applied in 2011 and 2012 are presented. Diving sites are described by Sieland et al. (2009).

Methodology

Sampling

In general, the fumarolic gases were collected on the sea bottom by means of a stainless steel funnel with a gas separating chamber (diameter 18.5 cm, height 40 cm, see Figure 1) which was put directly on the fumarole to capture the discharging gas. The Teflon quick connector at the top of the acryl glass gas separating chamber was used to tap the gas. For different analytical purposes three different sampling procedures were applied.

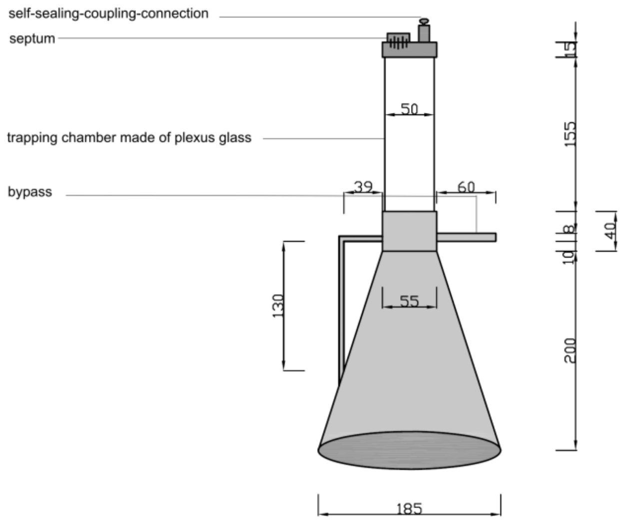

Figure 1. Stainless steel funnel for sampling of submarine fumarolic gases.

Sampling by gas sampling tubes

For the analysis of the major gas composition 40 mL gas sampling tubes with valves on both side made of glass were filled with fumarolic gas. Initially, the gas tubes were completely filled with distilled water in the field lab to remove any atmospheric air. The filled gas tubes were transported in a metal box during the dive. For sampling, the glass tubes were connected via a short Teflon hose to the stainless steel funnel. During sampling the distilled water is displaced and thus the glass tube filled with fumarolic gas (Figure 2a) according to the pressure of the sampling site. A sampling depth of e.g. 26 m will result in a total pressure of 3.6 bar which is well below the breaking point of the gas tubes.

Sampling by Giggenbach bottles

Sampling of volcanic gases into an evacuated chamber filled with an alkaline solution is a standard procedure (Giggenbach 1975) but is somewhat more difficult under water. In this case e.g. 0.3 L gas sampling tubes with valves on both side which were filled with 100 ml 4 M NaOH then evacuated and weighed have been used. At the sampling site the Giggenbach bottles were connected via a Teflon hose and the Teflon quick connection to the stainless steel funnel (see Figure 2b). But, very important is to replace seawater from the inlet connector of the glass gas sampling bottles by volcanic gas by using a syringe with a needle and tapping gas through the septum contained in the gas chamber of the funnel. Acidic gases (CO_2, SO_2, H_2S, HCl, and HF) react with the alkaline solution. Less reactive gases, such as N_2, O_2, CO, H_2, and He, remain mainly in the headspace. The amount of fumarolic gas that can be collected in a Giggenbach bottle is rater high, because volcanic gas is composed mostly of water and carbon dioxide (95 to 99% CO_2 in Panarea):

Figure 2. (a) Sampling by gas sampling tubes connected to a steel funnel. (b) Shaking Giggenbach bottle will gain faster equilibrium reaction of NaOH with fumarolic gas.

Sampling by a gas bag

Larger amounts of fumarolic gases are needed for the determination of the sulfur isotopic composition of hydrogen sulfide (delta^{34}S) or for determining aerosols, volatile metals, and metalloids in fumarolic gases (Merkel et al. 2011).

During the sampling campaign from 2006 – 2010 the gas was conducted upwards to the sea surface via a 50 m long hose and filled in a 80 L gas bag on the boat (Merkel et al. 2011). The main disadvantage of this method is that condensation of water vapor occurs within the hose due to depressurization and cooling of the gas during the ascent to the water surface.

Since 2011, the sampling procedure was adapted by filling a 40 L gas bag (Kynar, SKC) directly under water. To fix the gas bag under water as close as possible to the fumarole to be sampled the bag was enclosed in a net which is connected with a number of weights. The necessary amount of weight is calculated prior to the dive by the expected water depth from which the gas sample is to be taken and the maximum volume (and potential lift) of the gas bag. This volume should never be exceeded to avoid the destruction of the gas bag by expansion during the ascent to the sea surface. To avoid a contamination of the gas sample with seawater due to turbulent gas flow, the funnel is not directly connected with the gas bag but via a gas sampling tube as water trap. In this water trap the velocity of the gas flow abruptly decreases and water droplets which might be carried in the gas flow will adhere on the walls of the tube. When the gas bag is filled to equalize the attached weights by buoyancy sampling is interrupted immediately. The gas sample is then dispatched by its own buoyancy along a finger spool or spool reel to the surface (Figure 3b).

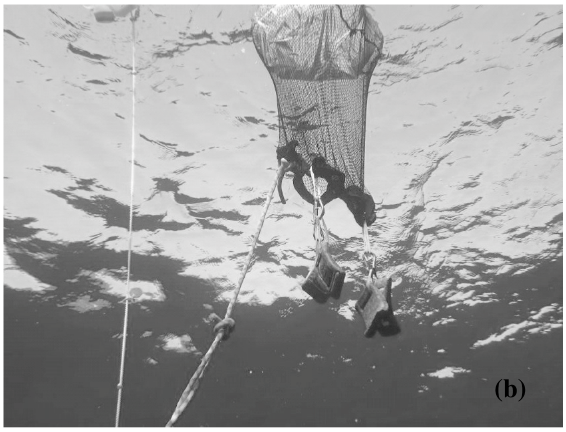

Figure 3. (a) The 40 L gas bag, secured in a plastic net, is connected to a glass tube for gas/water separation and the stainless steel funnel for gas collection from the fumarole. (b) Filled gas bag with weights after ascension to the water surface.

Analytical Methods

The composition of the gases was determined by using a Thermo Scientific Trace GC Ultra gas-phase chromatograph with helium and nitrogen as carrier gases. In order to evaluate the concentrations of CO_2, N_2, and O_2, a thermal conductivity detector was used while the CH_4, and C_2H_4/C_2H_6 concentrations were determined by flame ionization detector. Argon was measured by GC-MS. Table 1 shows the determined gases, as well as some instrumental parameters.

The detection limits were about 0.01 vol.% for CO_2, N_2, O_2, 0.005 vol.% for He and H_2, and 0.00001 vol.% for CH_4 and C_2H_4.

Table 1. Instrumental parameters used for the determination of the gaseous composition.

	CO_2, N_2, O_2	H_2, He	CH_4, C_2H_4/C_2H_6	Ar
instrument	Trace Ultra GC	Trace Ultra GC	Trace Ultra GC	Trace Ultra GC
column	ShinCarbon column (2 m x 1 mm)		AT-Q (30 m x 0.32 mm)	TG-5MS (30 m x 0.25 mm x 0.25 μm + 5 m guard)
carrier gas	He	N_2	N_2	He
detector	TCD	TCD	FID	MS

The H_2S and CO content was determined in the field by using Dräger tubes. The acidic gases in solution were analyzed by ion chromatography (Metrohm 881 Compact IC Pro) for F^-, Cl^-, Br^-, NO_3^-, SO_3^{2-}, PO_4^{3-}, SO_4^{2-}, $S_2O_3^{2-}$, SCN^-, and S^{2-} and by TIC analysator (LiquiTOC elemental analyzer, Elementaranalysen Systeme GmbH) for TIC. The amount of H_2O was then calculated by taking the difference between the weight gained and the weight of all other gaseous species (Giggenbach 1975).

Volatile trace elements and aerosols were trapped according to the method described by Merkel et al. (2011) and analyzed by ICP-MS (Thermo Fischer XSeries 2).

Results

The concentration of volcanic gases varies considerably from one volcano to the other. Water vapor is typically the most abundant gas, followed by carbon dioxide and sulfur dioxide. However, in the submarine fumaroles of Panarea water vapor is mostly scavenged by seawater and cooling (Merkel et al. 2011) and thus, CO_2 is the most abundant gas. The analytical results of the gaseous samples are listed in Table 2. The gases generally show a CO_2 concentration greater than 80 vol.%. The H_2S ranges between 0 and 4.4 vol.%. According to Husain and Krouse (1978) the interaction of gases like H_2S with marine sulfates and with dissolved oxygen in seawater, leads to white snow-like colloidal sulfur which occurred at most of the sampling locations.

Methane is always present, ranging between 1 and 7200 vol.ppm. 62.5% of the samples show H_2 concentrations below the detection limit (50 vol.ppm), in some samples H_2 was detected up to 1400 vol.ppm. Helium ranges between < 50 and 160 vol.ppm.

Table 2. Composition of fumarolic gases sampled in Panarea in 2011 and 2012. CO_2, H_2S, N_2 and O_2 are expressed in vol.%; H_2, He, CH_4, CO and C_2H_5 in vol.ppm.

Sample	Year	CO_2	H_2S	N_2	O_2	H_2	He	CH_4	CO	C_2H_5
P21	2011	93.9	3.4	0.23	0.10	25	25	135	80	0.05
B(N)	2011	89.4	4.3	0.51	0.15	25	111	1	76	0.05
P21(cold)	2011	93.8	2.4	0.01	0.01	25	148	189	62	0.05
CAL	2011	96.9	0.0	0.79	0.20	25	25	7162		32.8
HL(F)	2011	95.0	2.3	0.08	0.05	763	62	4	50	0.05
B(W)	2011	94.3	1.3	0.02	0.02	25	159	33	40	0.05
CAL	2011	95.9	0.3	0.38	0.14	1308	68	4099	1	19.4
CAL(ter)	2011	72.7	0.0	16.7	5.46	1067	108	3393	1	13.1
BP	2011	95.8	0.5	0.31	0.09	25	25	974	1	0.05
P21	2012	85.9	1.8	5.86	2.39	25	25	218	25	1.00
BP	2012	94.4	0.5	2.59	0.80	410	25	1035	1	5.10
BP	2012	100	0.7	2.24	0.60	70	25	761	1	5.10
B(N)	2012	93.5	4.4	2.03	0.60	25	25	1	100	1.70
B(W)	2012	99.0	0.7	1.64	0.44	25	25	38	5	0.05
P21	2012	80.8	2.5	2.51	0.64	25	25	171	67.5	2.50
HL(F)	2012	85.7	2.6	4.05	1.01	185	25	13	56	0.05
CAL	2012	94.3	0.2	3.08	0.82	1398	25	4458	1	20.9
CAL	2012	74.6	0.2	19.1	5.47	702	25	4683	1	20.0
Average values of gas samples from 2011 – 2012										
Median		94.1	1.01	1.83	0.518	25	25	204	32.5	1.35
Min		72.7	0	0.005	0.01	25	25	1	1	0.05
Max		100	4.4	19.1	5.47	1398	159	7162	100	32.8
Average values of gas samples from 2006 – 2010										
Median		77.5	1.5	15.7	4.56	n.d.	n.d.	200	42.5	2.2
Min		26.8	0	10.1	2.54	n.d.	n.d.	0.928	1	0.05
Max		87.0	4	58.1	15.4	n.d.	n.d.	1540	80	17

n.d. – not detected

The lack of oxygen and the N_2 concentration ranging from 0.025 to 19.1 vol.%, imply that the oxygen was consumed by redox reactions or the N_2 has a different origin than from atmospheric air (Italiano and Nuccio 1991).

Comparing data from 2011/2012 with data from 2006-2010, some differences are obvious: For CO_2 the median increased from 77.5 vol.% to 94.1 vol.%, while for N_2 and for O_2 a decrease from 15.7 vol.% (min 10.1 vol.%, max 58.1 vol.%) to 1.83 vol.% (min < 0.005 vol.%, max 19.1), respectively 4.56 vol.% (min 2.54 vol.%, max 15.4 vol.%) to 0.52 vol.% (min < 0.005 vol.%, max 5.47 vol.%) was detected. Minor gas components like CH_4 show larger differences in min-max-values (max 2006-2010 1540 vol.ppm, max 2011-2012 7161 vol.ppm), while median concentrations remain similar. The decrease of atmospheric constituents and the increase of hydrothermal gas concentrations can be a hint for a possible contamination with atmospheric air during sampling in 2006 - 2010. The direct sampling in a gas sampling tube during the dive and the method of water displacement is a good way to prevent atmospheric contamination.

For H_2S no significant changes were determined, in both periods concentrations were measured in a range of 0 to 4.4 vol.% (median 2006 – 2010 1.5 vol.%, median 2011 – 2012 1.01 vol.%). CO shows a similar behavior: We observed a median of 42.5 vol.ppm (2006-2010) and 32.5 vol.ppm (2011-2012), respectively. This might be due to the fact that investigations with Dräger tubes had been carried out in the field lab by using the large gas bag. Thus, there was only a small change in the sampling procedure (gas bag below / above water surface), but no difference in the treatment of the sample and the following analysis.

Discussion

The gained results from 2011 and 2012 demonstrate the complexity of gas sampling in submarine hydrothermal systems. Advantages and disadvantages of the described methods are shown in Table 3. Solely sampling of large amounts of gas in a large gas bag, and performing a number of analytics on this sample (Giggenbach, NaOCl trapping) is not adequate due to possible contamination with atmospheric air during sample transfer.

Table 3. Advantages and disadvantages of certain gas sampling techniques

Method	Pro's	Con's
Gas sampling tube	▪ no field treatment necessary ▪ applicable for small gas vents (low gas volume needed) ▪ no atmospheric contamination	▪ fragile material
Giggenbach bottle	▪ no field treatment after sampling ▪ condensable, acid gases will be trapped + enrichment of non-soluble gases in the headspace → better analytical precision	▪ fragile material ▪ time consuming to reach equilibrium
Gas bag under water	▪ large sample volume in one dive (necessary for isotopic analyses)	▪ buoyancy → experienced divers necessary
Gas bag on the sea surface/boat	▪ large sample volume in one dive (necessary for isotopic analyses and volatile trace metal enrichment)	▪ distance of sampling location and boat is essential, limited due to the length of the hose ▪ non-tightness of the automatic hose couplers → entering of sea water ▪ condensation processes in the hose during the long way to the gas bag

The amount of gas needed for gas-phase chromatography is very small, thus, using gas sampling tubes seems to be the most effective method. By displacing water with fumarolic gas, atmospheric contamination can be excluded.

Larger amounts of gas can be sampled with the help of Giggenbach bottles. Contamination by seawater can be avoided by a well-considered working procedure. Regarding isotopic analysis and sampling for volatile trace metals, the use of a large gas bag can be recommended. Direct sampling under water can be performed within few minutes and avoids condensation processes during the uplift of the gas. If condensate is observed in the preceding gas sampling tube or in the gas bag, it can be analyzed by ion chromatography or ICP-MS to check whether its origin is water vapor from the hydrothermal gas or seawater.

Additionally in-situ long-term measurement of certain gases is recommended, as sampling and following laboratory analyses are costly and not sufficient with respect to sampling intervals (Schipek and Merkel 2011).

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Session 3

Education, Techniques and Legal Aspects

DOBB: water sampling device for SCUBA divers to obtain in situ data

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Abstract. Multiple ways to collect water samples for the determination of certain parameters e.g. oxygen content or pH-value have been introduced over the years. However, all of them were not manageable enough to take samples from distinct microhabitats, such as boundary layers. The easily to manufacture and inexpensive DOBB (Double bottles without Bottoms after Brümmer) allow the collection of water samples by SCUBA divers without the disturbance of surrounding water or bottom sediments and, at the same time, obtaining a visual impression of the in situ situation with. Even fragile samples like medusa or mucous aggregates can be collected in a non-destructive manner.

Introduction

Within the field of limnology and oceanography several established methods to take water samples are in use of some sort of bottle with a closing and opening device attached to a rope to determine depth as well as the possibility to retrieve the apparatus. Such free-flow samplers were developed with different levels of complexity such as the Ruttner, Meyer or Van Dorn water sampler (Clark et al. 1967; Finucane and May 1961).

From early on, water samplers were also designed to obtain "sterile" samples to enable microbial studies and to avoid any type of contamination (Folsom and Jennings 1962; Kriss 1963; Niskin 1962). Several different designs allow to obtain multiple replications at once (such as Rosette or CDT samplers) or large volumes (Gerard and Ewing 1962). The requirement to analyse and integrate water samples from a defined water column, as requested by the European Water Framework Directive (LAWA 1998), lead to the development of electronically controlled sampling bottles that take exact volumes of water throughout a given depth, a so called integrating water sampler (Hydro-Bios 2006). Most of these devices have to deal with the problem of creating a swirl, hence, changing, for example, the real oxygen concentration. Most of these water samples are taken from boat or ashore (Bayes and Ansell 1964), providing samples from a known depth but without knowledge of how the surrounding looks like. Taking into account the patchiness of most phenomena this is a major drawback. Moreover, samples from close to an organism or bottom cannot be taken without the possibility of disturbing the organism or sampling sediment as well. Limits are about one meter above the bottom (Edwards and Richards 1956).

SCUBA divers can, however, take samples in accurate microhabitat or the biocoenosis surroundings. Such microhabitats of interest can include but are not exclusively for example the surrounding waters of filter feeding organisms, such as mussles, sponges or corals. Samples can be taken without disturbing the organisms and still getting information on biotic and abiotic factors. In addition, samples can be taken on a centimeter scale if the water of interest is a defined layer of a chemocline, such as sulfur bacteria or ciliates (Peduzzi et al. 2003; Stöck et al. 2007; Tonolla et al. 2003) or just above the sediment. Furthermore, divers can take samples in water bodies where the use of a boat, for example, is not practicable, and they can specifically take samples of desired subsamples of patchy phenomena like e.g. mucous aggregates.

Due to the necessity to obtain samples within small boundaries of layers and organisms the double bottles without bottoms after Brümmer (DOBB) were designed and manufactured.

Materials & Methods

Manufacturing of DOBB

The manufacturing of DOBB allows the use of inexpensive and accurate water sampler. The bottoms of two conventional glass laboratory bottles (e.g. Schott-DURAN) have to be sawed off and the two bottles are being melted together at the bottoms (Fig. 1). Care has to be given to the volume of the bottles. The screw caps can be both used with "normal" single bottles. DURAN-labglass is especially suited for SCUBA dives into deeper depths as it can well withstand the ambient pressure. Furthermore, the bottles can be autoclaved or even sterilized, depending on the type of bottle. Additional advantages are the transparency of the bottles, allowing for immediate visual control of the sample, as well as the fact that the bottles can be easily written on.

Sampling method

The bottles can be filled with water at the surface, to be able to open them under pressure at depth. If the bottles have to be sterile for microbial or other analyses, they have to be filled with sterile water before hand, or can be transported empty, however, opening them might become more difficult. After the descending, the SCUBA diver has to find his buoyancy to stay motionless at the desired depth. Here, the two lids are unscrewed and the bottle has to be drawn vertically through the water with slow movements (Fig. 1). If the bottles were filled with surface water, the diver has to empty the bottles at a slightly different spot with the same movements and then take the samples at the desired area. Both lids have to be tightened carefully and the bottle can be placed in a collection bag.

Discussion

DOBB were tested and used in multiple aquatic, freshwater as well as marine research projects.

They were used for water samples in fresh and seawater for analysis of abiotic parameters such as nitrate, nitrite, sulfates, phosphates and oxygen. Samples were easily taken at multiple, distinct depths throughout the water column. As SCUBA divers were able to examine the sampled area, additional samples were taken situational, for example, close to the bottom in small, deeper holes with differing aerobic conditions etc. (Klöppel et al. 2009). A better, more fine-scaled picture of the situation was possible to obtain, by collecting also by sight not only by depth. Although samples have to be taken at larger intervals than with electronic sensory devices, the cost and efficiency are much greater.

DOBBs were used for plankton samples surrounding a filter feeding sponge to determine potential food present in situ. Samples could be taken very close to the filter feeding sponge, as well as in the more distant surrounding water, enhancing the insight in potentially present plankton and comparing the results to the actually present food items within the sponges (Pfannkuchen et al. 2009a; Pfannkuchen et al. 2009b). Due to the extreme patchiness of planktonic organisms, such as potential food items for sponges, water samples had to be taken from the close vicinity of the sponges. DOBB allowed collecting water around the sponge and even to distinguish between the intake and output water, near the ostia and the osculum, respectively (Fig. 1).

Samples for molecular analysis of bacterial components (Fritz et al. 2012) as well as samples of boundary layers for identification of associated organisms such as ciliates in or near the chemocline of Lake Alat (Stöck et al. 2007) were taken using DOBBs. The very dense bacteria layer in Lake Alat, Bavaria, Germany, occurs in varying depths depending on season. The use of DOBB allowed SCUBA divers to take precise samples from within the layer, below and above. With such samples the analyses of the species compositions in small boundary layers above the chemocline allowed the identification of a possibly new species of ciliates.

DOBBs were used to take samples of delicate planktonic organisms such as the freshwater medusa *Craspedacusta sowerbii* (Fritz et al., 2007; Fritz et al., 2009). The freshwater jellyfish is a small, delicate medusa, drifting in the open water column of lakes. Even minor water disturbances cause the medusae to drift away, in the worst case, even to get damaged. Due to the swirl-free use of DOBB, the jellyfish could be collected without disturbance.

Selective sampling of special habitats and their inhabitants such as, for example, the water surface to sample mare sporco or organisms such as *Vellela* sp. is possible with DOBB as well as sampling surface layers for neuston such as mare sporco, adding no parts from the surrounding area.

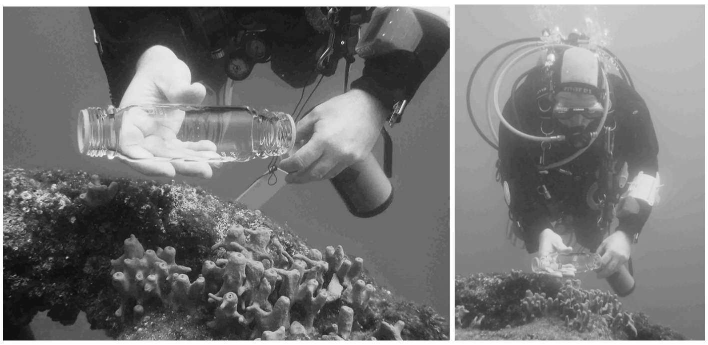

Fig. 1. Sampling surrounding water of a pumping sponge, *Aplysina aerophoba* (M. Pfannkuchen)

Gas bubbles from methane sources were collected using DOBB. Opening only one lid allows also the sampling of gas such as methane from underwater sources such as the Bromboli, Rovinj, Croatia.

DOBB bottles have proven themselves to be very useful, accurate and easy to handle water samplers for many different research projects. Sampling delicate objects from the water column proved to be easy and non-destructive in the case of freshwater medusae and mucous aggregates. The specifically interesting boundary layers between adjacent water bodies can be sampled by divers under visual observation and without the artifacts produced by negative pressure, suction pressure and whirling.

The use of DOBB has several distinct advantages. Besides the possibility to take water samples in close vicinity to, for example, organisms and sediments in well-defined depths, different sized bottles can be used to adjust to required volume sampled. Other methods used by SCUBA divers, like using syringes to obtain close by water samples, are less easy to handle and to store. In addition, sterile sampling is possible for analysis of microorganisms, such as bacteria, as well as inorganic contents, such as nutrients. The bottles can be autoclaved or sterilized to avoid trace contaminations. A clear advantage is the low cost of DOBB. Maybe matched by easy-to-use, easy-to-obtain devices such as simple champagne bottles with a cork (Klee, 1998), these devices, however, cannot be sterilized, and samples are less secured and much more imprecise.

Disadvantages include, most of all, the depth and time limitations of SCUBA divers, which should not exceed 40 m for air breathing divers following the guidelines of the Confédèration Modiale Acitivité Subaquatique (CMAS), but can be extended when diving with gas mixtures. The retrieve of the samples back to the surface and further handling can be also facing time constraints due to diving protocol. For example, in stratified lakes, temperature may increase due to the slow ascend of SCUBA divers to prevent decompression sickness. However, additional methods, such as a retrieving rope, might solve this problem. Multiple replications, easily taken with other water samplers, are possible by using multiple bottles, but are time consuming and work intensive. In addition, samples taken at precise depths are of course depending on the diving skills of the researcher. During sampling the SCUBA diver cannot lose buoyancy or samples are not accurately taken. Collecting close to substrate or organisms also requires enhanced diving skills as no substrate must be raised and dispersed, and organisms must not be disturbed. Therefore, accurate sampling depends highly on well-trained SCUBA divers.

In summary, although the use of DOBB is only limited by the constraints of the SCUBA diving technique, they are valuable water and organisms samplers within these limitations. They can be used for a multitude of aquatic research projects, are easy to handle and a rather inexpensive water sampler device.

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Efficiency and reliability of eCC Rebreathers for the underwater scientific research beneath the pack-ice

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Abstract. During the Antarctic summer season 2012/13, for the first time (at least within the Italian National Programme of Researc in Antarctica – PNRA) the efficiency and reliability of electronic Closed Circuit Rebreathers (eCCRs) were tested in a series of shallow ice-dives beneath the pack-ice.

At the beginning of November 2012, nine dives were performed, in three different days, by two divers having on Ambient Pressure "Evolution Plus" machines with the latest release of the Vision Electronics.

Test site was the Tethys bay, a small cove behind the Italian base "Mario Zucchelli station" (Ross Sea, Victoria Land, 74° 41' 42" S – 164° 07' 23" E) usually covered by a thick layer of sea-ice (up to 3 metres) until late December, where PNRA performs underwater activities to support scientific research since 1987.

This year the thickness of ice was a little reduced (about 2.20 metres) although still sufficient to allow the construction of the landing airstrip for the PNRA C-130 Hercules.

During the days of the test, the air temperature ranged approximately between -15 and -20 °C and the water temperature was -1.88 °C.

Under the pack-ice there was a layer of platelet-ice more than half a meter thick which, constantly filling the hole in the ice, made the access operations to the surface of the divers more difficult.
In the water both eCCR worked properly whitout presenting any malfunction and no alarm (both visual and acustic) was never put into operation.

Before diving, at the beginning of pre-breathing, on some occasion the temp stick indicator in the display warned the possible phenomenon of gas channeling inside the scrubber that then disappeared when the sofnolime filter reached the operating temperature.

In general, the pre-breathing lasted few minutes more respect to temperate climates (overall 7-8 minutes).
From the point o view of the functionality, the polar diving with the eCCR presented a significant superiority compared to the open circuit, above all with regard to the thermal comfort of the diver that was expressed in more operational capabilities.

Furthermore, the eCCR is able to provide greater safety in icy waters since it is less subject to the risk of free flow; and the whole system is based on the redundancy of an additional stage tank (or more) that allowed the diver to switch to open circuit very, very quickly.
The eCCRs are generally used for very deep dives in temperate waters but this first experience beneath the Antarctic pack-ice showed that they will have a great use to move forward the boundaries of explorations and underwater scientific research in the extreme polar seas.

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Teaching shallow-water research

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Abstract. Already before the invention of modern diving equipment marine scientists tried to get a hands-on experience of their study subject and used the scaphanders of sponge divers to immerse themselves into the sea. 20th century pioneers in the field like Hans Hass, Jacques-Yves Cousteau and others boosted the knowledge of shallow-water habitats and with their spirit created a generation of followers who with the technique of the self-contained underwater breathing apparatus (SCUBA) founded "schools" in their disciplines with many dozens of students as scientific offspring. Names like e.g. the Goreau family in the US and the Caribbean, Rupert Riedl in Austria, Francesco Cinelli in Italy or Helmut Schuhmacher and Hans W. Fricke in Germany, and their respective working groups are linked to a wealth of publications and have shaped the scientific image of the coastal underwater world as we see it today. The boom of sports diving and the availability of standardized and safe SCUBA equipment in the late 1980s and early 1990s led to a wider acceptance of SCUBA as a regular tool for underwater research. Along with this there arose an increasing demand in training for scientific diving.

In 1995 the HYDRA Institute for Marine Sciences was founded with a field station on the Italian island of Elba and one of the first field courses offered was a class called "Methods of Underwater Research". The aim has been ever since to provide the student or young scientist with a flexible and accessible training program to apply the technique of SCUBA diving to scientific issues under three main themes: safety, scientific efficiency and feasibility.

Given the short time of an only 10-days field course the pre-requisites for the participants besides their medical aptitude are that they have already a basic knowledge of SCUBA diving (1-star certification or equivalent). Second there is the limitation of the environmental conditions to warmer water (18°C), good visibility (10 m or more), and moderate depth (5 to 12 m for work and 18 m for observation only). In addition the tasks are of increasing complexity from day to day, and the gradual approach is accompanied by a tight supervision by the instructors.

The course is structured in three daily units: a seminar with lectures, a practical part on land and an underwater training unit. In the first days the main goal is to form a team where the members are responsible for each other and for the task. With simple tasks in very shallow water the students are directed from a leisure-oriented sports diving approach to task-oriented scientific diving. It is the challenge for the team to plan and execute the dive in order to bring the participants safely in the water, to successfully fulfill a task and comfortably get back out again. In the following days the students learn and experience some techniques and modes of diving that are different from commonly taught sports diving. Revising the safety measures after each training unit makes the students evaluate the limitations of the method in general and their current knowledge in special. Along with certain techniques for sampling, measuring and documentation under water the students learn how to plan, prepare, execute and successfully accomplish an underwater project: In the planning phase the safety aspect is the leading element. With a risk assessment students learn to integrate

potential hazards from external and intrinsic factors, to accordingly minimize risks or find alternative methods. The technical aspects comprise both diving and scientific equipment, whose functionality is crucial for the success of the project. One important goal is to encourage students to find simple feasible solutions for underwater tasks.

Also the scientific aspect plays an ever-increasing role during the course. After the introduction to the topic by the tutors the students should ask the right question, develop a method to answer it, and check the feasibility of the method or the planned workload per diver per dive. During the preparation phase the students set up the dive team, divide tasks, prepare check-lists and coordinate the divers with a dive plan, or a set of possible scenarios. The execution of the dive should follow the chosen scenario, with all means of communication, documentation and supervision as planned. Upon the accomplishment of the dives, be it with a regular or irregular termination, there follows the equipment maintenance and data saving process, and an intense de-briefing (risk assessment, equipment, team, tasks, feasibility). In this mode the class usually after 5 to 6 days is ready for a small 2 – 3 day research project, which is introduced by the faculty and then planned by the class.

Since 1996 there have been projects that thanks to the great number of coordinated dives allowed for the coverage of large areas (mapping of the dispersal of the invasive green alga *Caulerpa taxifolia* over several km of coastline), or the continuous recording of the activity of animals (24 h activity patterns of sympatric species of the starfish *Astropecten*), or the en-detail exploration of special habitats (shallow-water gas seeps, habitats of chemosynthetic clams and worms) within short time. To see the outcome of a coordinated project of only a few days after a thorough training in a joint teamwork is one of the most satisfying experiences for the students.

The drawback of this kind of course is mainly the selectivity in topics and methods, because of its limited time. It does not allow for in-depth training of specific skills, like e.g. underwater photography or visual census methods. Being one of the few courses of this kind at all it still gives access to a wide range of aspects with large hands-on experience with close reference to various projects through experienced faculty (> 100 underwater projects in 20 years). Even to the advanced students the gradual approach allows for a steep learning curve and the team building and discussions serve as a good reference for own skills. The group learns from mistakes of all the group members and can improve together. The main advantage of this class is that the participant learns how to safely plan and execute a small project within the limits of his/her scientific diving knowledge.

For many of the approximately 200 participants of the last 17 years the course of "Methods of underwater research" was a kick-start of their scientific diving career. Alumni of this class later on reported on projects in literally all aquatic habitats of the planet, some joined more advanced training at other institutions or could integrate their experience into their own teaching, or even founded a field station themselves.

This kind of course gives a great opportunity to learn the basic concept of shallow-water research. It provides an important experience to valuate the limits of what you can do and what you cannot do and it is a good starting point for more specific training (e.g. deeper depths, cold-water, low-visibility, high-current, confined environments, mixed-gas diving, leading a scientific diving team).

The concept of education and training at the Scientific Diving Center of the TU Bergakademie Freiberg

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Abstract. Working as a scientist under water poses a certain risk similar to e.g. working in a mine or an alpine rock face. Therefore, in such cases scientists need a special training and certain rules of safety have to be implemented by the employer. In the first part of this extended abstract, legal aspects, especially for Germany, are shortly discussed. In the second part the educational concept of the Scientific Diving Center of TU Bergakademie Freiberg is explained.

Risk and legal aspects

Risks related to scientific diving are comparable to risks related to working in a laboratory or working in a mine. In contrast to working in an office there is an inherent risk for accidents with small or severe injuries (invalidity or death as worst case) to the respective person or to other persons. In addition to this risk the private and legal liability for causing harm to third parties or by directing or tolerating the scientific underwater work of employers, trainees, or students has to be considered.

As long as the acting person (e.g. a diver) is a private person he/she may cover the risk by a private insurance for accidents, invalidity, death, and liability. However, the situation is different for employees, trainees, and students of enterprises, universities, schools and research institutes. In this case one has to distinguish between those who work actively/directly (e.g. diving for scientific purposes) and those who direct the activities (both education and/or research) and tolerate it, respectively.

It is commonly accepted that risks (e.g. for working in a laboratory or a mining environment) that may endanger workers and employers can be minimized by implementing certain rules of safety. These rules must be known and be accepted by all participating or involved persons and one person has to be responsible that these rules are observed properly.

In Germany,”Berufsgenossenschaften“ are repositories of the legal accident insurance (“gesetzliche Unfallversicherung”). They enact rules according to §15 of the “Siebtes Buch des Sozialgesetzbuchs” (SGB VII) (“Berufsgenossenschaftliche Vorschriften”, BGV), which have to be approved by the Federal Ministry of Work and Social Affairs (“Bundesministerium für Arbeit und Soziales”).

The legal accident insurance autonomously issues accident prevention regulations related to working conditions for all kinds of employers. These regulations have force of law. Employers may deviate if alternative regulations are documented and comparable. However, an interesting question is who defines and thus writes these regulations in particular for rather exotic working conditions such as scientific work under water? The problem exists because the legal accident insurance does have neither specialists nor experience with work and risk assessment in this field. So far in Germany no clear legislative regulations do exist with respect to this issue of legitimation to set up regulations related to working conditions in these cases. Independent from this question the GUV-R 2112 is the recent German accident prevention regulation for scientific diving.

Since the end of the 80s regulations are issued by the European Commission defining minimal standards of working safety in Europe. Member countries have to implement these regulations in national law within a certain time without violating minimum requirements. The most important directive is the EU framework directive 89/391/EWG of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. This directive was supplemented by the EU directive 2007/30/EG and the revision of 89/391/EWG from June 20, 2007.

Globally, accident prevention regulations are being harmonized step by step. In particular global players are often certified according to ISO 18001 OSHAS (Occupational Health and Safety Assessment Series). In general Commonwealth countries and North America have the highest requirements due to their penal and private law.

Companies and NGOs worldwide recognize the need to control and improve health and safety performance. This can be achieved with occupational health and safety management systems (OHSMS). However, proliferation of national standards and proprietary certification schemes cause confusion and fragmentation, and undermine the credibility of each individual scheme.

Educational and scientific concept for scientific work under water

Professional diving means that divers are paid for their work. Branches of professional diving are

- Commercial diving with many branches
- Military diving
- Policy diving
- Scientific diving (e.g. archaeology, biology, microbiology, geology, hydrogeology)
- Media diving
- Diving instructors

All branches require a rather different education of the diver and rules of safety depending on the work to be done under water. In the following only aspects of scientific diving are addressed.

In many cases of scientific work under water in freshwater and marine environments recreational diving education, recreational diving equipment and recreational diving regulations are a feasible basis of further training of scientific divers.

The scientific diving center (SDC) of the Technische Universität Bergakademie Freiberg (TUBAF) (http://www.sdc.tu-freiberg.de/de) therefore requires a two star diving education according to VDST (CMAS) or equivalent education as entry level. Based on these diving skills two courses are offered: Scientific Diving I and II. Each module is equivalent to 4 ECTS credits.

The module Scientific Diving I comprises 30 hours of lectures and 60 hours of practical exercises covering different tasks such as:

- Documentation (photography, video documentation, mapping),
- Mapping (surveying with the help of different tools, GPS mapping, transects),
- Use of lift bags,
- Sampling (gas, water, sediment, biota),
- In-situ measurements (temperature, electrical conductivity, measurements with a multi-parameter probe),
- Drilling to obtain cores
- Communication (hand signals, text communication),
- Use of different knots,
- Diving safety (use of decompression buoys, rescue and transport exercises)

Furthermore, Scientific Diving I comprises a minimum of 4 days of scientific diving exercises in lakes.

Scientific diving II is a 10- to 14-days diving field trip in marine environment where the students have to work under water in a buddy team on a certain scientific problem under the supervision of a scientist and a scientific diving instructor. After they have completed these two modules successfully they are certified Scientific Divers according to CMAS International.

The CMAS standard for scientific divers is a minimum requirement integrated in the Regulations for Scientific Diving ("Arbeitsschutzanweisung") of the SDC of the TUBAF. These regulations of the TUBAF are an accepted alternative to GUV-R 2112. Furthermore, because the standards of the European Scientific Diving Panel (ESDP) are identical to the CMAS standard for scientific divers, the regulations of the SDC of the TUBAF are as well in agreement with the ESDP standards.

Scientific divers having a certain record of scientific experience can be certified as well as advanced Scientific Divers according to CMAS. In addition to these two certifications the SDC of the TUBAF offers special training such as diving with NITROX, Trimix, full-face mask including voice communication, or diving with a rope (line signals). This modular concept allows for effective specific and individual project-related training.

Multi-disciplinary diving-based science: recent research supported by the UK National Facility for Scientific Diving

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Abstract. The UK Natural Environment Research Council funds National Facilities that provide specialist equipment or services in support of high-quality science programmes. Scientific Diving has been funded as a UK National Facility since 2003; during that time it has developed a growing portfolio of projects that, although united in its use of diving as a research tool, is diverse in terms of the scientific disciplines supported. This account provides an overview of the funding mechanism that facilitates the overall delivery of the national service while highlighting some of the recent science that has been supported.

Introduction

The Natural Environment Research Council (NERC) is the UK's main agency for funding and managing research, training and knowledge exchange in the environmental sciences. NERC's work covers the full range of atmospheric, Earth, biological, terrestrial and aquatic science, from the deep oceans to the upper atmosphere and from the poles to the equator. NERC maintains an extensive portfolio of Services and Facilities which support environmental science. These Services and Facilities are diverse, including the NERC aircraft, several Earth observation capabilities and numerous specialist laboratories. NERC invests in facilities for several reasons: cost effectiveness through collective negotiation; some of the facilities are unique; some facilities have a large capital investment, such as the aircraft, that would not otherwise be possible; provides training to PhD students and Early Stage Researchers; and maintains capability and reduces the risk associated with uneven demand.

The NERC Facility for Scientific Diving was instigated in 2001; initially it was funded on an *ad-hoc* basis with annual review but from 2003 onwards has been supported by 5- or 6-year grants. Each review process is undertaken by an independent Services Review Group and is open to competitive tender. Since its inception, the NFSD has been hosted at the Scottish Association for Marine Science (SAMS), near Oban in Scotland. The NFSD provides divers, equipment, training and scientific/technical support that underpins a wide range of interdisciplinary research in the underwater environment. The primary level of service delivers practical support for diving-related underwater scientific projects through providing additional manpower for groups with limited diving experience, total project management for scientists with no diving experience and/or specialist equipment loans for groups with diving experience but limited resources. On a secondary level, the Facility undertakes to ensure proper adherence to Health and Safety legislation as applied to diving at work activities (Sayer 2004; Sayer and Forbes 2007). This can be through targeted training programmes, communicating advice and guidance for senior management with legal responsibilities for diving at work, undertaking safety audits on behalf of the NERC Health and Safety management structure and facilitating a wider interactive dialogue with others in the higher education field and the Health and Safety Executive. The NFSD is the main service provider and the major supporter of research within the UK that involves scientific diving through: support and maintenance of an extensive underwater research programme; support for the UK Scientific Diving Supervisory Committee (SDSC); interactions with other diving industry bodies; ongoing diving research and evaluation programmes; and a focussed training programme for scientists and technicians involved with working underwater. In addition to diving services per se, the NFSD also provides support and training in associated small boat operations and in emergency diving medicine (e.g. Wilson and Sayer 2008; Sayer et al. 2008; Ross and Sayer 2009; Sayer et al. 2009; Wilson et al. 2009; Wilson and Sayer 2011).

The science programmes supported by the NFSD are granted following an ongoing peer-reviewed proposal procedure. Peer-review is through an invited Steering Committee and the proposals are ranked on the basis of scientific excellence. A minimum grading (7 from a full scale of 10) must be obtained prior to entering the ranking process; only at this stage is the feasibility of the diving operations required to support the science evaluated. The final decision on which programmes are supported is based on discussing the relative influences of scientific merit/need/excellence against the practical feasibility of the diving operations, the overall capacity of the facility and any health and safety implications.

A significant number of diving based studies have been supported over recent years. The remainder of this account highlights some of the main science areas that have gained backing with the selection aimed at demonstrating the multi-disciplinary nature of research that can be driven by scientific diving.

Examples of NFSD-supported science programmes

A main uniting driver for the science that is supported through the NFSD is to ensure that the work contributes to the overall NERC Science Strategy goals. NERC science is delivered through seven strategic science themes, supported by research programme funding, and through unrestricted responsive mode funding. Scientific Diving contributes to all seven of NERC's strategic science themes: Climate System; Biodiversity; Sustainable Use of Natural Resources; Earth System Science; Natural Hazards; Environment, Pollution and Human Health; and Technologies. These are delivered through seven science areas of which scientific diving is used in five: Marine; Terrestrial & Freshwater; Polar; Earth Observation; and Science Based Archaeology.

The following sections provide some examples of research programmes that have delivered or are continuing to contribute to NERC's strategic science themes.

Climate System Science

There are two general areas where scientific diving contributes to the overall theme of climate system science: paleo-climatic / environmental reconstructions; and impacts of sea-ice changes.

An example of how scientific diving has contributed to the field of paleo-climatic reconstruction is through two related studies that are investigating climatic signals that may be deposited in the growth patterns of long-lived marine molluscs. Species such as the heart cockle (*Glossus humanus*) and the dog cockle (*Glycymeris glycymeris*) may live for many decades or even upto and beyond 100 years of age. Quahog clams (*Arctica islandica*) have been aged to nearly 500 years old. Up until recently, scientists researching the potential of these long-lived animals as potential marine palaeoenvironmental archives were mostly dependent on ship-based dredging to obtain specimens. Invariably, the dredged samples were predominated by dead shells and, whereas there were methods that could match the growth rings on the dead shells to produce chronologies dating many centuries, there was an increasing need to obtain live specimens which, if they overlapped with the dead-shell chronologies, could be employed to resolve or "anchor" the time-series. Although some live specimens were obtained by dredging, the recent employment of scientific diving has markedly increased these numbers. At the same time, scientific diving has produced a much wider distribution of live specimens through being more flexible and precise than research vessels while, at the same time, undertaking sustainable sampling with minimal environmental disturbance compared with dredging. The type of study supported through diving-based sampling includes production of long-term growth records, and the determination of long-term stability of $\delta 13C$ with respect to biological and sclerochronological archives (Stott et al 2010; Butler et al. 2011; Reynolds et al. 2013).

The West Antarctic Peninsula is a hotspot of climate change. Diving-based research conducted by the British Antarctic Survey (BAS) has found that the sea surface has frozen (into 'fast ice') for a shorter period each winter over the last 25 years. This means open water persists longer which allows icebergs to drift around more and collide with the sea bed in the shallows (termed scouring). This long-term research has produced evidence of increased seabed disturbance from a decade of diving-based monitoring an extensive grid of underwater markers near Rothera Research station. A strong relationship has been found between how long the sea surface is frozen for and how many seabed markers are hit by icebergs. The increased scouring is affecting the survival of marine biodiversity there; For example, the lifespan of one of the most common shallow benthic species, the bryozoan *Fenestrulina rugula*, has critically decreased in 12 years. The chance of colonies reaching two years old, the age at which they typically begin to sexually reproduce, has halved since 1997. The cold and extreme seasonality are a challenge for Antarctica's rich marine biodiversity, but the cascade effects of warming seem set to make life in the shallows even tougher (Fig. 1; Barnes and Souter 2011)

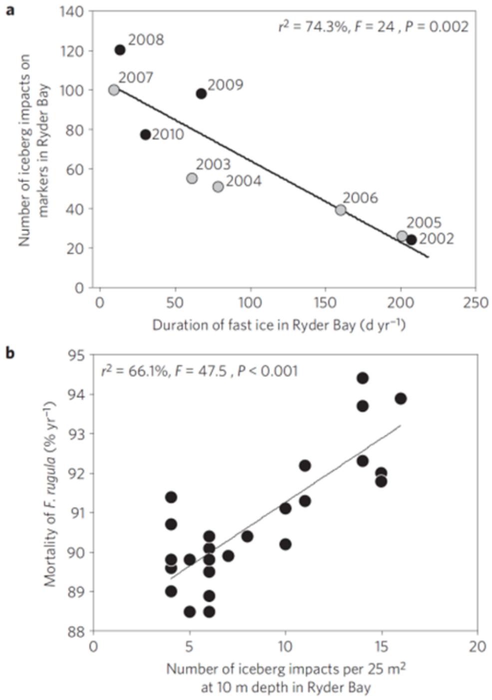


Fig.1. Correlations between fast-ice duration, ice scour and mortality of Antarctic benthos. a, Annual fast-ice duration and ice-scour frequency at 5-25m depth for years 2002-2010. b, Ice-scouring and mortality of *F.rugula* at 10m depth. The relationships shown are significant regressions; points in grey are from the literature (from Barnes and Souter 2011).

Biodiversity/physiology/genetics

The following section gives examples of where scientific diving has been employed in programmes that are united in the research themes of biodiversity and genetics. In the polar regions, diving is an almost essential tool for retrieving specimens from locations that may be difficult to get to (either the general location, or from under ice).

Projects supported by scientific diving in Antarctica have included a year-round study of the physiology of five species of predators showing considerable variation that was not consistently linked to environmental seasonality. Whole genome analyses have shown that a commonly occurring limpet, whose shell structure varies widely with water depth, is in fact one population. Investigating why shells vary so widely is crucial to understanding the capacity of calcified organisms to resist the effects of ocean acidification. Similar tools have also been used to show population structure differences between broadcast spawning and brooding reproductive modes. Genomic techniques, including microarrays and high through-put 454 sequencing (with support from the NERC Biomolecular Analysis Facility), have been used to investigate which genes respond to environmental stressors such as ocean warming. 454 Sequencing can sequence any double-stranded DNA and enables a variety of applications including de novo whole genome sequencing, re-sequencing of whole genomes and target DNA regions, metagenomics and RNA analysis. Two 454 datasets from this project have been made publicly available, thus generating new tools and resources for both polar and non-polar marine biologists. Further evidence has been found that Antarctic marine invertebrates have very poor ability to cope with increased temperature. The Antarctic limpet takes between 3 and 9 months to adjust its whole animal physiology to an elevated temperature. Studies of the mechanisms underlying this capacity to cope with change are ongoing; studies related to this area of work have been published recently (Grange et al. 2011; Hoffman et al. 2011a and b; Obermüller et al. 2011; Smale et al. 2011; Branco et al. 2012; Burns et al. 2011, 2012; Clark and Souster 2012; Hillyard and Clark 2012; Hoffman et al. 2012a and b; Morley et al. 2012a and b).

A diving-based expedition to the Cape Hatt area, northern Baffin Island, Nunavut, Canada produced collections required for the completion of an inventory of the region's seaweed flora, an assessment of changes in the seaweed community composition, an overview of pathogens affecting Arctic seaweeds and provided the first-ever photographic and video survey / documentation of the seaweed communities dominating the coastal ecosystems of the region. In summary, the work has produced several hundred herbarium specimens of seaweeds on paper; several dozen microscope slides (permanent mounts); around 70 live isolates of marine algae; over 150 samples of seaweed tissues for characterizing seaweed-associated oomycetes and other eukaryotic pathogens; 5 isolates of freshwater cyanobacteria; over 10,000 images; approx. 20 hr of video footage (about half of this under water); over 50 marine sediment samples for microbial / algal isolation work and approximately 10 isolates of Arctic freshwater oomycetes (Kawai et al. 2013; Küpper et al. 2013).

Technologies

Deliverables under the Technologies theme can be divided between studies that evaluate some of the scientific techniques employed by diving, studies that seek to develop new technologies that could enhance the quality of the delivery of underwater science, and studies that aim to validate current diving technologies in relation to how they may be used by scientific divers.

The NFSD has supported a number of programmes in recent years where the main objective has been to evaluate new or existing scientific techniques. Several studies have attempted to experimentally compare subtidal animal population estimates obtained from different underwater survey techniques employing SCUBA diving and have demonstrated significant levels of variability between both technique and individual observer. However, published work investigating sources of variation within the methodology of single techniques remains scarce. Sayer and Poonian (2007) investigated individually scale-, tidal-, equipment-, and observer-induced variation through analysis of animal population density estimates obtained using a number of techniques based on SCUBA diver visual survey. The study was based on shallow subtidal sites on the west coast of Scotland including natural rocky slopes and recently deployed artificial reef sites. Groups of species investigated varied in levels of size, abundance, mobility and detectability. Density estimates obtained from photographic and remote underwater video sampling were compared with those obtained from in situ survey. Variability in estimated densities between different sizes of sampling unit, state of tide, type of SCUBA equipment used (open circuit versus rebreather) and observation technique was found to be considerable. A decreasing asymptotic relationship with quadrat size was evident in the majority of cases for estimated density, coefficient of variation and number of samples required to attain a given precision. However, the size of the sampling unit employed had to be large enough to encompass the variability in spatial distribution of the target organism. Mobility of the diver was beneficial to the precision of estimates obtained for rare animals by increasing detection rates; and detrimental to those for common animals because of observer confusion. Improved precision for estimates of cryptic species was obtained from relatively small sampling units, which focused the observer’s attention onto a specific area. Underwater photography as a population estimation technique produced data comparable with that from visual surveys but was limited by the size of sampling unit. The use of remotely-deployed infra-red video demonstrated that certain animal species and life-stages actively avoid divers and were largely absent from the diver-based surveys. Although larger quadrats generated more precise estimates, the longer sampling times involved reduced their overall efficiency for most groups surveyed, resulting in the creation of optimum sizes of sampling unit for particular groups.

Another comparative study was carried out to evaluate the efficiency of a number of techniques commonly used for assessing the structure of subtidal epifaunal communities (Beaumont et al. 2007). Assessments were made of the epifaunal assemblages fouling two substrata: concrete and PVC plastic. Where possible, each technique was undertaken in three ways, namely, in situ underwater, in the laboratory and using image analysis on photographs taken in situ. Comparisons were also made of biomass estimates made on samples taken in situ and in the laboratory. All method and technique combinations assessed detected differences in the epibiotic communities associated with the two fouling substrata. Sampling in situ, in the laboratory and using image analysis gave similar estimates of percent cover. However, there were significant differences in measurements made for most taxa with respect to abundance and frequency counts depending on how the technique was carried out. Laboratory-based sampling of abundance and frequency counts and biomass determinations, rather than in situ or image-analysis based sampling, are recommended for use in future studies of epifaunal fouling.

Photoquadrats enable efficient and cost-effective quantitative estimation of epibenthic communities. Despite their utility, however, there has been limited use of photoquadrats for such purposes in temperate north-west Europe, where there is also a growing need for standardized approaches to marine monitoring. A rapid photoquadrat-based methodology was trialled by scuba divers on a heterogeneous boulder-slope habitat in a Special Area of Conservation (SAC) in Northern Irish waters (vanRein et al. 2011). To investigate the monitoring potential of the method, the benthic community was randomly sampled in the summers of 2009 and 2010. The community was represented at species level (community composition) and by functional group (community structure), and the data-extraction resolution was varied using different numbers of point intercepts per image (25, 50, and 100) to assess the balance of precision and efficiency with regard to detection of community change. The method was efficient in situ and yielded sufficient sample images for estimation of local benthic community diversity (number of species). The community varied significantly, with six distinct sub-communities identified within the survey area. High spatial variability obscured detection of temporal changes in the overall community composition and structure. However, spatial variability was substantially reduced by testing only the dominant sub-community, in which significant changes were detected between 2009 and 2010. The ability of the photoquadrat to detect individual taxa was related to data resolution: the more point-intercepts sampled, the more taxa were discovered, but the data-extraction effort was greater. After considering the ability of the photoquadrat method to quantify number of species and to detect change in community structure, as well as its precision and efficiency, the inspection of 50 point intercepts per sample image was found to be optimal. These findings demonstrate the benefits of photoquadrat-based methods and highlight their potential as a standard approach to marine monitoring.

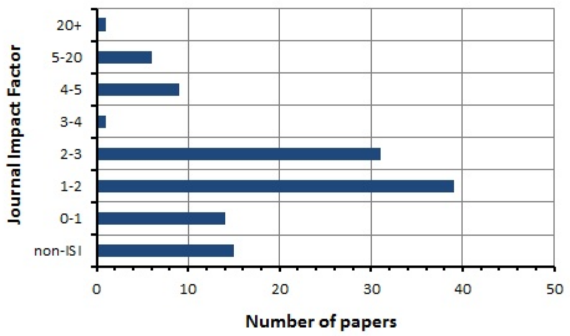
Obtaining accurate and affordable geo-referencing is not straightforward for divers because there is a lack of through-water penetration by global positioning systems (GPS). Although a number of commercially available systems exist, few are low-cost or operationally flexible enough for use in scientific diving. A study by Kuch et al., (2012) detailed a new GPS diving computer that supports navigation and Global System for Mobile Communications (GSM) underwater. The unit displayed the distance and heading information to set points and tracked the dive in three dimensions (position, depth and time). When downloaded, the tracked dive profile can be visualised in 3D in Google Earth. By synchronising the dive computer clock to external recording devices (for example, cameras), any recording event can be geo-referenced with attached data relating to GPS position, temperature and depth.

Dive computers are widely used by scientific divers both to monitor and control their decompression obligations but also sometimes as scientific instruments. However, there is little standardisation in how the computers function (Azzopardi and Sayer 2010; Sieber et al. 2012). In an NFSD study, forty seven models of diving computer were subjected to a range of nominal depths (10, 20, 30, 40 and 50m), in freshwater and seawater, in a simulated temperate environment (Azzopardi and Sayer 2012). The depths downloaded from the computers were adjusted for density and compared to the published limits of the EU standard EN13319:2000 for depth-time measurement. The estimated depths for most of the computer models were close to or within the limits for the standard, but were not always near to the accuracies claimed by the manufacturers. Testing was complicated by the manufacturers' lack of specification of the salinity standards used by most dive computers for the conversion of pressure measured to depth displayed. The mean estimated depths tended toward the simulated nominal test depths; maxima/minima depth differences from nominal were 2.4m/-1.5m and 1.6m/-0.8m for freshwater and seawater tests, respectively. The results from the temperature trials generated a measured range of 5.1°C from nominal values, although the differences in the methods employed either by the computers or the download software to record or display temperature negated standardised comparison. It was concluded that caution should be employed when using displayed and/or recorded depth and temperature data from dive computers in scientific or forensic studies.

Discussion

Today, scientific diving is often considered an essential tool for many research projects, predominantly in depth ranges of between 0 and 50m water depth but with the technical capability of now going deeper and longer (Lang and Smith, 2006; Sayer, 2006). As such, diving is a research tool that is employed widely throughout Europe in support of a large number of high-quality research programmes (Sayer 2007a & b; Sayer et al, 2008). It is becoming increasingly more important to demonstrate the cost-effectiveness and scientific credibility of diving support. The NFSD has been analysing all published outputs arising from the support given to research programmes. Two metrics are employed: the Impact Factor of the journals being published in; and the number of citations being generated from those publications (Fig. 2).

In addition to scientific credibility, safety is the other major concern sometimes suggested by regulators or employers as a reason for limiting scientific diving operations. Maintaining databases of diving records against which incident rates can be generated has proven useful in a number of countries as a means of demonstrating the relative safety of scientific diving compared with other diving industry sectors (Sayer 2005; Sayer and Barrington 2005; Sayer et al. 2007; Dardeau et al. 2012).



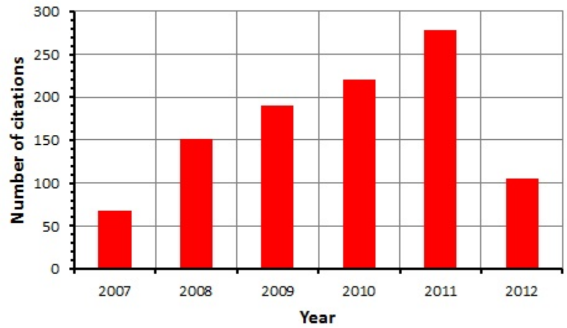


Fig.2. NFSD output and citation analyses (2006-2012). NFSD-supported research that was published in the years 2006 to 2012 was collated and grouped according to the journal Thompson-Reuter ISI Impact Factor (IF) for the year of publication. Citations from these publications were tracked from 2007 to end of June 2012 using ISI Web of Knowledge and presented as annual totals. Since 2006, NFSD support has generated 101 ISI-rated publications (IF: median 1.97; mean 2.48); these have been cited 1013 times with a current H-index of 18.

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Project and development of instruments for flora metabolism and radiation absorption measurements in seawater

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Abstract. Studies of marine environments and organisms require measurements of several physical and chemical parameters. In this paper two instruments for solar radiation absorption and flora metabolism, designed and realised by CNR-IBIMET Institute and planned for joined running, are presented: a plexiglas benthic chamber and a low-cost spectroradiometer that provides the ratio between underwater and outside the water radiation for the four spectral ranges (global, red, green, blue) fundamental for photosynthetic activity.

Introduction

Studies of marine environments and organisms require measurements of several physical and chemical parameters. Benthic chambers are widely used in studies concerning both marine sediments and flow of solutes through them up to high depth. They are also used for studies on coral reefs metabolism and vegetable biomasses; these studies can be carried out up to a few meters of depth because the instruments can be placed above the water surface. Difficulties arise when these measurements have to be made to depths of several tens of meters. In these cases, the instruments should be waterproof for pressures up to several bar.

Life for plants and animals whose habitat is the aquatic environment depends on the possibility of solar radiation to penetrate the water. Many underwater spectroradiometers are available on the market, some with a single spectral band (Hamamatsu 2001), others have more but narrower bands (Satlantic 2000) and still others offer a continuous band (Li-Cor 1994). One common feature of these instruments is their cost which, even for the simplest, is rather high. This is, in part, due to the fact that they provide, for the various ranges of wavelength or for the various spectral lines, the absolute value of the incident radiative potential.

Hardware and software

For a research activity, funded by the Ministry of Education, University and Research (VECTOR Project Line 7: VulnErability of the Italian coastal area and marine Ecosystems to Climatic changes and Their rOle in the Mediterranean caRbon cycles), in collaboration with the Department of Biology of the University of Pisa, a plexiglas benthic chamber was designed and built by the Instruments Section of the Institute of Biometeorology- National Research Council (CNR-IBIMET) of Italy. The chamber (Fig.1) is able to carry out metabolic measurements of underwater flora at depths between 0 and 50 m. It is large enough (diameter 900 mm, height 1000 mm, volume 0.5 m^3) to contain several plants and provide a reasonable compromise with chamber handling. Parameters which can be measured are underwater solar radiation (global, red, green, blue), depth, temperature, pH, conductivity, dissolved oxygen. Two operational phases are foreseen: measurement of water physical-chemical parameters, altered by biological activity of plants and a water exchange with external water. A pump system avoids the water stratification and allows the water renewal.

The instrument, by monitoring physical parameters related to metabolic activity of plants, allows to deduce the "health" of marine waters in the euphotic zone. Results of several tests confirm full compliance of the benthic chamber with respect to the requirements of marine biologists and to the project data.

The parameters which can be measured are:
depth, temperature, pH, conductivity, dissolved oxygen by means of a multiparametric probe (Table 1).

Table 1. **Principal Metrologic characteristics of the multiparametric probe**

PARAMETER	RANGE	ACCURACY	RESOLUTION
Depth	0 ÷ 61 m	± 0.12 m	0.001 m
Temperature	- 5 ÷ 45 °C	± 0.15 °C	0.01 °C
pH	0 ÷ 14 pH	± 0.2 pH	0.01 pH
Conductivity	0 ÷ 100 mS/cm	± 0.5 % of reading	0.1 mS/cm
Dissolved Oxygen	0 ÷ 20 mg/l	± 0.1 mg/l or 1 % of reading	0.01 mg/l
	20 ÷ 50 mg/l	± 15 % of reading	

The electronics control is based on an Atmel microcontroller ATMega168 and was developed using Arduino, an open-source electronics prototyping platform; the control unit allows two modes of pump operation, selectable by the user:

- Alternating mode: the two pumps do not operate simultaneously and the time in which a pump is working corresponds to the interval time when the other is off. The user can set the ratio (in %) between periods of activity and inactivity (duty cycle) during the working time. There are two operation phases in the chamber:
  - measurement of water physical-chemical parameters, altered by biological activity of plants (circulating pump on);
  - water exchange; water inside the chamber is replaced by external water to set new initial conditions (charging pump on).
- Independent mode: the pumps operate in a completely independent mode and for each one the user can set: time-on, time-off and their starting delay after control unit power-up. Each pump also can always be set on or off.

Solar radiation is measured by a low-cost instrument, joined to the chamber and called SuMaRad (Sub-Marine Radiometer) and made up of two identical radiometers that differ only for the shape of the container that, in which one underwater operating, includes the acquisition system (Fig. 2).

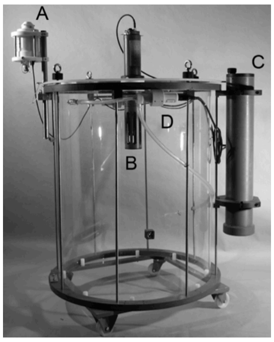

Fig.1. **Benthic chamber on its trolley with annexed measuring instruments: A) SuMaRad (SubMarine Radiometer), B) Multiparametric probe, C) Electronics control with battery pack, D) Internal circulating pump**

The instrument does not measure the absolute value (watts/square meter) of the radiation in the various bands, but it provides, at different depths, the ratio between the underwater and the outside the water radiation (a pure number between 0 and 1) for the four spectral ranges (global, red, green, blue), fundamental for photosynthetic activity. So the instrument provides indications about water transmittance; to have indications about the value of the radiative power it is sufficient to calibrate the radiometer in the air in absolute terms. The two radiometers operate in the same bands: one acquires radiation outside the water and the other underwater radiation at a pre-established depth. The two acquisition systems are synchronized when the instruments are turned on and then, during data elaboration, the ratio is obtained between underwater radiation and outside water radiation for each spectral band.

This ratio, in accordance with the Beer-Lambert equation, represents the transmittance of the medium crossed by the radiation. By applying the Linke equation to the collected data, it is also possible to determine the turbidity of the medium.

Fig. 2. Components of the SuMaRad measurement system; on the left the air radiometer, on the right the underwater one.

The system can acquire as many as 1472 data, with programmable temporal scanning; in order to avoid opening the hermetically-sealed container of the underwater radiometer, programming and data downloading have done by way of an optical interface through a Plexiglas window in the radiometer covering.

The measurement system was designed to function in the photic zone at a depth of 0 to 50 m.. Also the radiometer’s underwater positioning system was specifically planned and built. More than one underwater radiometer can obviously be attached to the rope in order to provide an underwater radiation profile at a fixed moment.

This instrument has been used also in studies concerning the relationship between solar radiation and photosynthetic activity of Posidonia Oceanica. This instrument has a relatively low cost making it particularly suitable for applications that require numerous instruments to monitor sea, lacustrine, or fluvial water in various points at the same time.

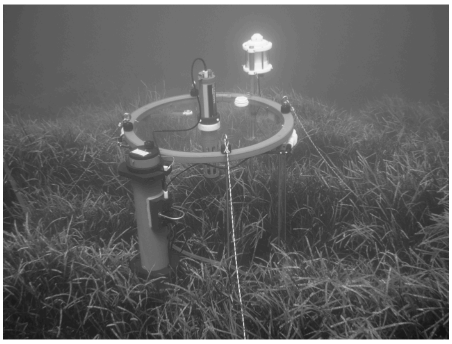

Fig. 3. Benthic chamber running in a Posidonia prairie

Results

In order to verify chamber and SuMaRad functionality, a test was conducted in Cala Villamarina (Santo Stefano Island, Archipelago of Maddalena, northern Sardinia) on a Posidonia Oceanica meadow at a depth of 9 m in July 2009 (Figure 3 and 6).

Fig. 4 shows, for a typical July day, as an example the plot vs. time of the percentage transmittance of the water, the ratio between underwater radiation and outside water radiation in the indicated spectral bands (left ordinate). The dashed line (right ordinate) shows the plot vs. time of the water temperature.

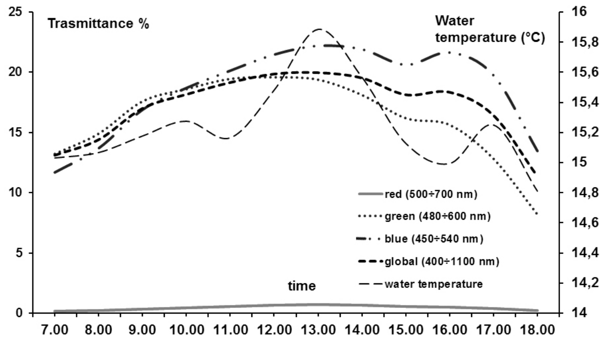

Fig. 4. Trasmittance/Water temperature/day hour

Fig. 5 illustrates the plot vs. time of two other measured parameters: dissolved oxygen (upper line, left ordinate) and pH (lower line, right ordinate). Rectangles indicate the time intervals (adjustable from 10 minutes to 24 hours) in which the water inside the benthic chamber was replaced with external water. When the charging pump is off the circulating pump is activated to prevent stratification of the water in the chamber.

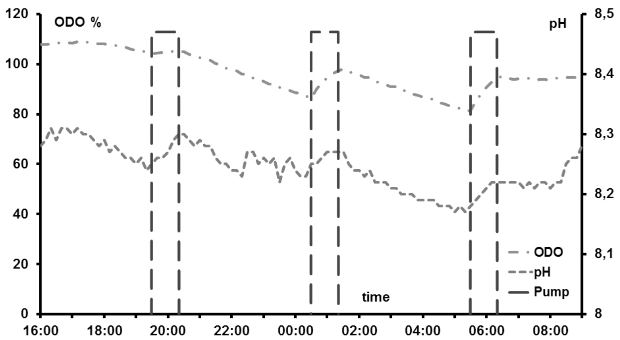

Fig. 5. Dissolved oxygen / pH

It is possible to observe how, at night, plant respiration reduces dissolved oxygen in sea water and gives off carbon dioxide, lowering the pH (in Fig. 5, approximately from 20:00 pm to 5:30 am); vice versa with the return of sunlight, plants absorb carbon dioxide (pH increases) and emit oxygen. The measurement cycle is repeated with each water re-newal.

To better verify the instrument functionality the SuMaRad was also tested over a sandy sea floor of approximately 40 m depth and the radiation extinction profile was measured about every 5 m from the surface to a depth of 35 m. Measurements in the air were carried out on the coast some hundred meters from the measurement points at sea.

As a function of depth, Figure 7 presents, for the same measurement day with a variably cloudy sky and rough sea, the, the water transmittance τ, as the ratio between the solar radiation measurement in water (Iz), at a certain depth z, and that measured in the air (Ia) at the same time and in the same spectral band (eq. 1):

1) $$\tau = \frac{I_z}{I_a}$$

Fig. 6. The underwater radiometer nearly hydrostatic neutrality allows the operator to have extreme maneuverability

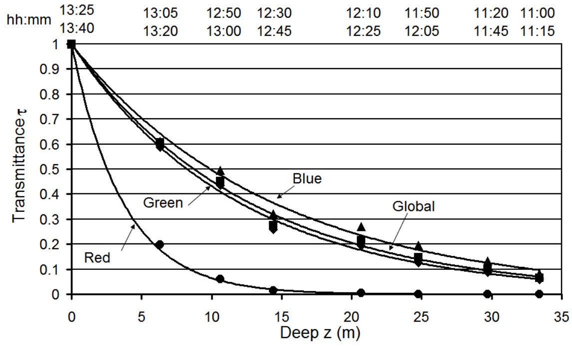

Fig. 7. Measurements of water transmittance as a function of depth

Conclusions

These two instruments are very versatile ones for measuring the metabolic activity of marine flora in the euphotic zone due to their size, instrumental equipment, automatic operation, operative autonomy and low construction cost; their applications of the instrument can be:

- obtain absolute radiation values for the various bands at different depths simply by calibrating the air radiometer for absolute value, to compare with standard solarimeters having the same spectral bands.

- in certain applications (for example to measure coastal erosion) water turbidity can be more useful than water transmittance. In this regard, use of Linke index which is already a standard for atmospheric turbidity measurements can be suggest (eq. 2):

2) $$T = \frac{\ln I_a - \ln I_z}{\ln I_a - \ln I_{z0}}$$

where:

Ia is air radiation (in a certain spectral band)

Iz0 is the radiation (in the same band) at the chosen depth z, in a zone selected as reference for "clear water"

Iz is the radiation (in the same band) in the zone under study at the selected depth z

Also in this case the SuMaRad can be used to provide indications on water turbidity in the four spectral bands.

Many other measurements can provide information about the biological activity of aquatic plants and algae in relation to the quantity and quality of light. The relatively low cost of the SuMaRad makes this instrument particularly suitable for applications where several instruments are needed to carry out monitoring in more than one place at the same time. Obviously, in situations where the underwater sensors are not far from each other (at the most some hundred meters) a single radiometer can be set up outside the water, either on the coast or on a boat.

In the present paper use of instrumentations in studies concerned marine habitat have been reported, but they can also be used in lacustrine or fluvial habitats, which often present the same problems of eutrophication or coastal erosion.

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Legal aspects and issues of scientific diving in Croatia

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Abstract. The Republic of Croatia was one of the founders of the diving organisation CMAS – a unique world diving association which has scientific diving in its program (Scientific commission). The Croatian Diving Association, as a member of CMAS, also has a scientific commission. In the Maritime Legal Code of the Republic of Croatia, in 2004, it was stated that the Diving Legal Code will be declared soon. However, this has still not happened. There are around forty scientists in the RC who use diving in their research (biologists, archaeologists, chemists, ecologists, geologists, geographers). They are mostly well experienced divers, only a few have less than 5 years of diving experience. The majority of them are 2 star divers. Their health check is performed by departments of occupational medicine or family practitioners with subspecialisation in hyperbaric medicine, and a minority of them dive even without a health check. Only a few possess diving insurance and accelerated work service. Although the diving of scientists in the RC is usually accompanied by formal documents (permission for research issued by a competent ministry and a travel order from the institution of employment), such activities in Croatia are still in the grey zone. Some scientists even do not have these formal documents so their diving/research is completely illegal. The situation is similar in most Mediterranean countries. In the Republic of Croatia, as in many other countries, at the moment there are no unidirectional legal rules which cover this important and complicated activity.

Posters

An underwater survey for the study and conservation of marine biodiversity in an Aegean island (Agios Efstratios, North Aegean Sea)

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Abstract. Currently reinforcement of marine conservation is considered a critical need across the Mediterranean Sea. The regional lack of scientific data concerning marine biodiversity has proved to be an impediment to marine conservation efforts particularly in its eastern and southern areas. The Greek territorial waters encompass more than 100 sites enlisted in the Natura network which have not been surveyed for their marine diversity and in most cases do not receive any management plan. The island of Agios Efstratios and its surrounding marine zone (2159.72 hectares) have been characterized as a 'Special Protection Area' (GR4110014) and as a 'Site of Community Importance' (GR4110002). Because of its geographical isolation in the centre of North Aegean Sea the area presents great scientific interest. However its marine ecosystem is poorly studied and remains practically unprotected. Within the present study, a baseline survey was carried out in 20 marine sites of the island by means of SCUBA and skin-diving with the aim to record marine biodiversity through qualitative sampling and non-destructive methods (underwater photography and visual observation). In total 201 species were recorded, out of which 38 are protected by national and EU environmental legislation and 40 present commercial interest. Moreover a significant spatial coverage of EU priority habitats (*Posidonia oceanica* meadows, rocky reefs and underwater caves) was observed. Management measures compatible with sustainable development are neccessary in order to safeguard the conservation of its rich marine habitats.

Long term monitoring of gas discharges at submarine fumaroles of Panarea, Italy

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Against the background of predicting volcanic and tectonic activity, respectively, one possibility for prediction can be the monitoring of submarine volcanic gas emissions. Their intensity and composition is assumed to be an indicator for volcanic activities.

It is our goal to develop a device, suitable for long term measurements of the flow rate of submarine gas discharges. In recent years, several concepts have been tested by our research group, all with drawbacks. The main problems are the harsh conditions at the observation site such as low pH-values leading to strong corrosion and bacterial agglomerations at the test section.

So far, gas has been collected by a funnel and guided through a test section (Fig. 1 (a)) where the flow rate is measured. The whole device is called FSVG (**F**low Meter for **S**ubmarine **V**olcanic **G**as emissions). The flow rate is captured by two independent mechanisms. Firstly, by counting the revolutions of an impeller and second by measuring the thermal loss of the gas passing the test section. The longest measuring duration was about 3 months. The goal is to gain data for at least one year and furthermore to increase the measuring range, especially for lower flow rates at smaller fumaroles.

A new measuring principle will be presented, here, which will be suitable to measure smaller gas flow rates. It is based on the buoyancy which the discharged gas causes in a collecting container (Fig. 1 (b)). The lifting force is measured by a load scale and linear dependent on the flow rate. The gas finally leaves the container through slits whose size is adapted according to the strength of the fumarole. This way, smaller flow rates can be captured.

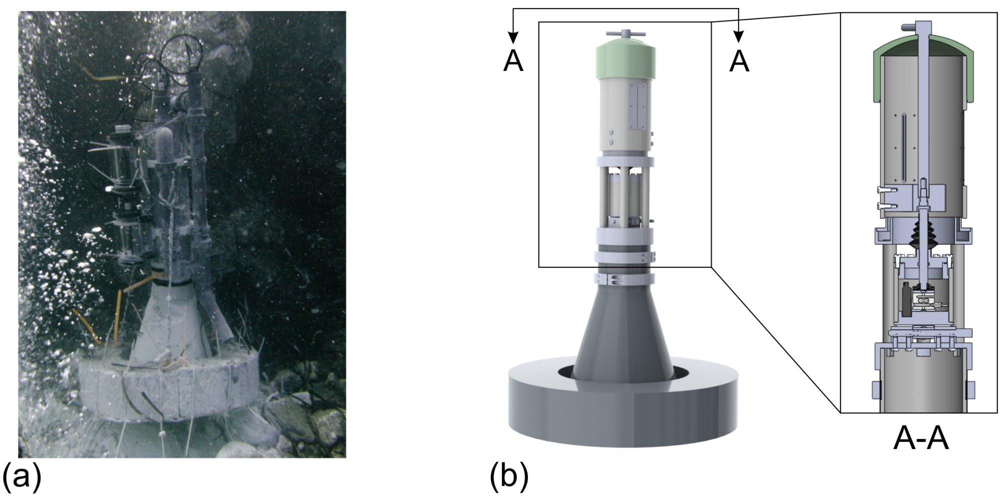

Fig. 1. (a) Recent FSVG mounted on top of a fumarole at Point 21, Panarea, Italy, (b) schematic of new FSVG.

Geothermal investigations of the submarine caldera of Panarea

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Abstract. Based on submarine in situ measurements of temperature, temperature gradient, heat flux, tracer tests and thermal conductivity determination in the laboratory, some submarine geothermal active spots of Panarea, Italy, were characterized. Heat transport with respect to conduction and convection were investigated to quantify the influence of upwelling hot geothermal water. Newly acquired data are compared to data from previous field work. First results regarding installing thermosiphons for extraction of thermal energy to produce electricity for submarine monitoring equipment are presented.

Introduction

Panarea is one of the 7 main Aeolian Islands in the southern Tyrrhenian Sea as part of the Mediterranean Sea. It is located approximately 50 km north of Sicily. Panarea belongs to the Strombolian volcanic active system. The subduction of the African plate under the European plate caused the back-arc system with an area of about 460 km2. Panarea is the smallest of the Aeolian Islands (3.3 km long). The residual part of a large strato-volcano with a caldera, which underwent prolonged evolution and was volcanically and tectonically active up to ~25,000 years B.P. is nowadays covered by ocean water.

Due to an increased need of submarine in situ measurements one major question is how to supply such online submarine monitoring systems with electrical energy. In particular for long-term monitoring and sending of data via ultrasonic devices to remote stations a reliable energy source is needed. The heat emitted by the volcanic system is a quasi-inexhaustible free energy source for the production of electricity as it could be used for long-term monitoring devices and hence replace batteries. The motivation of the work is to investigate the possibility of power generation with the help of peltier elements installed at thermosiphons. Especially for the use of the energy, the yield of the sources, their variations, and their steadiness must be known. To achieve this goal, it is necessary to understand and characterize the geothermal activity.

Methodology

Two types of heat transport have to be considered in submarine volcanic environment: Conduction occurs in both solid rock and water. On contrary convection is the heat transport by upwelling of hot geothermal water. Until now only the conductive heat transport in the sediment was measured quantitatively in Panarea in previous field work. The convection term was deviated and calculated from these data. Thereby, it turned out that the convection is dominant and conduction actually plays a minor role because the measured heat flux is much higher than the calculated heat flux (see table 1).

Table 1. Heat transfer measured and heat transfer calculated by conduction measurements using a temperature gradient sensor

measured heat flux [W m^{-2}]	calculated heat flux by conduction [W m^{-2}]
2500	95
1440	54
365	165
20	11

The nonlinear temperature gradient is a superposition of both forms of heat transport – conduction and convection. Only conduction would result in a linear temperature gradient. Therefore a tracer test was aimed to measure directly the amount of upwelling water and thus the convection.

Thermosiphons were tested to transport the heat from the ground in a very simple and efficient way. The main challenge of the work with thermosiphons was to investigate the possibility of producing electrical power to supply online measuring devices.

Temperature measurements were accomplished at 7 different spots whereas all other parameters were achieved at *La Calcara*. This spot was the major focus of the investigation. It is located directly along the shore line of Panarea at a water depth of 22 meters. It is mainly characterized by sandy sediments and randomly spread posedonia fields. Whitish bacteria are observed close to hydrothermal sources noticeable due to upwelling water. In *La Calcara* a 20 m long transect with edge lengths of 5 meters was laid out covering an area of 25 m^2 with 9 measuring points.

Temperature measurements were taken with a GMH 3350 device from GREISINGER electronic (in water proof housing) and a 50 cm long thermo couple. To interpret any temperature anomalies the ambient sea water temperature was documented as well.

For the measurement of **temperature gradient** a PCE-T 290 device in water proof housing was used. The sensor itself has a length of 50 cm (Fig. 1) including four thermo couples (Type "K") each at a different depth (490 mm, 350 mm, 200 mm und 50 mm). This allows for measurement of the temperature in four different depths at the same time. For comparison of the results it is important to insert the sensor completely. Thus a sufficiently thick sediment layer is necessary.

The **thermal conductivity** was determined by an ALMEMO® 2290 device from AHLBORN which allows for heating a sample and instantaneously measures the heat changes (Fig. 2). Sediment-water samples for the determination of thermal conductivity were taken under water and transported in plastic zipper bags to the field laboratory. The sediment-water samples were transferred into a cylinder with a volume of 1.6 L and the probe was fully inserted. According to the heat transfer throughout the sample the device calculates the conductivity in W m^{-1} K^{-1}.

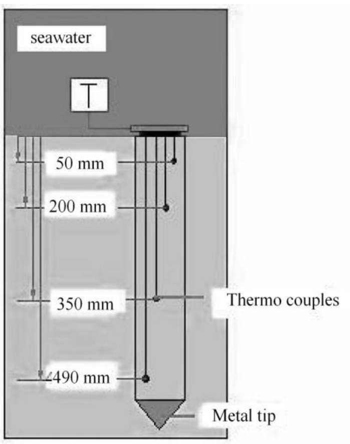

Fig. 1. Temperature gradient sensor with 4 integrated thermo couples (Müller 2011)

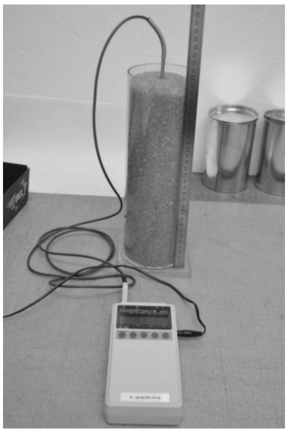

Fig. 2. Thermal conductivity sensor

Fig. 3. Heat flux measurement: Ahlborn, AHLMEMO® 2590-3S (Müller 2011)

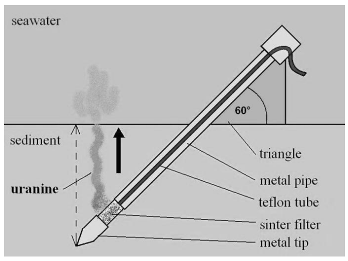

Fig. 4. Scheme of injection pipe

The **heat flux** can be calculated from the thermal conductivity and temperature gradient or can be measured directly with a modified ALMEMO® 2590 device from Ahlborn in W/m^2. The plate is a square with edge lengths of 120 mm and 1.5 mm thickness. Hence, it covers an area of 14400 mm^2 (Fig.3)
A tracer test was implemented with Fluorescein. The advantage of Fluorescein is the high sensitivity of detection, low sorption, low toxicity, low costs and small amounts necessary for the experiment. The injection lance for the tracer test had a length of 80 cm and a diameter of approximately 1 cm. The stainless steel tip allow for pushing the lance in the sediment. A sinter filter made of Teflon is mounted at the end and connected with a tube. A metal leading axle (triangle) guarantees an angle of 60° during penetration. Hence an injection depth of 50 cm will be achieved (Fig 4). The tracer was inserted by syringes through a three way valve connected to a flexible Teflon tube. The three way valve is necessary to flush the lance with ambient sea water as much as the dead volume of the lance to ensure that the entire tracer is injected in the sediment and no tracer is left in the tube of the lance. Water samples were taken with 20 ml syringes as close as possible to the sediment surface at the point of tracer discharge.

Thermosiphon with Peltier elements

Thermosiphon is a method of passive heat exchange based on convection, which circulates liquid without means of a mechanical pump. The length of the evaporation zone in the thermosiphon was chosen to be 50 cm because this is the maximum sediment depth in Panarea to be found. To use this system in solid ground one had to adapt the design. The working fluid is supposed to evaporate along the 50 cm of the tube inside the sediment. Therefore, the sediment should ideally have a constant temperature along the 50 cm depth. If the upper part of the sediment has a lower temperature it will cause condensation of the vapour. The thermosiphon will heat these areas up before vapour flows further towards the top. To lower the heat losses in the adiabatic zone, Polyamide insulation was installed at the upper 50 cm of the tube. The condensation process happens at the cuboid head of the thermosiphon. The Peltier elements will be mounted at the four 6x3 cm wide rectangular condensation areas. At each side two Peltier elements can be mounted (Fig. 5).

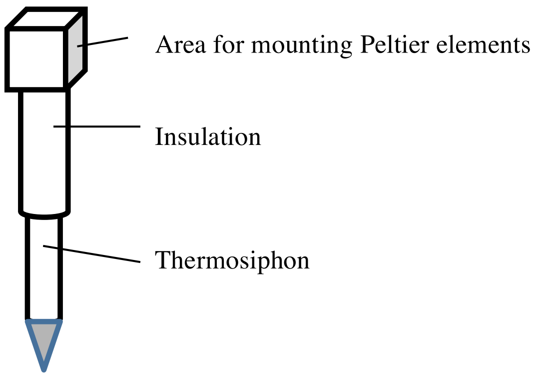

Fig. 5. Scheme of thermosiphon

Results

Temperatures varied greatly according to the location and changes in comparison to previous measuring could be noted. For surface temperatures and heat flux a high spatial variation could be observed. A non-linear temperature gradient curves could be measured repeatedly (Fig. 6). The highest temperature was measured with 136°C in a depth of 35 cm.

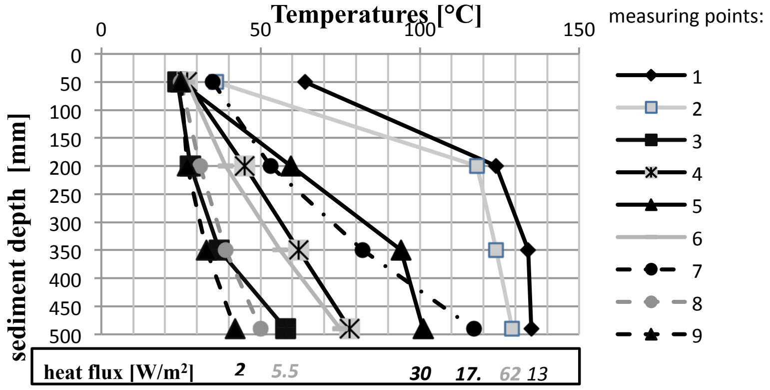

Fig. 6. Temperature gradients and heat flux at La Calcara

The monitoring with the logging modus over a period of 24 hours shows an 8 hour cycle. This cycle can be correlated to tides inducing differences in pressure, while the height of the water column above the ground varies (Fig. 7). This might influence and control the discharge of upwelling geothermal water. The tide was calculated with the programm WXTide32 version 2.4.

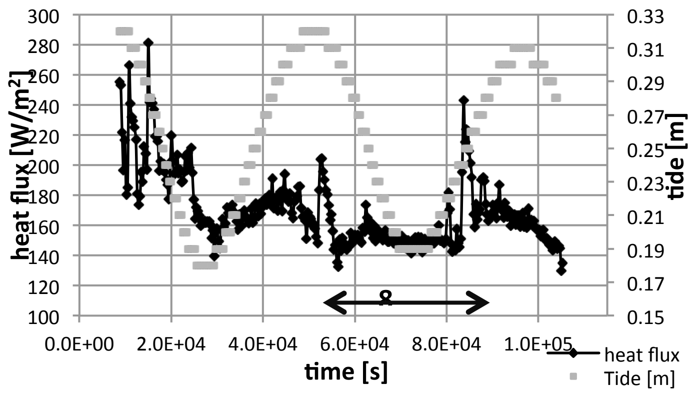

Fig. 7. Heat flux and tidal variation of sea level

The measured values of the thermal conductivity are much lower than expected. All 7 sediment samples taken at La Calcara have the same thermal conductivity of 0.315 W m^{-1} K^{-1}. However, the water has a thermal conductivity of around 0.604 W m^{-1} K^{-1} at 20°C. One sediment sample from La Calcara was analysed in saturated and dry condition. The average thermal conductivity of the dry sample was 0.199 W m^{-1} K^{-1} and thus 0.116 W m^{-1} K^{-1} lower than the saturated sample.

The most promising spot to test the thermosiphons is La Calcara. Therefore, a measuring grid was installed and temperatures in different sediment depths were read. After injecting the evaporation zone of the thermosiphon into the sediment the heat extraction started immediately and the device cooled the surrounding sediment from 136°C to 70°C. It was found that the temperatures close to the thermosiphon decreased up to 70 %. However, it has to be mentioned that the heat extraction of the prototype device is higher than at the final ones, because the Peltier elements will insulate the condenser area, so that the heat transfer coefficient will be smaller compared to the blank metal surface. The experiments with the thermosiphon showed that it is possible to extract heat at a high temperature level from the ground. The achieved temperatures at the condensation area were lower than expected. This results in a lower possible power output of the Peltier elements. The maximum power generation with a temperature difference of 70 K (100 K) is 0.7 W (1.3 W) per each Peltier element (Fig 8).

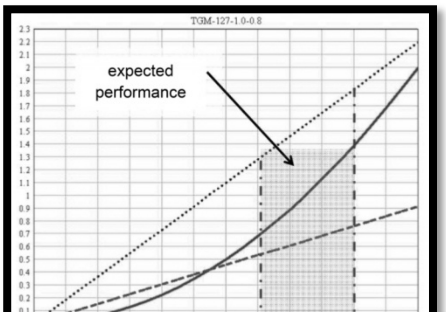

Fig. 8. Thermosiphon performance range[1]

One tracer test could be performed successfully. The measured Fluorescein concentrations show a typical Gauss distribution. The mean velocity of discharging water, however, couldn‘t be determined due to limited time of sampling. For quantitative statement, thus longer continuous sampling is needed. But, so far the maximum velocity and the velocity of the concentration front of the tracer could be determined.

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A Status of the Diversity and Composition of Coral Communities within the Fringing Reef Eco-Systems of the southern Egyptian Red Sea

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Abstract. The effect of anthropogenic impact on fringing reef eco-system in consideration of coral reef diversity and community composition from reef-flats down to 10m was studied at different locations along the coastline of the Southern Egyptian Red Sea coast. During the survey a point line transect was used and data on coral communities to determine anthropogenic impacts as affects on reef communities were collected by snorkeling as well as scuba diving activity. A disturbance and decrease of live coral coverage, lower diversity of coral communities and increased percentage of rubble were found.

Introduction

The coral reef eco-system is one of the world's most diverse eco-system (Bellwood and Hughes 2001). Worldwide the coral reefs are under increasing anthropogenic disturbance (Sebens 1994; Hodgson 1999). Over the past decades over fishing and global warming became major threats to coral reef communities, resulting in reduced fish stock and bleached coral colonies (Chabanet et al. 2005; Gray 1997; Reef Check Germany 2008; Richmond 1993).

The Egyptian Red Sea coastline contains more than 1.500 km of coral reefs, protecting the coastline from storms and other events which may otherwise lead to coastal erosion (Frihy et al. 2004, Maragos et al. 1996). Especially at the southern Egyptian Red Sea coast a rapid touristic growth is causing environmental degradation by means of uncontrolled coastal zone development. The fringing reef eco-system is exposed to several anthropogenic impacts, such as beach tourism, snorkeling and scuba diving activities, land filling, hotel, road and jetty construction (Egyptian Tourism Development Agency 2003, Shaalan 2005).

Disturbance by coastal development affect coral reefs by altering the terrestrial area adjacent to the reefs, altering the reef topography itself and/or by dramatically increasing the amount of marine recreation in the area; scuba diving (Baker and Roberts 2004, Hawkins et al. 1999), snorkelling (Allison 1996), reef walking (Hawkins and Roberts 1993, Liddle and Kay 1987), as well as simply swimming (Chabanet et al. 2005, Frihy et al. 1996, Shaalan 2005), all of which can negatively impact coral reefs. Damage to corals from such activities will mean that the corals allocate energy to repair and regeneration instead of to growth and reproduction which will result in a decrease in coral coverage (Liddle and Kay 1987).

However, coral reefs are important as they provide many services; ecological, physical, biotic, biogeochemical, informational, cultural and social (Cesar 2000), as well as being economically important and providing a base for many coastal economies in tropical regions of the world (Cesar 2000, Chabanet et al. 2005, Hinrichsen 1991). They also provide a complex habitat structure, refuge and trophic link for many organisms (Jaap 2000, Richmond 1993), some of which may be endemic to that location. Reefs also play an ecological role globally by cycling nutrients.

Method

Data collection was carried out on different locations in the Marsa Alam region by point transect line method, on the reef-flat and at 5 m and 10 m depth of the fore reef. As sites with maximum anthropogenic impact 15 locations of constructed jetties on fringing reefs (length between 76m and 730m and age between 1 and 6 years) in front of tourist resorts were chosen. Beside the mechanical disturbance of construction additional anthropogenic impact by swimmers, snorkelers and scuba divers using the jetties as entry points to the reef and open sea.

To each chosen site a corresponding control site was selected, north of the jetty construction, as the wind generally blows from a northerly direction, inducing southerly currents, so any effects of the construction of the jetty i.e sedimentation and debris, would be transported south (Medio et al. 2000). Additional 5 remote locations of fringing reefs without recognized anthropogenic impact were selected as well as control sites.

The reef top survey was carried out by snorkelling to the same patch of a reef crest. Scuba diving technique was used for the data collection at the 5 m depth transects at the related fore reef. The method for the surveys was loosely based on that of the Reef Check (Hodgson 1999). A sample of the substrate was carried out using a point transect line (Hill and Wilkinson 2004, Hodgson 1999) of 20m, with a point at every 10cm along the line at which the substrate directly below would be recorded onto a pre-prepared grid on an underwater slate. At each location, 3 depth contours were sampled (Sheppard et al. 2009); reef-flat by snorkelling, 5m and 10m on the reef slope by SCUBA diving, for both the survey and the control site. At each depth data about diversity and composition of the coral communities were measured and compared. The transects at 5m and 10m depths lay parallel to the shoreline, whilst the transects on the reef-flat ran perpendicular to the shoreline. The line transects ran from the reef-crest shore-wards, as this area of a reef is the youngest (due to the outward growth) and so most likely to show any affect to coral community (Medio et al. 2000).

Coral families recorded included; Milleporidae; Tubiporidae; Alcyoniidae; Nephtheidae; Xeniidae; Actinodendridae; Pocilloporidae; Acroporidae; Poritidae; Agariciidae; Oculinide; Fungiidae; Pectiniidae; Faviidae and Dendrophyllidae. Other substrate included; sponge, algae, rock, rubble, sand, recently killed coral, and 'other' (i.e debris, metal, plastic, fish). The definition of recently killed coral was corals which were killed within the last year, but where the family could still be determined (Hodgson 1999).

As individual coral colonies vary in size, the data was transformed into percentage of the length of the transect line covered by each family (Connell et al. 1997). Primary substrate data was transformed from the number of transect points each family covered (out of 200 in each sample) to percentage of each family or substrate type in each sample. This transformed data of coral community composition from each site and depth was then ordinated using non-metric multi-dimensional scaling, once Bray-Curtis distances of similarity had been calculated. The coral community composition data was then used to calculate percentage of live coral cover; hard and soft, as well as percentage cover of rock and rubble. Percentage of live coral cover was calculated because live coral cover is an indicator of coral reef degradation (Cote et al. 2005, Gray 2000, Hughes and Connell 1999).

However, diversity, evenness and richness calculations were carried out. Firstly, the Shannon-Weaver (1949) diversity index was calculated. Secondly, Pielou's evenness index was calculated (Pielou 1966). Thirdly, Margalef's species richness index was calculated (Clifford and Stephenson 1975). For all data which was normally distributed (Shapiro-Wilks test for normality), independent Samples T-tests were run to test the hypotheses. If data was not normally distributed, either a Mann-Whitney U-test was run, or data (in percentage form) was arcsine transformed and tested again for normality.

Finally, families of corals were grouped in relation to their major growth forms; branching, encrusting; foliaceous and massive (Hawkins and Roberts 1993).

Results

The multi-dimensional scaling, testing for the different variables, revealed that there were differences between coral communities of each depth (Gray 1997, Loya 1972). Therefore, each of the hypotheses to be tested was carried out on each depth contour separately.

No significant difference in the Shannon-Weaver diversity index for corals was found between the survey site and control site for any of the depth contours; reef-flat, 5m and 10m. The same was found to be the case with coral family evenness and richness. However, at 5m (only) live coral cover was seen to be significantly higher at the controls than at the anthropogenic impact sites, with a mean of 45.73% ± 7.977% for the control sites and 34.97% ± 9.962% for the jetty sites (Independent samples t-test, $t = 3.306(29)$, p one-tailed < 0.05) (Figure 1)

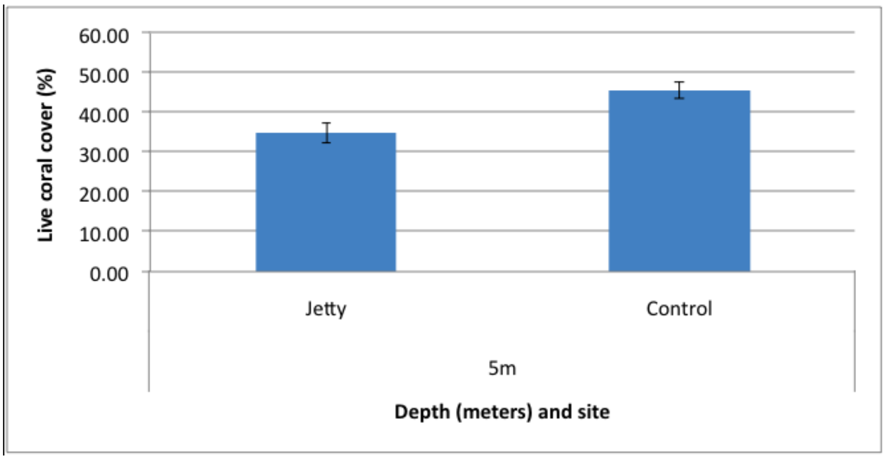

Fig.1. Percentage of live coral cover significantly higher at control sites than at jetty sites.

It was found that there was significantly more rubble substrate at the jetty sites than at the control sites for 5m; with a mean 5.813% ± 7.855% for the jetties and 1.433% ± 4.127% for the controls (Mann-Whitney U-test, $p < 0.005$), and for 10m; with a mean of 7.715% ± 2.100% for the jetties and 1.827% ± 1.086% for the controls (Independent samples t-test, $t = -3.159(28)$ $p < 0.005$ one tailed) (Figure 2). However, there was found to be no significant difference in percentage of rubble substrate on the reef-flat between the jetties and controls.

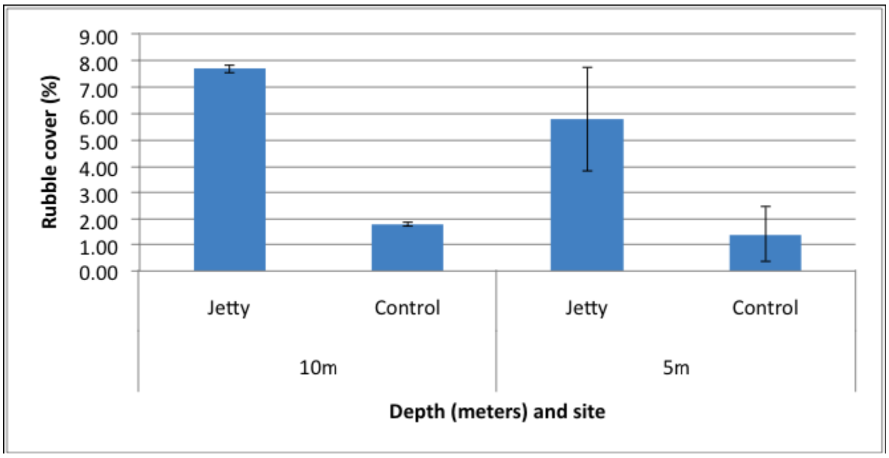

Fig.2. Percentage rubble cover significantly higher at jetty sites than control sites for 5m and 10m

Bare rock cover was found to be significantly higher at the controls than at the jetties for 10m only, with a mean of 51.47% ± 8.536% for the control sites and 42.63% ± 13.34% for the survey sites (Mann-Whitney U-test, $p < 0.05$). Control sites were found to have a significantly higher percentage of branching corals in the substrate communities than the survey sites for 5m; with a mean of 15.84% ± 7.049% for the anthropogenic impact survey sites and 22.60% ± 7.856% for the controls (Mann-Whitney U-test, $p < 0.05$) and for 10m; with a mean of 14.63% ± 6.446% for the surveys and 21.97% ± 9.897% for the controls (Mann-Whitney U-test, $p < 0.05$) (Figure 3). However, again, no significant difference was found in the percentage of branching coral cover on the reef-flat.

There was found to be no significant correlation between live coral cover and age of construction for any of the depth contours. The only depth at which a significant correlation between coral family diversity and age of the construction site found, was at 10m ($r = 0.019$, $p<0.05$ one-tailed). However, as can be seen in Figure 3, the results were not as expected, as there is a negative correlation; as age of construction increases, coral family diversity decreases.

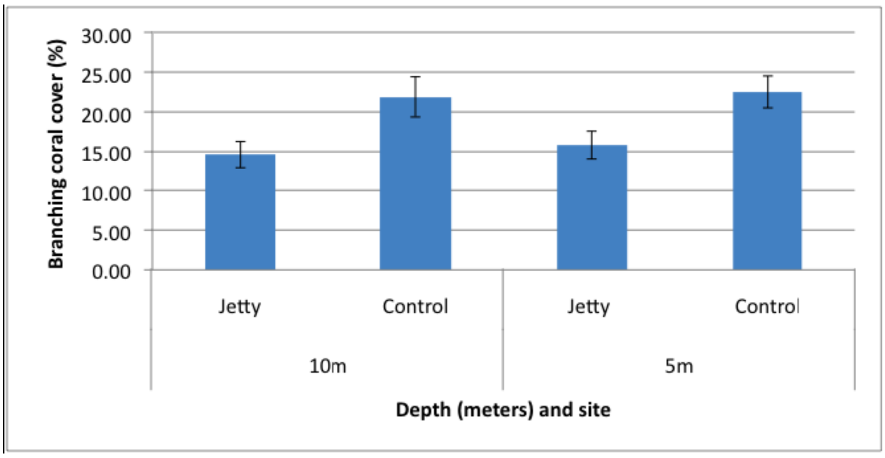

Fig.3. Percentage of branching coral cover significantly higher at control than at jetty at both 5m and 10m.

Conclusion

Increased monitoring of use and coral community composition and diversity is needed, as well as increased regulation of use if coral reef ecosystems are to be conserved.

There is an evaluation of the environmental impacts in Egypt, which is carried out by the Egyptian Environmental Affairs Agency (EEAA) in the form of environmental impact assessments (EIA). This is done in order to identify possible impacts on the environment of different development plans and to therefore be able to mitigate against such impacts prior to damage being done (Badr 2009). However, it is known that the system needs cooperation between the developers and EEAA as the developers are required to submit an environmental impact statement (EIS) before the project begins. However, many developers see the assessment as expensive and time-consuming, and so many try to avoid it or take penalties already in consideration and commence development without meeting standards (Badr 2009). Even once projects have been approved, Badr (2009) notes that there is a lack of regulation and follow-up of the project, and so it is not known whether the projects continue to comply with regulations throughout the project or not.

'The absence of environmental regulations at one point and the weak enforcement of newly developed environmental laws have increased the tendency to exploit all or most of the natural resources in a non-sustainable manner' (Shaalan 2005).

The results of this study have shown that anthropogenic impact not only leads to a decreased percentage of live coral cover and increase of rubble substrate, but also in significant correlation of the decreasing in diversity of the reef communities and construction age as well. It is suggested that this is due to the increasing pressure from tourism and recreation on the coral reefs.

'It is often the interaction of persistent and multiple synergistic disturbances that cause permanent ecological transitions, rather than the succession of individual short-term disturbances' (McClanahan et al. 2002).

The effect of anthropogenic impact as disturbance factors may lead to a 'cumulative impact of physical and anthropogenic stress, which will only increase over time' (Sorokin 1993).

Certainly, more work needs to be done on the effects of anthropogenic disturbances on coral reef ecosystems, however small the impact is perceived to be. In order to protect such ecosystems from shifting their community structure and so experiencing a loss of ecosystem services, monitoring and management of recreation must be put in place.

There is a need to educate private sector and tourists as well using the area in the correct way to behave and act.

It is recommended to impose legislation to limit the number of projects and stakeholders for the 'use' of coastal zones and/or fringing reef.

Also, ecologists and biologists should work closely with all stakeholders and companies contracted for any construction site and touristic operator to find a way, which will balance between the two sides; ecology and economy.

Minimizing human impact on the fringing reef and associated eco-systems, a well designed and thoroughly implemented coastal zone development and environmental management plan is essential to preserve the natural assets of the region.

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Teflon optical protection for solar radiation sensors in seawater

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Abstract. A limitation in operational use of optical sensors in underwater measurements is due to the phenomenum of bio-fouling. In case of measures of solar radiation, global or in large spectral bands, a perfect transparency is not necessary, being enough a good level of translucency. The present work examines radiometers in seawater; in particular global radiation and spectral bands necessary for underwater vegetation life have been considered. The aim has been to verify if the same process improves the efficiency of Teflon® protections, present on several underwater radiometers, and glass.

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Introduction

A limitation in operational use of optical sensors in underwater measurements is due to the phenomenum of bio-fouling, that is the colonization of transparent parts by micro-organisms, seaweeds, animals.

In case of measures of solar radiation, global or in large spectral bands, a perfect transparency is not necessary, being enough a good level of translucency.

The present work examines radiometers for solar radiation measurement in seawater; in particular global radiation and spectral bands necessary for underwater vegetation life have been considered.

Several studies have demonstrated that glass became rapidly colonised but became bio repellent if processed by oxides as those of titanium (TiO_2) or tin (SnO_2); in this work the aim has been to verify if the same process improves the efficiency of Teflon® protections present on several underwater radiometers.

Some non treated Teflon® protections have been compared with some of Teflon® treated with SnO_2, some of glass treated with SnO_2 and some of glass treated with TiO_2 e SnO_2.

To reduce the biofouling phenomenon and consequently make longer the maintenance interval of transparent components of measure instruments several methods have been proposed. Some of them are "active", that is they establish repellent conditions nearby the instrument by means of electric field or ultraviolet radiation; others are "passive", that is they are repellent materials put on interested surfaces.

In the case of image acquisition or narrow spectral radiation bands measurements, it is crucial that the transparency of protection tool be at high level, so that do not distort the image or radiative spectrum alteration; treated glass protections are the most used. When global or large bands radiation have to be measured, a relatively lower level of transparence can be accepted.

In this work radiometers for quali-quantitative solar radiation measurements at different depths in seawater have been considered; in particular global radiation and those bands necessary to underwater vegetation life.

Materials and methods

Several studies have shown that glass in seawater is quickly colonised but becomes repellent if treated with some oxides. The aim of this study has been to verify if the same process could improve the resistance to bio-fouling also of Teflon® protections.
For this purpose some non-treated Teflon® protections have been compared with some of Teflon® treated with SnO2, some of glass treated with SnO2 and some of glass treated with TiO2 e SnO2
The study of protective films and their installation have been carried out by Engineering Dept. of materials and technologies of University of Trento.
Test of biorepellent efficacy on Teflon® has been carried out in the sea at a depth of about 10 meters in May-September period (Fig.1). Several optical protection samples were positioned:

- four no-treated Teflon® diskettes
- four couples of Teflon® diskettes treated with SnO2;
- four couples of glass diskettes treated with SnO2;
- four couple of glass diskettes treated with TiO2 and SnO2;

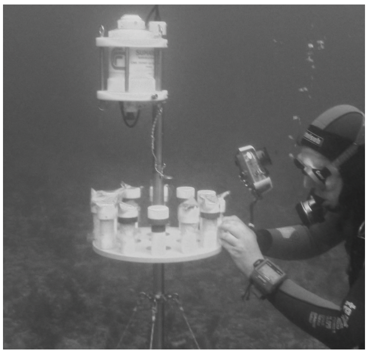

Fig. 1. **Instrument for test at 10 m. depth**

Weekly, a couple of glass diskettes (both type) and biweekly a couple of Teflon® treated diskettes and one no-treated. For each sample transmittance was measured and in short time, in order to not affect bio-colonizers, put again in the water and next time examined after 25 days (glass) and 50 days (Teflon®).

Results and conclusions

Experimental tests have shown that Teflon® , even if it has lower initial transmittance than glass, keeps transmittance value almost constant much longer than glass, treated or not (Fig. 2 and 3). But what is more interesting is the fact that treatment seems to have no effect to increase Teflon® resistance to biofouling and anyway a period of 100 days of constant transmittance value is more than enough for underwater solar radiation monitoring.

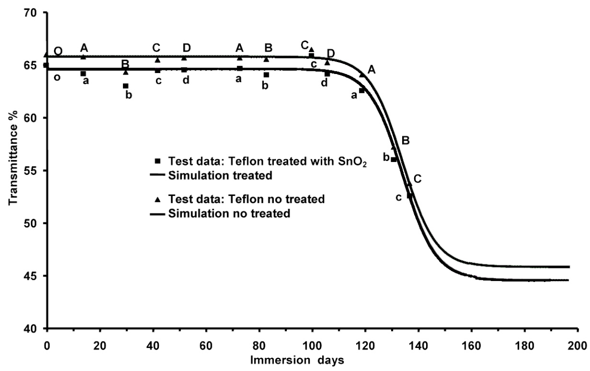

Fig. 2. **Test data and interpolation curves for treated and no-treated Teflon (see table 1).**

Table 1. **Teflon® protections. First column immersion days. Second column couples treated with SnO2 indicate with letters: a, b, c, d; couple indicated with o is samples never put in water. Third column percentage transmittance of sample couple treated with SnO2. Fourth and fifth columns are as second and third but referred to single no-treated samples.**

	Teflon®			
	Treated with SnO_2		No treated	
Days	Couple	$\tau_{\%}$	Sample	$\tau_{\%}$
0	o	65,00	O	66,00
14	a	64,20	A	65,80
30	b	63,04	B	64,34
42	c	64,50	C	65,50
52	d	64,57	D	65,71
73	a	64,70	A	65,71
83	b	64,09	B	65,57
100	c	65,90	C	66,50
106	d	64,17	D	65,26
119	a	62,60	A	64,10
131	b	56,05	B	57,23
137	c	52,60	C	53,80

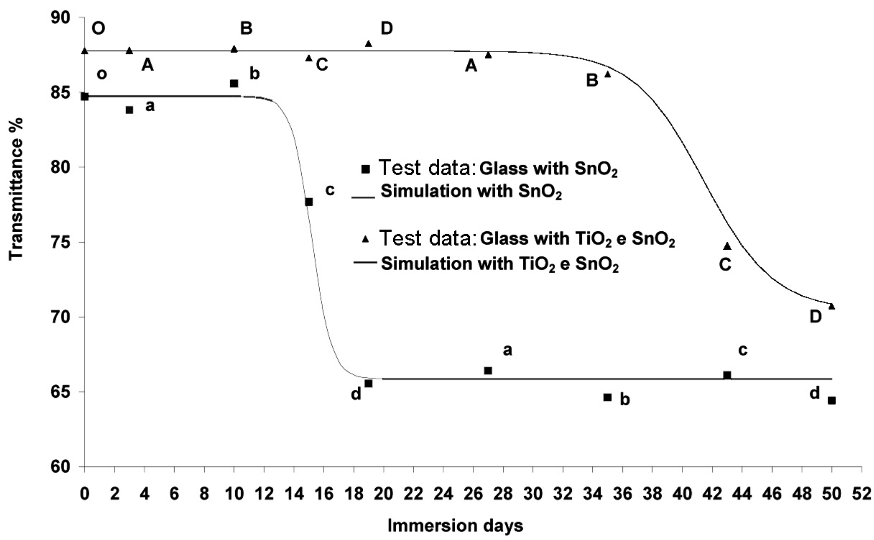

Fig. 3. **Test data and interpolation curves for glass treated with only SnO2 and with TiO2 together SnO2 (see table 2).**

Table 2. **Glass protections. First column immersion days. Second column couples treated with SnO2 are indicated with letters: a, b, c, d; couple indicated with o is samples never put in water. Third column percentage transmittance of sample couple treated with SnO2. Fourth and fifth columns are as second and third but referred to couples treated with TiO2 e SnO2**

	Glass treated with:			
	SnO_2		TiO_2 and SnO_2	
Days	Couple	$\tau_{\%}$	Couple	$\tau_{\%}$
0	o	84,70	O	87.76
3	a	83,81	A	87,79
10	b	85,59	B	87,91
15	c	77,68	C	87,29
19	d	65,55	D	88,25
27	a	66,41	A	87,51
35	b	64,62	B	86,62
43	c	66,09	C	74,74
50	d	64,41	D	70,71

This result can be attributed to nonstick characteristic peculiar of Teflon®, with low surface energy that is unfavorable to idrozoi (prevalent on samples). Taking in account also the higher strength and easier mechanic workability of Teflon®, comparing with glass, the choice of this material for optical protection of underwater instrumentation instead glass is surely more convenient. On the other hand Teflon®, has a transmittance much lower than glass, so it can be used only if a high radiation level is present, i.e. in euphotic zone (40 m.) in Mediterranean coasts.

Transmittance is at maximum level at moment To, then colonization goes on and transmittance decreases. It is almost constant for a period, then decreases rapidly and finally assumes the lower value the remains again almost constant. Out of the best-fitting functions examined, that one better interpolating experimental results is the following:

$$\tau_{\%} = \left(\frac{\beta}{1 + e^{\alpha(t-\eta)}} + \mu \right) \cdot 100 \quad (1)$$

Transmittance function of immersion days (time, t)

Parameters:
–μ: lowest asymptote, indicates samples completely colonized;
–$\mu+\beta$: highest asymptote, indicates samples completely clean;
–β: distance between asymptotes;
–α: parameter determining tangent slope;
–η: inflection point abscissa.

It is possible to see:
until 12th day the colonization go on slowly;
between 12th and 18th day the colonization increases quickly with consequent transmittance deterioration;
From 18th day transmittance become again practically constant, maybe because a competition between colonizers takes place, limiting their proliferation

Experimental data show that transmittance variance between sample completely clean and completely colonized one is about 20%.
Tests in seawater have shown that Teflon® keeps initial transmittance value longer than glass from three up to ten times. The most interesting result has been that Teflon® transmittance is time constant independently by the treatment, that means that SnO2 seems to have no effect on bio-fouling

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Extreme habitats, extreme organisms: sulfur bacteria in a meromictic lake

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Abstract. The meromictic alpine Lake Alat exhibits not only a stable chemocline but also a well-defined sulfuretum making it a unique lentic habitat. Abiotic and biotic factors where analyzed after sampling the layer surrounding the chemocline using DOBB. At its surface a typical oligotrophic, alpine habitat can be observed with low plant and algal diversity and growth. The obvious presence of the zebra mussel *Dreissena polymorpha* and an extensive field of water-lilies deviate from a natural alpine lake. At approx. 14 m the dense layer *purple* sulfur *bacteria* becomes visible, quickly forming a light impenetrable boundary. The bottom layer of the lake is oxygen and light depleted. Few organisms can be observed, but e.g. an endemic ciliate has been discovered here. Hydrogen sulfide can also be detected in the effluent creek Faulenbach ("Fouling Creek"). Furthermore, bacterial diversity from the sulfuretum was studied using sequences of the phylogenetic marker molecule 16S rDNA. Phylogenetically, most of the detected bacteria were γ-Proteobacteria. More specific analyses grouped the bacteria mostly to the family Chromatiaceae.

A rapid method for 3D mapping and visualization of marine cave topography

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Abstract. In marine caves, site-specific topographic features play determinant role in the spatial distribution of cavernicolous assemblages. Mapping and visualization of cave topography constitute integral elements of any attempt to describe the cavernicolous environment and examine the potential mechanisms underlying the observed spatiotemporal physico-chemical and biotic variability. Underwater cave research is logistically challenging given the limitations in time, space and visibili-ty conditions. The described method provides an easy and flexible mapping sche-me for producing scaled 3D models of fully and semi-submerged caves in a rapid and cost-effective manner. The method can be applied by two divers over 1–2 de-dicated dives and requires a regular dive line, an inexpensive handheld echosoun-der, and standard diving equipment. Post-processing is performed automatically by the accompanying custom software. The realistic 3D cave representations en-able the depiction of particular geomorphological and biological features, thus facilitating the dissemination of scientific results to the wider community.

This research has been co-financed (01/2011 up to date) by the European Union (European Social Fund) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework - Research Funding Program: Heracleitus II. Investing in knowledge society through the European Social Fund. The first author also benefited from "Alexander S. Onassis Public Benefit Foundation" fellowship for postgraduate studies (10/2009-12/2010).

CEDIP Underwater Nature Guide – between scientific education and environmental protection

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Abstract. In the last 20 years SCUBA diving developed to very a popular sport – estimations about the global number of active recreational divers in 2012 come to several millions. A vast number of marine and limnic diving sites is visited one to several times a day by groups of divers, whereby on the one hand the divers collect authentic experiences, on the other hand they leave their marks.

Every dive in more or less intact habitats affords the opportunity to become acquainted with aquatic (and close-by terrestrial) living environments and their inhabitants, to learn to understand them a little and to esteem them sincerely. The learning effect, however, significantly depends on the previous knowledge on natural history, concrete (scientific) questions, alertness under water and the options to document and postprocess the experiences.

The destructive impact of divers on terrestrial and underwater worlds logically results from the frequency and severity of single interventions. Besides clearly apparent mechanical impacts on the Benthal and Benthos also any constructional, energetic and pollutant-related "side"-effects of traveling, residing, equipment production and disposal have to be considered. How long and how good intact nature and living conditions are preserved, depends inter alia on the cognition, valuation, attention and readiness to act of every single person involved in recreational diving. To meet the requirements of environment education and protection the today diver needs a training that concedes high importance to ecological aspects and minimally invasive diving performance and provides easily accessible and versatile opportunities for continuing natural studies.

Several established diving associations have established codes-of-conduct for sustainable diving and offer courses and seminars in the above mentioned, popular scientific spirit. Now, the European umbrella organization of professional diving instructor associations CEDIP (comité européenne des instructeurs plongée professionelle) in cooperation with the LMU-university Munich provides an own, sound skill enhancement module for diving instructors - the Underwater Nature Guide (UWNG) - with the objective to develop competent contact persons in the matter of hydrobiology and environment friendly diving in many places. The candidates have to pass a three-step training: (1) weekend seminar on the concept of UWNG and the content of an 85 page workbook (to be worked through in advance) with a written examination, (2) participation in an at least 5-day course on aspects of hydrobiology under professional supervision (depending on national options, disposable for natural scientists and teachers with university degree), and (3) elaboration, execution and evaluation/documentation of own teaching units in theory and practice relating to the local diving sites. The explicit suggestion for further reading and qualification is an essential element of the UWNG concept.

Having successfully absolved the UWNG training, the instructors should be able to offer guided dives and theory modules tailored to the local circumstances on request. In so doing they not only serve customer demands and the requirements of habitat- and species-protection, but additionally open up an exciting new facet of their dream job and an additional source of income:

Diving as a tool for environmental education

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Abstract. It is the aim of environmental education to stimulate the ecological awareness and the responsible environmental behavior by using all senses. The information Centre for the Schleswig-Holstein Wadden Sea National Park Multimar Wattforum tries to establish the personal dialog which is necessary for a sustainable environmental education.

Diving can also be used as an instrument for environmental education as it can be used variously. Diving sessions in the Multimar Wattforum are carried out according to GUV-R2112.

Animals and plants have to be collected before being presented to the visitors in a lifelike reproduction of nature. Diving proves itself as a very gentle method of catching for various species as the species could be collected selectively.

The diving sessions are carried out in dry suits because of the low water temperature. In the big aquarium of the Multimar the divers use a full face mask with microphone and headphones. The diver's earphones are connected to the lifeline which has the communication wires in its core. This provides clear and steady communications. A person above the aquarium follows the communication and is able to intervene in case of emergency by holding the lifeline connected with the diver.

Communication is one of the main topics in environmental education. During the diving sessions the visitors are able to put a question to the diver by use of a microphone handed to them by a presenter who moderates the show in the forum. The diver is able to answer those questions underwater due to his appropriate equipment. By this means it is possible to show the animals' mode of behavior and to answer or discuss morphological questions directly.

The key task of the diving sessions is the feeding of the bottom-dwelling animals. In case of a feeding from above those would not get enough food. On this occasion the diver is able to observe the animals closely. They are very tame and one can examine them for external injuries.

The cleaning of the aquarium panels is another important task during the diving sessions. This activity also offers the opportunity to communicate with the visitors and to give them an understanding of diving and the animals. Those activities are purposely carried out during the opening hours of the Multimar.

Special diving sessions also take place apart from the regular diving, e.g. diving as a Santa Claus or diving by night. Despite the fun of such an event the visitors can obtain interesting information from the diver.

Bioactive substances in a benthic prosobranch gastropod (Vermetidae, Mollusca) of the sublittoral

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Abstract. The sessile suspension-feeding gastropod Dendropoma maxima, Sowerby 1825 (Vermetidae, Littorinimorpha) is a dominant, very abundant encrusting species of outer tropical reefs and widespread throughout the Indo-Pacific. They mainly live in the infralittoral and upper-circalittoral between the breaker zone and the outer reef edge facing the current. Vermetids secrete a mucus net to capture planktonic prey for feeding. The nets are spread out over the corals and often have remarkable deleterious effects on them like changes in growth form and pigmentation shifts not uncommonly resulting in tissue necrosis. Until now, there is no explanation for this phenomenon although the indication as well as theories about its genesis are mentioned in several publications. Vermetids are well studied concerning the intraspecific competition with neighbouring individuals but not in their interaction with different species like corals or fish. We did extensive *in situ* video recording and observed not a single fish biting in the plankton-load nets even though several reef fish are known to be molluscivores, mucivores and/or feed on plankton. Due to many molluscs use chemical weapons to combat feeding pressure and to defend themselves against predators we screened empty and plankton-load mucus nets for potential bioactive metabolites. Bioactivity testing was performed with a recently developed system based on a chromatographic separation (High-performance thin-layer chromatography (HPTLC)) and a bioassay with luminescent bacteria *Vibrio fischeri*. Thus, we found at least two active compounds exclusively accumulated by the wormsnails themselves. This is the first record of bioactive properties in the whole family of Vermetidae.

Keywords:

Vermetidae, suspension feeding, bioactivity, marine natural products, chemical defence, interspecific competition, competitive advantage, mucus net

Underwater visual stimulation and videography of bivalve behavior

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Abstract. As a reaction to outer stimuli or inner urges, both, sessile and vagile animals show species-specific motor behavior (e.g. change of body posture, locomotion, eating, sheltering, social interaction etc.). Also mussels (Mollusca: Bivalvia) have a certain behavioral spectrum - as a rule it is little comprehensive, mostly inconspicuous and hence eluding the common notice. In this context the discrepancy of the restricted behavioral scope and the highly developed architecture of complex eyes and/or lens eyes at the mantle magin of certain species (e.g. from Pectenidae, Archidae) is of peculiar interest. Our project aims at the documentation, stimulation and analysis of visually guided behavior of several bivalve species in the natural habitat, and to better understand this complex but barely investigated aspect of mussel life in combination with histological and neuroanatomical examinations. For the field studies we had to compile and test a setup, that enables us to transmit video data (real time and time lapse) from the animal's location under water (max. 20 m of depth and 100 m distance from the operator) to a laptop ashore, and at the same time to face the animal with freely programmable visual scenarios in situ. For this purpose a HD dome network camera (Panasonic WV SC 385) was water-tightly encased below a custom-made acrylic glass dome and positioned at the sea floor by SCUBA divers (island of Murter, Croatia). Power supply, motor control and data transfer to a laptop were effected by means of a 100 m LAN cable. The projection of visual scenarios (BlueJ software) happened via a 12 inch Distec color-display within an Evamarine protective cover, again connected with the laptop via a 100 m LAN cable.

First under-water experiments were conducted with *Arca noae* and *Cerastoderma edule*. The sudden appearance of dark areas can trigger the closing-reflex in bivalves. In parallel 3D-histology and neuroanatomy of the eyes (*Arca noae, Barbatia barbata, Clamys varia*) and visual central nervous systems (visceral ganglion: *B. barbata*) was investigated at the EM-Lab of the BioCenter of the LMU Munich.

The combination of high quality technical components (though affordable due to large-scale production) made it possible to create and test a setup that enables us to undertake protracted behavioral measurements with acceptable spatial and temporal video data resolution. After first successes in the stimulation of behavioral reactions of mussels we now have to carry out test series to determine triggering levels (visual angle, contrast and speed of shadow stimuli). The morphological findings on the other hand allow the estimation of sensitivity, spatial resolution and, to a certain extent, the complexity of visual signal processing in the mussel "brain". The setup is also intended to investigate other animal groups with inconspicuous behavior like sedentary polychaets etc.

Diving as a tool for environmental education

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Abstract. It is the aim of environmental education to stimulate the ecological awareness and the responsible environmental behavior by using all senses. The information Centre for the Schleswig-Holstein Wadden Sea National Park Multimar Wattforum tries to establish the personal dialog which is necessary for a sustainable environmental education.

Diving can also be used as an instrument for environmental education as it can be used variously. Diving sessions in the Multimar Wattforum are carried out according to GUV-R2112.

Animals and plants have to be collected before being presented to the visitors in a lifelike reproduction of nature. Diving proves itself as a very gentle method of catching for various species as the species could be collected selectively.

The diving sessions are carried out in dry suits because of the low water temperature. In the big aquarium of the Multimar the divers use a full face mask with microphone and headphones. The diver's earphones are connected to the lifeline which has the communication wires in its core. This provides clear and steady communications. A person above the aquarium follows the communication and is able to intervene in case of emergency by holding the lifeline connected with the diver.

Communication is one of the main topics in environmental education. During the diving sessions the visitors are able to put a question to the diver by use of a microphone handed to them by a presenter who moderates the show in the forum. The diver is able to answer those questions underwater due to his appropriate equipment. By this means it is possible to show the animals' mode of behavior and to answer or discuss morphological questions directly.

The key task of the diving sessions is the feeding of the bottom-dwelling animals. In case of a feeding from above those would not get enough food. On this occasion the diver is able to observe the animals closely. They are very tame and one can examine them for external injuries.

The cleaning of the aquarium panels is another important task during the diving sessions. This activity also offers the opportunity to communicate with the visitors and to give them an understanding of diving and the animals. Those activities are purposely carried out during the opening hours of the Multimar.

Special diving sessions also take place apart from the regular diving, e.g. diving as a Santa Claus or diving by night. Despite the fun of such an event the visitors can obtain interesting information from the diver.

Poleward Range Extension of Foraminifera (Protista): Species Distribution Models of Current and Predicted Future Ranges

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Abstract. Climate warming and the poleward widening of the tropical belt have induced range shifts in a variety of marine and terrestrial species. To project future species distributions, we applied a species distribution model (SDM) to various species of larger foraminifera. Our model indicates that further warming is likely to cause a continued range extension, and projects poleward range expansions of up to 4° latitude for the year 2100 (up to 13 km year-1).

Introduction

Climate warming and the poleward widening of the tropical belt have induced range shifts in a variety of marine and terrestrial species. Range expansions may have broad implications on native biota and ecosystem functioning as shifting species may perturb recipient communities. Larger symbiont-bearing foraminifera constitute ubiquitous and prominent components of shallow water ecosystems, and range shifts of these important protists are likely to trigger changes in ecosystem functioning. We have compiled global occurrence records to compute current range shifts of larger foraminifera. The study provides new evidence that selected species of foraminifera are rapidly progressing polewards, and that shifting of key species impact native communities. To project future species distributions, we applied a species distribution model (SDM) based on ecological niche constraints of current distribution ranges. Our study focusses on the following taxa: *Amphstegina* spp., *Calcarina* spp., and *Archais angulatus*. The extended abstract provided here focusses on the larger symbiont-bearing miliolid *Archais angulatus*. Unlike many other larger foraminifera, this species has a predominantly Caribbean distribution. It is among the most abundant species of foraminifera in shallow-water reefal and lagoonal system at depth between 0 and 60 meters.

Material & Methods

A total of ~ 100 records of three foraminiferal species have been available through previous research on the biogeography of larger foraminifera (Langer & Hottinger, 2000, Langer et al, 2012). Occurrence records were computed for *Amphistegina* spp., *Archaias angulatus*, *Calcarina* spp. All of these records were situated within unique grid cells of 4 km. The accuracy of coordinates was assessed with DIVA-GIS 7.1.7 by comparing information provided with the records with locality (landshape, bathymetry).

Information on oceanographic data was obtained from remotely-sensed data sets. For sea-surface temperature (SST) we used daytime (maximum temperature in °C) and nighttime (minimum temperature in °C) monthly averages from 1985 to 2007 from the AVHRR Pathfinder data set with a resolution of 4 km. For salinity [psu], nitrate concentration [µmol/l], phosphate concentration [µmol/l]and silicate concentration [µmol/l]we used annual mean images from the World Ocean Atlas 2005 in 0.25° and 1° resolution. The datasets were converted to raster formats compatible with GIS-programs and, if necessary, interpolated with ArcGis 9.3 using a smoothing spline of available oceanographic values and landshape as limiting barrier. Annual mean temperatures were calculated from the monthly averages with DIVA-GIS.

As a future climate change scenario, we obtained the AquaMaps dataset, which describes variations in SST as expected in 2050. The grids were overlaid by a bathymetry-grid derived from the ETOPO1 Global Relief Model, leaving only the coastal regions between 0 and 1350m water-depth. We used Maxent 3.3.3a to model the potential distribution of the foraminiferal species and project them into geographic space. The program uses a grid-based machine-learning algorithm following the principles of maximum entropy.

The logistic output format with suitability values ranging from 0 (unsuitable) to 1 (optimal) was used (Phillips & Dudik, 2008), where the probability of presence at sites with typical conditions is set to 0.5 (Elith et al., 2011). The SDMs were created in a two-step modeling process in order to avoid a biased relation between the variables temperature and the ion concentrations (previous modeling attempts resulted in an unlikely high contribution of salinity in expense of other variables). In the first SDMs, we used only SST which was subsequently projected on the future climate scenario. The second SDM was built on salinity, nitrate, phosphate and silicate. In doing so, we achieved a climate-model based on temperature which was later overlaid and clipped by a habitat-model based on ion concentrations. The editing of the climate model was performed with DIVA-GIS.

Results

The AUC-values received from the climate-Species Distribution Model (SDM) provide an explanatory data set for *Archaias angulatus* ($AUC_{training}$: 0.8374;
AUC_{test}: 0.8394), *Amphistegina* spp. ($AUC_{training}$: 0.8096; AUC_{test}: 0.7858) and *Calcarina* spp. ($AUC_{training}$: 0.7616; AUC_{test}: 0.7669). The evaluation of the variable contribution with regard to ion concentration in the habitat-models showed that for *Archaias angulatus*, "phosphate concentration" had the highest explanatory power (94.8 %). For both *Amphistegina* spp. and *Calcarina* spp. "nitrate concentration" was deemed the most useful variable for the building of the SDMs (67.9 % and 82.4 %, respectively).

Under current climate conditions, all three taxa displayed distributional ranges quiet consistent with their native occurrences. The native distribution of *Archaias angulatus* lies within the Western Atlantic Ocean, mainly within the Caribbean. Its latitudinal range expands from 32° N in Bermuda to 4° S in Fernando de Noronha, Brazil (Langer & Hottinger, 2000). The SDM based on current climatic conditions displayed a potential distribution, which is overall well presenting the actual core region of *Archaias angulatus* (Fig. 1). In the North, the model suggested habitat suitability up to 33° N, with an area of relatively low suitability along the northern part of Florida, Georgia and South Carolina. In the South, the model predicted the potential distribution of *Archaias angulatus* to extend to 23° S, up to Rio de Janeiro in central Brazil.

Under future conditions, areas of highest habitat suitability for *Archaias angulatus* were predicted to expand, resulting in an area-wide coverage of the Caribbean Sea from Southern and Eastern Florida (30° N) to Bahia in Brazil (11° S). The additional areas in the Pacific and Eastern Atlantic Ocean were also suggested to increase their suitability. The latitudinal range of *Archaias angulatus* was predicted to expand both to the North and to the South. The expected range expansion in the North was 2 degrees (approximately 220 km), up to 35° N, resulting in acceptable habitat suitability for *Archaias angulatus* along the coast of North Carolina. The Southern range limit will presumably lie at 27° S, at Santa Catarina province in Brazil, which would lead to a range expansion by 4 degrees (about 450 km).

Discussion

The SDMs created in this study for *Archaias angulatus* provides new insights into distribution patterns and ecological constraints regulating these patterns in larger foraminifera. Furthermore, the SDMs offered an outlook to possible effects of future climate change on the distribution. As we analyzed the influence of environmental parameters on the distribution of the taxon, we observed that *Archaias*

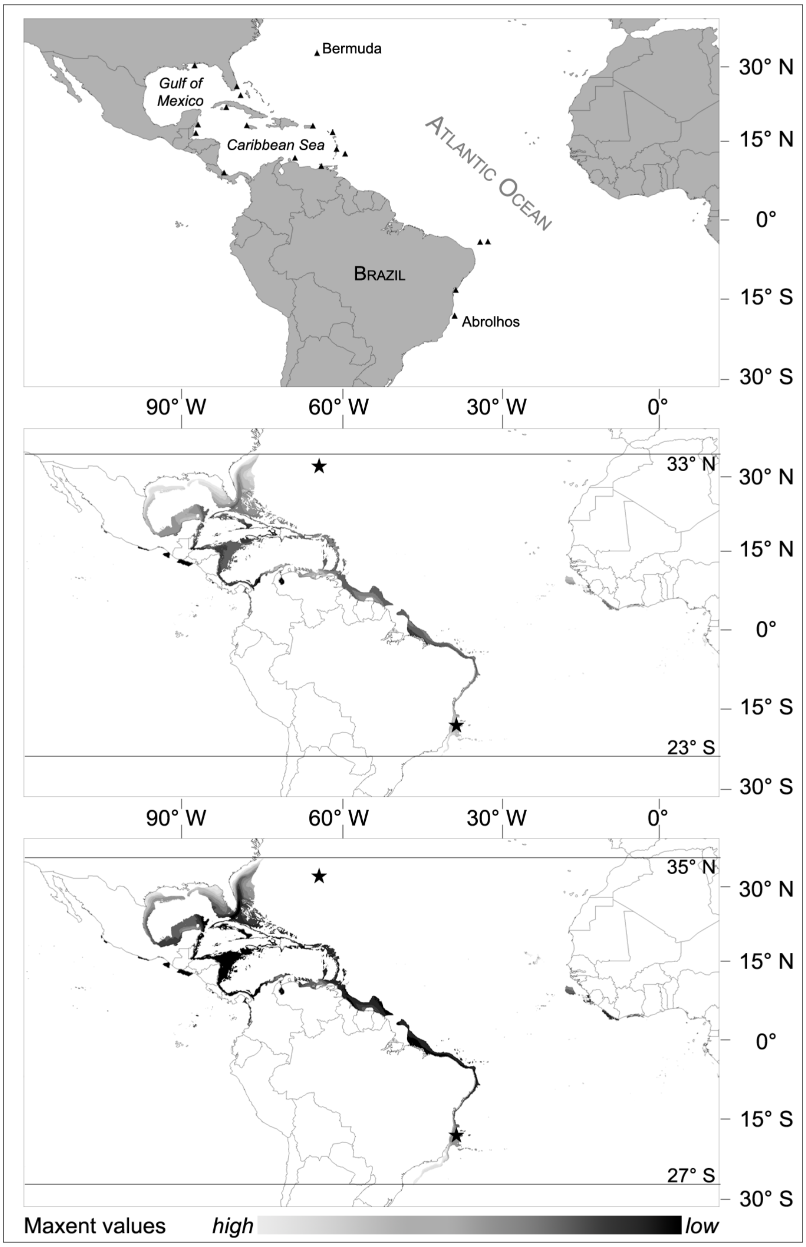

Fig.1. Species distribution model for *Archais angulatus* showing range expansion scenarios under future climate conditions

angulatus did not occur in temperature regions below 22° C and that 60 % of all occurrence records lay in regions that exceed 28° C of annual mean water temperature (Fig. 1). The Northern border of the distribution range of *Archaias angulatus* is limited by the separation of the warm Gulf Stream from the coast. North of Florida, the coastal waters become significantly colder as the Gulf Stream follows the outer continental shelf before turning east.

All of the studied taxa displayed a suggested range expansion with future climate warming (Fig. 1). These results are consistent with observations of range expansions during the last decades, which have been reported from various marine and terrestrial taxa. Recently it has been stated that these range shifts occur at a much faster rate than previously assumed. Range shifting and species invasions due to rising sea surface temperatures have been documented for numerous taxa (Lejeusne et al. 2009; Zenetos et al., 2010) including foraminifera (Langer, 2008; Koukousioura et al., 2010; Langer et al., 2012). It is known that larger foraminifera have shown wider latitudinal ranges and increased abundances during exceptionally warm periods in earth’s history (Langer & Hottinger, 2000; Goldbeck & Langer, 2008).

Conclusions

Our SDM model indicates that further warming is likely to cause a continued range extension, and predicts a poleward dispersal. The average rates of foraminiferal range shift were computed between 0.5 and 4° for the year 2100.
Distribution patterns of larger foraminiferal taxa like *Archaias angulatus* are mainly governed by temperature and restricted by specific isotherms. Under future climate conditions, all of the studied taxa displayed potential latitudinal range expansions and local increases in habitat suitability, suggesting that some larger foraminifera may represent important carbonate producers under future climate conditions. The fossil record of larger foraminifera provides abundant evidence, that selected species (e.g. nummulitids) may constitute important carbonate producers under much warmer climates. Our results thus corroborate findings from the fossil record, that some larger symbiont-bearing foraminifera cope well with rising water temperatures and are beneficiaries of global climate change.

Acknowledgements

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Georeferenced UW-video taken by divers

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Abstract. Georeferencing is not a problem for terrestrial work – we have GPS now! But there are physical reasons that prevent the reception of electromagnetic waves in water, and hence also the direct reception of GPS signals. That’s why it is not possible to take the GPS receiver without external antenna below water, because high frequency Radio waves (L1 1.575,42 MHz; L2 1.227,60 MHz) that transmit the GPS signal are not able to penetrate the water column more than a few centimeters. Different methods are used to circumvent the problem. A gateway is required between the GPS receiver and a surface buoy containing the GPS antenna; this can be a cable or an acoustic signal linking both units. But sometimes it is not necessary for the diver to get an accurate information of his current place and it is sufficient to know the dive track later. And later means that it is possible to associate a video frame to a geographical position e.g.. It is obviously an important task to be solved: However, the deviation between the diver’s position (he can carry a GPS receiver or not) and the surface buoy increased the positioning error under some circumstances. A special situation was given when the divers used a scooter for locomotion. This error term was corrected quantitatively using specific algorithms and information about heading and additional cable length in relation to water depth. We used a Garmin 76csx handheld connected to an antenna for our studies. Images and video sequences were georeferenced using interpolated positions from the tracks, which were recorded every 5 seconds. Ideally these data are accompanied by other georeferenced physical and chemical datasets. We used in some of our studies diving depth or CTD data as additional information. Cable-towed GPS receivers have been recently used by the authors in biodiversity studies in the Antarctic as well as in archaeological projects in Northern Chile and in monitoring studies in the Baltic Sea.

Keywords: Scientific diving, UW-GPS, Georeferencing of uw-foto, uw-video, uw-sampling, correction of positioning errors

Monitoring of the invasive American bullfrog *Lithobates catesbeianus* (Shaw, 1802) in small shallow water bodies in Germany

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Abstract. Biological invasions of the American bullfrog *Lithobates catesbeianus* (Shaw, 1802) are one of the most serious threats in small shallow water bodies to biodiversity outside of North America. In the Northern Upper Rhine Area in Germany, several bullfrogs and their tadpoles have been observed during the last years. Only little information about patterns and processes of establishment of the bullfrogs are available. Repeatedly frogs have been caught in the past to reduce the number of animals, however, it can be assumed that there are already well established populations. We monitored the bullfrog population in one pond by scuba-diving in order to get a deeper insight into the life-cycle of the bullfrogs in Germany.

Forschungstauchen als Methode am Institut für Ostseeforschung

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Abstrakt. Die marine Forschung ist traditionell ein Schwerpunkt im wissenschaftlichen Leben nicht nur an verschiedenen Fakultäten der Universität Rostock, sondern auch in anderen Einrichtungen der Hansestadt. Im Leibniz-Institut für Ostseeforschung, an der Landesforschungsanstalt für Fischerei MV, im Verein Fisch und Umwelt e.V. oder auch beim Verein für UW-Archäologie MV spielt das wissenschaftliche Tauchen bei der Erfüllung der Projektaufgaben stets eine bedeutende Rolle.

Am Institut für Ostseeforschung wird das Forschungstauchen vor allem in der Geologie, der Biologie und vor allem bei der technischen Umsetzung von Meßaufgaben angewendet. Dabei arbeiten wir mit den oben genannten Einrichtungen eng zusammen.

Das Poster soll zeigen wie diese Arbeiten aussehen und welchen Anforderungen erfüllt sein müssen. Es wird dargestellt wie die Methoden aussehen und welche Hilfsmittel verwendet werden. Speziell am Beispiel der Wartung von Meßstationen werden die Aufgaben erläutert. Daneben wird die Kooperation im Bereich des künstlichen Riffes vor Nienhagen und bei der Unterwasserarcheologie gezeigt.

Scientific Diving in Polar Regions – An Essential Tool in Marine Research

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Abstract. The use of scuba diving in marine research provides multiple advances. Selective and low invasive sampling, continuous monitoring in structurally complex habitats and the set-up of even complex experiments is often only possible by assistance of a trained group of scientific divers on site. In Germany, scientific diving is best done in compliance with the "Rules for Scientific Diving" (BGR/GUV – R 2112). These rules provide a save and effective framework to support scientific projects and to conduct in situ research even in extreme environments and under rough conditions like in the Polar Regions. With the two land based stations Koldewey- (AWIPEV-) Station and Dallmann-Laboratory the Alfred-Wegener-Institute operates two well equipped bases for polar diving and has built up a high level of expertise with meanwhile far more than 3500 dives in Arctic and Antarctic water.

Scientific Diving at the Leibniz Center for Tropical Marine Research

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Abstract. Advances in science have frequently been attributed to the use of new tools. The invention of the Cousteau-Gagnàn Aqualung for example provided access to the sublittoral and enabled ecologists to conduct experimental in situ work. Scientific diving has become an indispensable method in marine science, and the Leibniz Center for Tropical marine Ecology GmbH (ZMT) is dedicated to coastal marine ecology and thus heavily dependent on diving. Realizing the crucial importance of SCUBA diving for excellence in science, the ZMT is committed to expand its capacity by setting up a specialized dive unit that will support its four departments through advice and logistics, but also by offering specialized training. To this end, the ZMT turned to the German Commission for Research Diving (KFT) and in collaboration with the Alfred Wegener Institute for Polar and Marine Research started developing a government recognized training course for tropical research diving. As a research facility working exclusively in the tropics, the ZMT intends to make its expertise in tropical scientific diving available to others, and last not least train the next generations of marine research to the highest standards.

MarGate - the underwater *in situ* lab off Helgoland

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Abstract. "MarGate" is a 270 x 60 m large underwater experimental area off Helgoland installed in February 2010 with support of the company HC-Hagemann. The field is designed as experimental facility to study processes in costal hard-bottom ecosystems and to develop and test state-of-the art scientific equipment in high-energy (stormy) coastal environments.

The area comprises 3 tetrapod-fields (four-footed concrete breakwaters) in the 5 and the 10 m depth stratum each serving as study object for the effects of complex structures in strong tidal environments. Furthermore the structures serve as carrier system for *in situ* experimental installations.

Since summer 2012, the MarGate "lab" contains the first German COSYNA (Costal Observation System for Northern and Arctic Seas) underwater node system. This system provides online measurements of the main abiotic and biotic variables (temperature, salinity, depth (tide), turbidity, oxygen, chl-a fluorescence, 3D-current) in real time (1 Hz). Recent projects at the node system focus on online zooplankton and fish recording devices.

The technical systems of the COSYNA node are operated by the Helmholtz-Zentrum Geesthacht (HZG) in close cooperation with the Alfred Wegener Institute for Polar and Marine Research. The AWI Center for Scientific Diving, located on Helgoland, provide access to the experimental field all the year round.

The experimental field MarGate and its technological components are specifically designed for national and international cooperation in the field of climate change related sciences and offer joint projects to external researchers.

Integrative taxonomy of marine organisms: A case study of diatoms and porifera

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Abstract. The observation of elusive and difficult or unexplored areas is supposed to discover new species. However also rather well examined regions like e.g. the northern Adriatic Sea (NA) are spatially highly structured and diverse ecosystems containing almost unexamined mini habitats. Our examination of such mini habitats revealed an unexpected high content of species knew to the area and new to science. We present a case study of diatoms and porifera using integrative taxonomy. Chosen taxonomic markers were the 18S and 28S rDNA sequences, morphological features that were observed with microscopic methods and in some cases ecological data. Diatom species from the NA showed a high degree of complexity in spatial and temporal distribution. However the combination of molecular and morphological as well as ecological characters delivered a more accurate and detailed view on the NA ecosystem. In searching the benthic habitats as well we also found a new sponge from the genus Clathrina. Based on molecular and morphological data we were able to characterize a novel sponge species.

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