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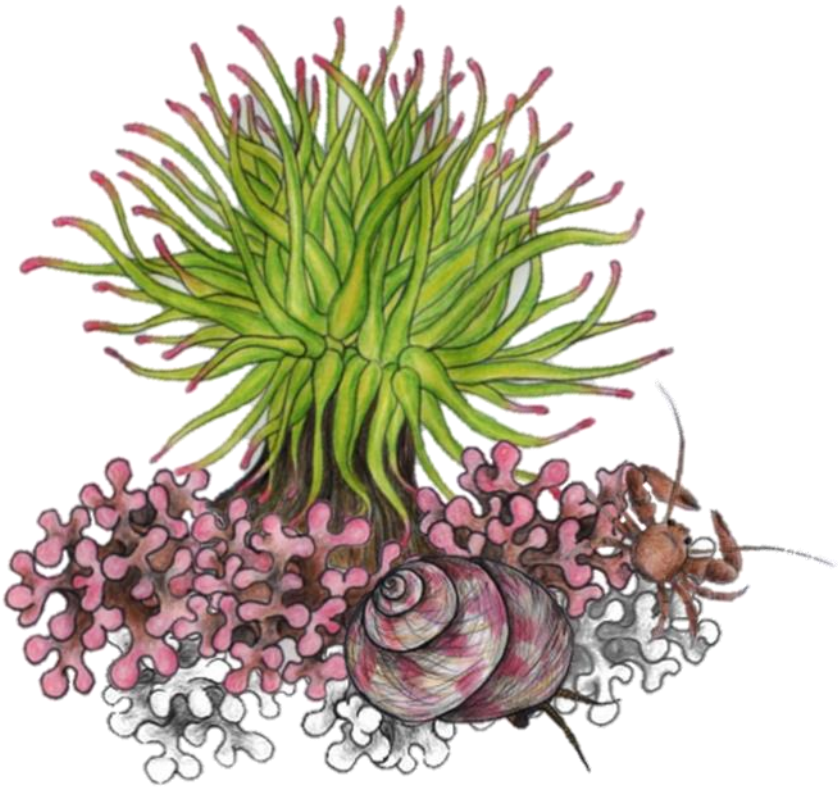

Abstract book

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Taxonomy

Molecular systematics: toward understanding the diversity of Corallinophycidae

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Coralline red algae conform an extremely diverse group with a global distribution and ecological relevance. Since Philippi (1837) recognized them as photosynthetic organisms, their taxonomy and systematics has been influenced by different methodological approaches. Nowadays, the application of molecular phylogenies using comprehensive datasets fostered our understanding of their affinities within the Florideophyceae. The extensive fossil record left by corallines has been also employed as a timeline for calibrating phylogenies. In the recent years, the achievement of sequencing type specimens with a relatively high success allowed us to bridge the gap between operation taxonomic unit and taxonomic names. The extensive molecular data obtained from recent collections enabled us to redefine the species distribution. In addition, the DNA barcoding approach became a useful tool to assess the species diversity and to reveal cryptic diversity in taxa that passed by under the same morphological species name. However, further research is still needed in regions and habitats that have not been studied in detail yet, such as the rhodolith beds in the Western Pacific (Kato et al. 2017). Here it is presented an on-going DNA barcoding study conducted in rhodolith beds located in two areas of the eastern coast of Japan (Shimoda and Shikine-jima).

Keywords: calibrated phylogeny, DNA barcoding, diversity, maerl, rhodolith, species distribution, systematics, taxonomy, type collections

*Speaker

Simplified coralline specimens' DNA preparation, mini barcoding & HRM analysis targeting a short psbA section

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The CoralAlg-project, funded by the Norwegian Biodiversity Information Centre, aims at assessing the coralline species diversity of maerl beds along the Norwegian coast. Toward this goal, molecular systematic methods were used along with traditional morphological studies for species identification. Corallines typically show high levels of morphological variations within a species as well as convergence between phylogenetically distant taxa, DNA barcoding is therefore the preferred method for accurate species identification. Hence, one of the objectives of the project was to develop a simple method for barcoding this group. Using a subset of 47 specimens collected in five localities during surveys conducted in 2016, we showed that direct DNA preparation method without any purification step was of sufficient quality for qPCR and sequencing. For DNA barcoding, we developed a new *psb*A qPCR assay producing a 350bp product (about half size compared to traditional barcoding assays). A shorter product is advantageous making the assay more robust by allowing more degraded DNA to be amplified. However, the shorter fragment needs to retain sufficient variability to fulfil its taxonomic identification purpose. We showed that our new assay successfully differentiated eight taxa in total amongst which two closely related maerl-forming species, *Lithothamnion* cf. *glaciale* and *Lithothamnion erinaceum*. Finally, high resolution melt analysis was successfully applied to the qPCR assay for identification of *L. cf. glaciale* and *L. erinaceum*.

Keywords: Maerl, biodiversity, corallinales, rhodolith, sequencing, HRM, psbA, barcoding, mini barcodes, DNA preparation

*Speaker

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Reassessment of Lithophyllum kotschyanum and L. okamurae in the North-Western Pacific Ocean

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Lithophyllum kotschyanum and *L. okamurae* are common in the North-Western Pacific Ocean, both have warty to fruticose thalli and *L. okamurae* often forms rhodoliths. Three formae of these species have been described in this region; *L. kotschyanum* f. *subtilis, L. okamurae* f. *okamurae* and f. *angularis*. *Lithophyllum okamurae* f. *trincomaliensis* and f. *valida*, described from the Indian Ocean, were thought to be heterotypic synonyms of *L. okamurae* f. *okamurae*. However, this set of taxa have never been revised in a modern taxonomic context. Here, morphological data and DNA sequences (partial LSU, *psb*A and *rbc*L) were obtained from the type specimens of the above-mentioned formae and compared with branched *Lithophyllum* specimens recently collected in shallow water off Japan and the Philippines. Specimens of *Lithophyllum okamurae* from Japan were genetically divided into two independent lineages, which were conspecific with type materials of *L. okamurae* f. *okamurae* and f. *angularis*. The lectotype of *L. okamurae* f. *okamurae* should be reassigned because all original material was identified as f. *angularis*. We found that specimens of *Lithophyllum kotschyanum* from Japan and the Philippines were also genetically divided into two independent lineages. One (from Japan) was the widespread tropical taxa *L. kaiseri* since *rbc*L sequences matched the *L. kaiseri* isolectotype. The other lineage (from Japan and the Philippines) did not match to any known *Lithophyllum* species in our molecular analyses and is likely to be a new species. Our study of *L. kotschyanum* and *L. okamurae* in the NW Pacific Ocean shows that these two taxa are in fact made up of seven species and that *L. kotschyanum* f. *subtilis*, *L. okamurae* f. *trincomaliensis* and f. *valida* should be raised to specific rank. Further studies are required to assess the distribution of these species and the presence of other related species.

Keywords: Molecular phylogeny, nongeniculate coralline algae, branched Lithophyllum species

*Speaker

Phymatolithopsis gen. nov. (Hapalidiaceae, Rhodophyta) based on molecular and morphological evidence

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In the Hapalidiaceae, the genus *Phymatolithon* was established by Foslie (1898) for a single previously described species, *P. polymorphum* (L.) Foslie. The basionym of *P. polymorphum*, *Millepora polymorpha* L. is a superfluous substitute name *for Millepora calcarea* Pallas, and consequently the correct name of the type species of *Phymatolithon* is *P. calcareum* (Pallas) Adey & McKibbin. Since 1898, at least 47 specific and infraspecific taxa have been referred to the genus, and it has undergone several changes in circumscription. Currently, 17 species of *Phymatolithon* are recognized mostly based on morphological analyses. However, the genus *Phymatolithon* has been known as polyphyletic group during long time. A multigene phylogeny of the genus *Phymatolithon,* using COI-5P, *psb*A, and *rbc*L, was constructed to assess generic boundary. Based on our morphology and molecular analysis, we have concluded that some *Phymatolithon* species represent a distinct new genus *Phymatolithopsis*.

Keywords: COI 5P, Hapalidiaceae, morphology, Phymatolithon, Phymatolithopsis gen. nov., psbA, rbcL, taxonomy

*Speaker

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Morpho-anatomical descriptions and DNA sequencing of the species of the genus Porolithon occurring in the Great Barrier Reef

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Crustose coralline algae from the genus *Porolithon* are one of the most common, abundant and important organisms in tropical coral reefs. As a reef-building species, *Porolithon* not only cements the reef framework but also provides essential habitat for a number of marine organisms. In addition, some species of this genus (e.g. *Porolithon onkodes*) are highly sensitive to ocean acidification, making them ideal climate change indicators. Despite the key ecological roles *Porolithon* play in coral reefs, very little is known about basics aspects of its biology, taxonomy, ecology and evolution. Over the past few years, we have focussed on filling in some of those gaps, in particular we are aiming at providing a floristic account of the species belonging to this genus on the Great Barrier Reef (GBR), Australia. Importantly, our own molecular data and those from other research groups show that there are numerous species of *Porolithon*, however, the most significant species of smooth, reef building (encrusting forms) taxa lack obvious morphological and anatomical characteristics. Therefore, it is vital for algae ecologists to be able to recognise different species within the genus. The aim of this study is to provide detailed descriptions of the most common *Porolithon* species from the GBR by collating morpho-anatomical and molecular data and presenting this information in a comprehensive format to facilitate their taxonomic identification and recognition in the field. Using histology, scanning electron microscopy (SEM) and DNA sequences (*psb*A, COI, SSU and LSU) we have been able to recognise 7 taxa in the GBR. In this presentation, we will present preliminary results from our taxonomic and phylogenetic analyses and discuss potential characteristics that may be useful to identify the most common *Porolithon* species in the GBR. This information will greatly assist future ecological studies, ocean acidification and warming experiments and reef monitoring programs.

Keywords: Taxonomy, red algae, Corallinaceae, DNA barcoding, sequence diversity

*Speaker

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Ecophysiology

How do rhodoliths get their energy?

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In this talk, I will explore how rhodoliths take up and assimilate inorganic and organic material for photosynthesis and growth. By presenting results from a series of studies using microsensors and stable isotopes, I will discuss the flexibility of carbon concentrating mechanisms in rhodoliths and the implications this has for their adaptation to climate change. Furthermore, I will present evidence that rhodoliths take up and assimilate organic matter, how this relates to their morphology and ecology, and how this trait may be a key adaptation to low light environments.

Keywords: carbon concentrating mechanisms, organic matter, stable isotopes, microsensors

*Speaker

Effect of seawater carbonate chemistry and other environmental drivers on the calcification physiology of two rhodoliths

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To better understand the calcification mechanisms of coralline algae it is critical to determine the extent to which seawater carbonate chemistry influences their physiology, most notably the chemistry of the calcifying fluids (CF), where the skeleton forms. In addition to carbonate chemistry, natural variability in pH, flow, and light could all potentially modulate the response of reef organisms to ocean acidification. We specifically designed three laboratory experiments to investigate and understand the role of all of these drivers for the physiology of coralline algae. One experiment investigated the role of pH variability, one the combined effect of water velocity and light, and the last one was created to separate the effects of the different species of the carbonate systems. Flow, Light, pH variability and carbonate chemistry speciation affected the physiology of the organisms to a certain degree. We found that there were complex interactions between chemical conditions in the calcifying fluid and conditions in the surrounding seawater. We also found that despite the role played by these environmental drivers, the rhodoliths had a great control on their internal chemistry and were able to withstand a large range of environmental conditions. Understanding the key mechanisms controlling coralline algae calcification is critical to making further progress in determining their future in a more acidic ocean.

Keywords: Calcification, Calcifying flluid, Flow, Light, pH variability

*Speaker

Short- and long-term effects of high CO2 on the photosynthesis and calcification of the free-living coralline algae Phymatolithon lusitanicum

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The combination of ocean acidification (OA) and global warming is expected to have a profound effect on marine ecosystems, particularly those dominated by calcifying algae, such as m'aerl beds. While OA is widely identified as a global stressor for these algae, it is yet unclear how the higher availability of CO2 will affect fundamental metabolic processes like photosynthesis, respiration and calcification, particularly when combined with high temperature. Contradictory results have been reported, possibly due to different experimental approaches such as duration of exposures and co-influence of other factors. Here we report results from both short- and long-term experiments, in which *Phymatolithon lusitanicum*, the most common m'aerl species of southern Portugal, was submitted to different levels of pCO2 and temperature. In a short-term experiment, we tested the effects of temperature and CO2 on the net photosynthesis, respiration and calcification of *P. lusitanicum*. After 1 month of exposure at different temperatures and 15 days of high CO2, photosynthesis, calcification and respiration increased with temperature, and these responses were enhanced by high CO2. The same parameters were also evaluated in a long-term experiment (20 months), in which the algae were grown at three different pCO2 levels. Both the photosynthetic and calcification rates increased with CO2 after the first 11 months, whereas respiration slightly decreased. After 20 months, the pattern was reversed, suggesting that a metabolic threshold was exceeded. Acidified algae showed lower photosynthetic and calcification rates, as well as lower accumulated growth. Our results indicate that, in a short-term, the positive effect of global warming on the algae metabolic rates will be accentuated with increasing CO2, while in the long-term, exposure to high CO2 will decrease the resilience of *P. lusitanicum*, particularly in the shallow-water communities. The results also suggest that the time of acclimation is a determinant factor in ocean acidification experiments.

Keywords: ocean acidification, photosynthesis, calcification

*Speaker

Physiological responses of tropical (Lithophyllum pygmaeum) and temperate (Corallina officinalis) branching coralline algae to future climate change conditions

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Anthropogenically-induced ocean acidification, warming and declining water quality are major threats to the health of tropical and temperate marine ecosystems worldwide. Coralline algae play fundamental roles in these ecosystems, providing vital habitat and shelter to numerous invertebrates in temperate intertidal and subtidal areas, while cementing and stabilising the reef framework on tropical reefs. However, despite their importance few studies have examined how these key ecosystem engineers will be affected by future environmental changes. Understanding the impacts of rising pCO2 and its interaction with other key photosynthetic drivers such as temperature, irradiance and nutrient levels is fundamental to understanding, predicting and mitigating the impacts of ocean acidification and climate change in the upcoming years. The aim of our research was to examine the individual and interactive effects of increased pCO2, temperature, nutrients and irradiance on the growth rate and algal metabolism of two abundant branching coralline algal species in two separate studies. The first study focused on the effects of increased pCO2, nutrients and irradiance on the tropical, non-geniculate coralline alga *Lithophyllum pygmaeum* from the Great Barrier Reef. The second, on the effects of increased pCO2, temperature and irradiance on the temperate geniculate *Corallina officinalis* from the west coast of Scotland. The highlight of these multifactorial experiments was the significantly increased growth rate under high pCO2, which was further enhanced when combined with increased irradiance. Metabolic responses (i.e. net productivity and photosynthetic efficiency) to the experimental treatments were less clear than growth responses, and under some treatment combinations showed opposing trends. The results from these two studies highlight the importance of multifactorial experiments to gain a better understanding of the interplay between ocean acidification, warming, nutrient pollution and other environmental processes.

Keywords: Growth, physiology, ocean acidification, warming, nutrients, light

*Speaker

Role of evolutionary history in the responses of tropical crustose coralline algae to ocean acidification

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Crustose coralline algae play important roles in the ecology and functioning of tropical and temperate ecosystems. In coral reefs, CCA are critical in strengthening reef framework through cementation and substrate stabilisation, and some species induce settlement of coral larvae, thus contributing to coral reef recovery. While significant progress has been made in the field of ocean acidification and warming impacts on CCA, little is known about the variability in responses among coralline algal species to climate change, or, the role of their evolutionary history as drivers of such responses.

To address this we examined the responses of CCA from different evolutionary lineages to ocean acidification and warming in the northern Great Barrier Reef, Australia. The selection of species included representatives of basal (Sporolithales) and more derived groups [Hapalidiaceae, Lithophylloideae, and Mastophoroideae]. We assessed a range of physiological (photosynthetic oxygen evolution, maximum quantum yield, carbon stable isotope values), mineralogical (mineral composition) and individual (growth, calcification, survival) responses across species from different lineages to gain insights into potential mechanisms and processes driving the observed variability in response to ocean acidification and warming.

In this talk, we will present preliminary results from these experiments and discuss the outcomes in the context of the evolutionary history of the CCA. Our study provides insights into the biological traits that may have facilitated the survival and success of some CCA to past ocean acidification and warming events. This information is also important to predict species, or groups of species that may be more sensitive to rapid climate change, and potentially understand ecosystem functions that may be more at risk as a consequence of increased CO2 emissions to the atmosphere.

Keywords: Crustose coralline algae, Great Barrier Reef, ocean acidification, ocean warming, calcification

*Speaker

Coralline algal recruits gain tolerance to ocean acidification over successive generations of exposure

Christopher E. Cornwall *† [1,2,3], Steeve Comeau [1,2,4], Thomas Decarlo [1,2], Ellis Larcombe [1], Billy Moore [1], Quentin D'alexis [1], Kurt Giltrow [1], Francesca Puerzer [1], Malcolm Mcculloch [1,2]

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Ocean acidification is a major threat to calcifying marine organisms globally. However, some calcifying species already encounter natural diurnal pH variability exceeding the changes expected in the open ocean by the end of this century. It has been hypothesized that regular exposure to low pH could give resident organisms enhanced tolerance to ocean acidification. Additionally, high pH during the day due to macroalgal photosynthetic drawdown of dissolved inorganic carbon in these habitats has also been hypothesized to offset some of the impacts of ocean acidification. Here we conduct laboratory experiments aimed to investigate whether past exposure to low pH at night enhances the tolerance of a resident coralline algal population (*Hydrolithon reinboldii*) to ocean acidification compared to a nearby population of the same species that has not been exposed to low pH on a regular basis. We simultaneously examine how high pH variability (0.8 units daily) interacts with the effects of ocean acidification (0.4 unit decrease) over eight generations of exposure for both populations. We find that past exposure to nightly low pH did not provide coralline algae with enhanced tolerance to ocean acidification. After four generations of exposure to low pH, both populations of coralline algae began to display more robust responses to ocean acidification, with little impacts of pH variability. When half of all individuals were switched to treatments with the opposing means (i.e. pH 8.05 to 7.65 treatments and vice versa), coralline algae grown within ambient pH treatments for 7 generations grew much slower than those that had grown within ocean acidification treatments for 7 generations when both were exposed to ocean acidification. Our results demonstrate the importance of determining the impacts of climate change stressors across longer timeframes using robust experimental designs.

Keywords: ocean acidification, environmental variability, past environmental history, adaptation, trans, generational acclimation, coralline algae, coral reefs

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Rhodolith communities in a changing ocean: species-specific responses of Brazilian subtropical rhodoliths to global and local stressors

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Rhodolith beds, like many other marine ecosystems, are affected by the ongoing global climate change, which unfortunately doess not represent the only peril for these communities, as world's oceans are simultaneously affected by multiple human activities. Recent studies suggest that beside impacts of single stressors, the combined effects of climate change-related and local stressors on marine organisms will potentially change the community structure and lower the resilience of these marine systems even further, due to their potential interactions. In Brazil, rhodoliths form one of the most extensive benthic ecosystems along the coast. However, despite their vast distribution and ecological and economic importance, studies on rhodoliths in Brazil, related to the impact of the ongoing climate change and the possible interactions with local stressors, are almost non-existent. Thus, in the present study, we investigated the individual and combined effects of increases in temperature and nutrient concentration on the physiology of two dominant rhodolith species from the subtropical region of the Brazilian coast, *Lithothamnion crispatum* and *Mesophyllum erubescens*. The results showed species-specific responses, with an increase of respiratory demands at higher temperature in *L. crispatum* that resulted in significant lower net photosynthesis, while photosynthesis in *M. erubescens* was not affected. In contrast, elevated nutrient concentration did not have an effect on photosynthesis in either species. The differences between species were also reflected in other measured parameters, such as pigment concentrations and nutrient assimilation. At the community level, the species-specific differences in susceptibility to temperature increase might have potential consequences on future rhodolith bed community structure, which in turn will affect the associated fauna and flora. Also, even though higher nutrient levels are not seemingly affecting the productivity of the rhodoliths, a potential effect on the rhodolith bed-associated flora might result in even further changes in the community structure.

Keywords: temperature, nutrient enrichment, photosynthesis, nutrient assimilation, climate change

*Speaker

Maerl bed community physiology is impacted by elevated CO2

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Marine organisms are facing an increasing risk of acute (short-term) and chronic (long-term) CO2 exposure from natural and / or anthropogenic factors. It has been widely observed in both the laboratory and the field that elevated CO2 negatively impacts calcifying algae, including maerl/rhodoliths and crustose coralline algae (CCA). Importantly, the rate of change in ocean carbonate chemistry is known to be a vital determinant in the magnitude of these observed effects. However, the impact of elevated CO2 on maerl bed communities, rather than algal individuals, remains unclear, despite the global role of maerl beds as a biodiversity 'hotspot'. Here, we present results from a novel in situ experiment, where we exposed whole maerl bed communities to an acute elevation in water column CO2 concentration. Remarkably, even during this short-term experiment, we observed a significant shift in community physiology, and once CO2 levels were returned to normal, only a partial recovery was observed within the monitoring time frame. This study highlights the sensitivity of biogenic carbonate marine communities to acute CO2 enrichment and raises concerns over the capacity for the system to 'bounce back' if subjected to repeated acute high-CO2 events.

Keywords: Calcification, Photosynthesis, Biogeochemistry, Nutrients, Community, Ecosystem, Maerl bed, Carbon dioxide, Acidification

*Speaker

Relative importance of temperature and irradiance on rhodolith (Lithothamnion glaciale) growth

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Effects of water temperature and irradiance on apical growth in the rhodolith-forming coralline alga *Lithothamnion glaciale* were tested with laboratory mesocosm and field experiments. Stained (Alizarin Red) rhodoliths from southeastern Newfoundland were grown during one year under orthogonal combinations of five water temperatures (ambient, 2, 4, 7, and 10 ∘C) and three irradiances (_˜1, 5, and 14 μmol photons m-2 s-1) in flow-through mesocosms and at three depths (8, 15, and 25 m) in the centre of a large (_˜25 000 m2) rhodolith bed. In the lab, growth rate under thermally stable conditions was twice as high at high irradiance (236±72 μm y-1) than at intermediate (113± 19 μm y-1) and low (121±15 64 μm y-1) irradiances regardless of temperature. Growth in the thermally variable ambient treatment correlated positively with cumulative daily irradiance. In the field, growth rate peaked at a depth of 8 m (296±37 μm y-1) and was 26% and 51% lower at 15 m (219±26 μm y-1) and 25 m (146±24 μm y-1), respectively. Overall, results demonstrate that apical growth in *L. glaciale* rhodoliths is slow and modulated primarily by seasonal variation in irradiance, with a minor influence of temperature. Temperature might therefore play a lesser role in rhodolith growth than the literature suggests.

Keywords: Lithothamnion glaciale, Growth, Irradiance, Light, Temperature, Seasonal variation, Experiment

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†Speaker

Causes and consequences of rhodolith bed primary productivity: when descriptive ecology meets physiology

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This study present a two year characterization of a warm temperate rhodolith bed to analyze how environmental changes could influence rhodolith physiology and associated community ecology. We analyzed the biomass of rhodolith and associated species along this period and conducted *in situ* experiments, to evaluate the community production/consumption balance. The highest total biomass of rhodoliths occurred during Austral winter. *Lithothamnion crispatum* was the most abundant species in Austral summer. Epiphytic macroalgae occurred only in January 2015, with *Padina gymnospora* having the major cover. Considering associated fauna, the biomass of Annelida, Arthropoda and Mollusca had lower values in February 2015, and higher values in November 2016. Reef fish key species populations densities inside and around the rodolith beds showed significant variations in in time. Groupers (carnivores/piscivores) densities seems to be increasing in time, specially from 2015 to 2016. On the other hand, grunts (macroinvertebrates feeders) had a modest decrease in time (from 2014 to 2016). Other parameters such as oxygen production and calcification of *L. crispatum* were higher under enhanced irradiance and decreased in the presence of *P. gymnospora*. Community structure and physiological responses can be explained by the interaction of abiotic and biotic factors, which are drived by annual and interannual changes. Biomass changes can indicates that herbivores have a hole in epiphytes overgrowth, which is beneficial to rhodolith, since this avoid competition with fleshy algae for environmental resources. However, the epiphytes and invertebrates abundance could be related to temperature stochastic variations during austral winters or El Niño. These results foster further studies related to climate change impacts, as well as long-term monitoring programs and *in situ* experiments to improve the knowledge about how community structure of rhodolith bed responds to local and global stressors.

Keywords: Rhodoliths, Photosynthesis, Epiphytes, Herbivory, Carbonate System

*Speaker

CaCO3 production rate estimates of a southeastern Newfoundland rhodolith bed

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Discovery of rhodolith beds in coastal Newfoundland has stimulated research on quantifying Northwest Atlantic rhodolith CaCO3 production. The present study estimated gross and net annual CaCO3 production rates in the St. Phillip's Newfoundland rhodolith bed (> 500 m2) using weight gain and rhodolith abundances, and compared methodological approaches of using apical extension and weight gain to estimate CaCO3 production. Approximately 300 rhodoliths were collected from the centre of the rhodolith bed and weighed before being placed into 12 mesh cages. Each cage contained 10 live rhodoliths, 10 dead, and 3 stained with Alizarin Red. Cages were installed at _˜15 m depth and deployed for one year in June 2016. Six cages were placed _˜50 cm above the seabed to deter bioturbators (raised), while remaining cages were attached directly to the seabed (bottom). Mean dry weight gain of live rhodoliths in bottom cages was 0.99 g yr-1 (±0.54 SD, approximately 6.95% annual dry weight increase). Mean dry weight change of dead rhodoliths in bottom cages (-0.743 g yr-1 [±0.33], 5.29% decrease) was subtracted from live rhodolith weight gain to calculate net CaCO3 production. Applying weight gain estimates to rhodolith abundances (768 ind m-2 ±262 ind at _˜15 m depth) yields estimated gross and net annual CaCO3 production rate of approximately 757 g CaCO3 m-2 yr-1 and 186 g CaCO3 m-2 yr-1, respectively. To measure linear extension, five branch tips per stained rhodolith were sanded and imaged under a stereomicroscope. Maximum apical growth from the stain to the branch tip was measured with ImageJ. Mean apical growth was 0.558 mm yr-1 (±0.072), and did not vary between bottom and raised rhodoliths (p=0.730). Apical growth was a poor predictor of dry weight gain (r2=0.04). Estimated CaCO3 production for the Newfoundland site is similar to gross CaCO3 production in northern European rhodolith beds.

Keywords: carbonate production, apical growth, net and gross production, Newfoundland rhodolith beds

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Community production and calcification in a sub-arctic rhodolith beds in northwestern Iceland

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Rhodolith beds are found in many places in western, northern and eastern Iceland. Detailed information on rhodolith distribution only exists for limited areas in the northwest. The beds are formed mostly by *Lithothamnion tophiforme*. Very little is known on the ecology of *L. tophiforme* beds in Iceland or elsewhere. We report results of *in situ* production and calcification measurements that were done in the inner part of a sub-arctic fjord in NW-Iceland. Opaque and transparent incubation chambers (31 L) were deployed *in-situ* in a rhodolith-bed at 5 m depth. The experiments were conducted at various times over the annual production cycle. Each incubation lasted for 4 hrs. Oxygen concentrations and light levels were logged continuously in the chambers. Samples for determination of DIC, alkalinity, nutrients and salinity taken at the beginning and end of each incubation. At the end of each experiment benthic samples were taken to determine biomass of rhodoliths and associated fauna. Additionally, growth bands were measured and correlated with the CaCO3/MgCO3 ratio in the rhodolith. Community production and calcification were calculated taking into account ambient light and light attenuation at the experimental site. Growth bands, community production and calcification rates, indicate that rhodoliths in Iceland grow extremely slowly.

Keywords: Rhodolith, production, calcification, benthic community, Lithothamnion tophiforme, Sub, arctic, Iceland

*Speaker

Geology and Paleontology

Coralline algae in space and time: A palaeontological perspective

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Crustose coralline algae represent one of the most successful groups of recent macrophytes. They are marine organisms that are able to inhabit any place within the photic zone from the Equator to the poles. Nonetheless, new unexpected findings have shown that they survive even in freshwaters. Within this wide distribution, corallines are important ecological engineers creating particular ecosystems that represent diversity hotspots in which corallines provide refugee, and constitute nursery centres, for a plethora of organisms. The success of corallines is the result of a long evolutionary history of diversification that commenced in the Early Cretaceous, about 140 million years ago (Ma). In the last 25 years, investigations on fossil corallines have provided increasing fundamental information to reconstruct this macroevolutionary history. In addition, important advances on their potential use as palaeoenvironmental indicators have been made; most critical has been to infer key ecological factors controlling their development and distribution. All these progresses have been possible due to a parallel improvement on the taxonomy of fossil corallines. Nonetheless, the taxonomy of present-day corallines is continuously evolving due to new molecular and phylogenetic analyses. Palaeontologists work with morphospecies, therefore it is urgent finding those anatomical-reproductive characters identifying the taxonomic groups obtained with phylogenetic analyses and then evaluate whether they are potentially preserved and, therefore, possibly (and effectively) used for the identification of fossil corallines.

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How corallines calcify, build reefs and evolution of biomineralisation

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Over the past decade we have studied the cellular-scale carbonate properties and the carbon and oxygen isotope fractionation of coralline algae from the Arctic to the tropics. This work has revealed the fundamental process by which crustose coralline algae (CCA) are able to cement coral reefs, and the influence of photosynthesis and respiration on calcification. The results also suggest that the evolution of biomineralisation in coralline algae was much earlier than is presently estimated. Here we present here a summary of these studies. The capacity to build reefs is enabled by a complex composite of differing Mg–carbonate minerals – three types of Mg-calcite and dolomite (50 mol% MgCO3), which transforms the crust into a super-tough material equivalent in fracture resistance to metamorphic minerals formed under high temperature and pressure. Two different carbonates form the cell wall. 1) Primary cell wall (PCW) carbonate which has high Mg content unrelated to temperature, is often dolomite and has carbon isotope fractionation influenced by photosynthesis. PCW forms hypothallial cell walls and edges the perimeter of the perithallial cell wall. 2) Secondary cell wall is the distinctive radial Mg-calcite in CCA perithallial cell walls and has Mg-content that responds linearly to temperature, carbon isotope values influenced by respiration and oxygen isotopes values that correlated with Mg content, not temperature. We propose that mineralisation is an induced process either of, or on, cellulose. Finally, the discovery that cell walls can be dolomite, together with the observation that most early (Neoproterozoic) red algal and coralline fossils were found in dolomite rock, and the retention of dolomite cell walls over geological time, raises the possibility that biomineralisation evolved firstly as predominantly dolomite, not Mg-calcite, and that the start time for red algal biomineralisation has been substantially underestimated.

Keywords: Coralline algae, calcification, biomineral, evolution, isotopes, Mg, calcite, dolomite

*Speaker

Rhodoliths as pCO records: acidification in the pre-instrumental era

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The high-latitude oceans are expected to show accelerated acidification in response to global increases in anthropogenic CO (IPCC, 2013). Understanding the magnitude and drivers of this acidification since the industrial period has been limited by the lack of instrumental pCO records. Spatial limitations in the available pCO data also restricts detection of the latitudinal differences in acidification, and where acidification reconstructions exist they are typically restricted to the tropics (Foster and Rae, 2016). Coralline algae skeletons are sensitive to the rate of pCO change (Kamenos *et al.*, 2013) and have also been used as palaeoarchives to capture climate change in the ocean beyond the instrumental period (Kamenos, Cusack and Moore, 2008). Previous studies have demonstrated the feasibility of using coralline algal Mg-O bond strength as a proxy for marine pCO changes (Pauly *et al.*, 2015). Here rhodolith samples were collected from high latitude (Greenland) and temperate sites (Scotland) and Raman spectroscopy was used to analyse Mg-O bond strength. This reveals 100 years of pCO change at Arctic and temperate latitudes. Comparison of the two sites shows the influence of SST and fresh water inputs on the response of high latitude oceans to global anthropogenic change.

Keywords: Acidification, proxy, pCO, geochemistry, Greenland, Scotland

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Sclerochronological study in Saint-Pierre et Miquelon (Northwest Atlantic): A new method to explore growth patterns of Clathromorphum compactum for paleoenvironmental reconstruction

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Records of ocean/atmosphere dynamics over the past centuries are essential to understand processes driving climate variability. This is particularly true for the Northwest Atlantic, a key region with regard to global climate. Over the past decade, rhodoliths have been increasingly used as environmental and climatic archives in the marine realm. Whereas many studies have focused on environmental information recorded in geochemical properties of the coralline algae carbonate structure, e.g., to reconstruct sea surface temperature, less attention has been paid to the use of annual growth increment widths as an environmental proxy. Here, we studied if it is possible to extract climate and environmental information from annual growth patterns of the coralline red algae, *Clathromorphum compactum*, from Saint-Pierre-et-Miquelon (SPM), an archipelago situated close to the confluence of the warm Gulf Stream and the cold Labrador Current. However, analysis of *C. compactum* growth is challenging due to difficulties in resolving the annual banding pattern. Identification of these growth patterns is usually based on geochemical data of hard structure (e.g., annual variations of structural Mg/Ca allow indirect measurements of increment width). These methods are expensive and therefore prevent from analyzing a large number of specimens that would be representative of the entire population. For this reason, we enhanced the growth line readability by staining polished sections with Mutvei's Solution. Geochemical analyses were also carried out in order to validate the assumption that growth lines observed after staining were formed on an annual basis. Furthermore, growth patterns and trace element composition were investigated on multiple axes of several rhodoliths in order to assess the intra-specimen variability. This study confirms that it is possible to measure annual increment width of Mutvei-stained coralline red algae directly, without using expensive geochemical methods.

Keywords: Sclerochronology, North Atlantic, Climate change, Growth, Environmental proxies

*Speaker

Modelling maerl habitat dynamics in response to increased storminess

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Rhodolith (maerl) beds are unique, free-living, non-geniculate coralline red algae forming biodiverse habitats and dense biogenic debris beaches. This multi-disciplinary field experiment investigates the response of offshore maerl beds and maerl debris beaches to Atlantic storminess. Specifically, the morpho-sedimentary evolution of maerl beaches over timescales of seconds (swash dynamics) to months (seasonal response) will be measured using a suite of integrated, multi-disciplinary field and laboratory methods based on hydrodynamic modelling, bathymetric and topographic mapping, and groundwater fluxes. The experiments will utilise experimental results from previous research (Joshi et al. 2014, 2017a, 2017b, Farrell and Sherman 2015) to develop and validate process-response models for maerl. The impact of the Intergovernmental Panel on Climate Change (IPCC) scenarios on the regional hydrodynamic model will be used to quantify possible long term impacts of climate change on maerl. Using XBeach, an open-source numerical model with a domain size of kilometres, on the time scales of storms, outputs will be compared with nearshore-beach DEMs derived from UAV surveys, and supplemented with baseline seabed mapping (INFOMAR) LiDAR data from Greatman's Bay, Ireland. This project will integrate oceanographic observations to compliment sediment mobility indices in Greatman's Bay.

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Keywords: Sediment Dynamics, Beach Morphodynamics, Storminess, Climate change

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Coralline algal habitats in a late Miocene platform in Sierra de Gádor, Almería, SE Spain

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Mixed carbonate-terrigenous deposits onlap the Betic basement in the Chanata area in Sierra de Gádor, Almería, SE Spain. The 87Sr/86Sr compositions of oyster samples indicate a late Miocene (Tortonian, 10.7 to 8.1 Ma) age for these rocks, which formed at the southern margin of the Alpujarra Corridor, an ancient entrance of the Mediterranean Sea between the uplifting Betic mountains. Four main lithofacies were distinguished in the three main outcrops in the area: 1) heterometric breccia with bioclastic matrix; 2) bioclastic sandstone to packstone with large oyster shells; 3) *Heterostegina* rudstone; and 4) coralline-algal packstone to rudstone. Within the latter, two laterally grading coralline algal facies can be distinguished by assemblage composition and predominant growth forms. One is characterized by branching rhodoliths of *Lithophyllum* and melobesioids in a sand-sized bioclastic matrix, and can be interpreted as a maerl deposit. The other facies is dominated by laminar and foliose *Mesophyllum* plants, with frequent hooked and tubular morphologies, which mainly occur as fragments in a fine-grained or heterometric matrix. This facies probably accumulated in seagrass meadows. All these sediments formed on a homoclinal ramp from the shore line (breccia), to sandy shoals (sandstone and packstone), to deeper settings in which coralline algae were the main carbonate producers. Maerl rudstones occur both shorewards and basinwards of seagrass-meadow deposits, suggesting a patchy distribution of the original habitats. Modeled temperatures and salinities based on carbon and oxygen stable isotopes of oyster samples indicate normal marine salinities except for local fresh-water input in certain intervals. Estimated palaeotemperatures range from 14 to 24◦ C.

Keywords: Carbonate facies, coralline algal growth forms, palaeoenvironments, late Miocene, south-eastern Spain

*Speaker

Coralline algae in Pleistocene reefs in the Danakil Depression (Afar Triangle, Ethiopia)

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The Danakil Depression is located in the northern part of the Afar triple junction (Afar Triangle), formed by the rifting of the African, Somalian and Arabian plates. The depression is the subaerial, southern prolongation of the Red Sea Rift in northeastern Ethiopia. Fossil fringing coral reefs along the margins and other sedimentary features evidence successive episodes of flooding of the depression by marine waters from the Red Sea, followed by its isolation and desiccation. The last two episodes, dated at _˜210-231ka (Marine Isotope Stage (MIS) 7) and _˜ 121-122ka (MIS 5), respectively, took place during the last Pleistocene interglacial periods. In both episodes, reefs were built by diverse zooxanthellate corals, coralline algae, and encrusting foraminifers. Coralline frameworks are a prominent feature at the top of the oldest reefs (MIS 7). These frameworks, centimetres to decimetres in thickness, are flat topped and cover the reef surface for tens to hundreds of square metres. Upright branching plants of *Lithophyllum* gr. *kotschyanum* are the main builders, growing on corals or on each other. The branches are cylindrical to laterally flattened and anastomosed, forming a dense structure. *Porolithon* and *Neogoniolithon* are minor components. Flat-topped corals and milleporids are scattered throughout the framework. Corallines also occur as crusts on corals dispersed in the reef structure and as rhodoliths among the debris in reef-slope deposits. In the youngest reefs (MIS5), frameworks of *Lithophyllum* gr. *kotschyanum* are generally less developed and restricted to a few localities, although small crusts of *Lithophyllum* and other corallinales are relatively common on coral colonies. These *Lithophyllum* growths are fossil analogues of present-day frameworks in intertidal reef flats to shallow-subtidal back-reef areas in the northern Red Sea. Consequently, they constitute excellent indicators of local ancient sea level, which help to understand the complex sedimentary and tectonic evolution of the Danakil depression.

Keywords: Coralline frameworks, coral reefs, Pleistocene, Danakil, Afar Triangle, Ethiopia

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Ecology

Rhodolith beds as blue carbon repositories

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The oceans have taken up around 40% of carbon emissions since the Industrial Revolution, and, while only representing < 10% of the marine environment, coastal vegetated systems are comparable to terrestrial systems in their capacity for the burial of carbon in sediments – so-called 'blue carbon'. In the context of climate change, blue carbon is important as it can mitigate against anthropogenic releases of carbon. Seagrass, salt marshes and mangroves act as blue carbon repositories but rhodolith beds have received little attention due to their calcified nature; the process of calcification releases carbon rather than store it. Here we investigate the nature of carbon burial by rhodoliths from individual to an ecosystem level processes. We describe temporal carbon storage in rhodolith beds at millennial time scales considering the source of carbon as well as the drivers of storage using isotope tracing and carbon quantification. We also probe the dynamics and interactions between rhodolith photosynthesis and calcification using radioisotope tracing to determine the role of sub-rhodolith metabolic processes in carbon accretion and burial. Overall, rhodolith bed ecosystems appear to be important in carbon burial and their role in this aspect of ecosystem service provision requires more attention at national and international spatial scales.

Keywords: rhodoliths, biogeochemistry, carbon burial, blue carbon, photosynthesis, calcification, climate change, ecosystem services

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Spatio-temporal study of the diversification of coralline species (Rhodophyta)

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Corallines occur along all coasts from the tropics to the poles where they constitute an important element of the landscape (consolidation of coral reefs, formation of coralline reefs (e.g. coralligene), rhodoliths and ma'erl beds). With more than 600 species currently recognized, corallines are one of the most diverse group of red algae. However, these algae present both strong morphological variations within a species and phenomena of convergence between species which render their identification complex on the basis of morpho-anatomical characters. A proper evaluation of their species diversity should be assessed by molecular characters. Recent advent of molecular systematics and initiative such as DNA barcoding have leaded to a wealth of sequences of coralline from all over the world. Moreover, we were fortunate to organize expeditions in Guadeloupe, Martinique, Madagascar, Walters shoal, Papua, during which thousands of corallines were collected. All together, these dataset were analysed to assess the species diversity among corallines and to infer spatio-temporal patterns of species diversification to better understand the impact of past global warming / cooling events as comparisons with ongoing climate change.

Keywords: species diversity, global changes, calbrated phylogeny, taxonomy, climate

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Deep-water rhodoliths off Pico Island, Azores (NE Atlantic)

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Rhodoliths are particularly common around many islands of the North Atlantic archipelagos, including the Cape Verde, Canaries, Madeira, and Azores. However, few ship-based studies using specific sampling equipment have been conducted in these archipelagos in order to systematically characterize the sedimentology and benthic communities on insular shelves. The present study is the first to provide data on living rhodoliths and associated sediments from the deeper shelf of Pico Island, in the Azores Archipelago. Living rhodoliths were collected during a seabed sediment-sampling survey conducted off the south insular shelf between 64 and 73 m depth. For comparison purposes, additional shallow-water samples (2 to 4 m in depth) were collected by snorkelling at Maré (Lajes do Pico), a shallow lagoon, also on the south coast. Nearshore rhodoliths were composed of *Phymatolithon calcareum* and showed predominantly spheroidal shapes, while deep-water rhodoliths were composed of *Lithophyllum incrustans*, encrusted over inner layers of *P. calcareum,* and revealed predominantly ellipsoidal shapes. Although there is no systematic survey of seafloor currents in the Azores, the shape of the volcaniclastic nuclei and therefore the growth of the encrusting coralline algae, seem to be influenced by local hydrodynamics. *P. calcareum* nodules are probably formed in the middle shelf and tend to have ellipsoidal shapes. They are then transported downslope by storms and incrusted by *L. incrustans*. Transport by storms appears to be important in the formation of rhodoliths and their taxonomic composition around volcanic oceanic islands subjected to high-wave energy. Based on these results and comparisons with previous studies on beached rhodoliths from the Canaries and fossil rhodoliths from the Neogene deposits of Santa Maria Island (Azores) we propose an empirical model for the formation, transport and deposition of rhodoliths across the entire shelf of Pico Island.

Keywords: Rhodophyta, shelf transport, oceanic islands, ecology, Recent

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Use of high-resolution 3D imaging to identify the light-harvesting capacity of coralline algal carbonate nodules

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Rhodolith-forming coralline algae are found from the intertidal to 100+ m below the ocean surface throughout the world's coastal seas. Their complex 3-dimensional structure, created by a high-magnesium calcite skeleton, supports highly diverse ecosystems and plays a major role in the global carbonate cycle. The overall shape of rhodoliths is recorded as becoming less spheroidal with depth (and therefore decreasing light intensity). Here, we adopt a novel imaging approach to test the effect of changes in rhodolith calcite structure on photosynthetic potential. We have created high-resolution 3-dimensional models of rhodoliths of varying shapes and sizes at the μm scale. This has enabled us to accurately quantify key structural metrics (such as overall shape, surface area and branch density) that will impact the capacity of the algal individual to capture light for photosynthesis. Application of this technique to across a depth-gradient provides the first quantitative evidence for how these carbonate-producing algae are able to survive in lower light conditions than many other algae. The importance of the carbonate structure in facilitating photosynthesis has significant implications for the future survival of coralline algae, since their carbonate skeleton is likely to be highly sensitive to projected ocean acidification. This technique also holds potential for use in palaeoecological studies where high-resolution water depth information is required.

Keywords: carbonate, photosynthesis, photoefficiency, ocean acidification

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What have coralline red algae inside their cells?

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The high abundance and wide latitudinal distribution reinforce the importance of coralline red algae (CRA) as an essential component of photosynthetic communities, producing oxygen, precipitating carbonates, consolidating substrate, and functioning as autogenic ecosystem engineers and foundation species. Furthermore, CRAs are one of the major producers of dimethylsulfoniopropionate (DMSP), which, upon being metabolized by algal-associated microbiota, produces volatile compounds such as dimethyl sulfide (DMS). Besides calcification, which has received major attention in the last years, elucidation of ultrastructural aspects of CRA needs re-evaluation. Recent work, complementing ultrastructure with anatomic and molecular evaluation, propose that a rhodolith hosts an important endolithic biodiversity. They characterized aggregations observed in *Lithothamnion* cells as *Prorocentrum*, a dinoflagellate often associated with algal blooms. However, the notion that the spherical structures inside rhodolith cells are eukaryotic microorganisms is contrary to the available knowledge about the floridean starch composition of these grains. The seminal works have found robust evidence of structure and synthesis pathways of CRA floridean starch. Here we present evidence, considering CRA from North and South Atlantic, that sustains that these starch granules are constructed by concentric layers of radially arranged amylopectin-like polymers. However, it can not be ignored that endolithic microorganisms may be present in the internal micro-niche or in the intercellular space. This topic deserves major efforts as the abundance and systematic presence of endosymbionts can change our understanding of rhodolith bed ecosystem global functions.

Keywords: Ultrastructure, Floridean starch, CCM

*Speaker

Coralline algal skeletal mineralogy affects grazer impacts

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Herbivory is a major driver in controlling ecosystem structure in among coralline algae. However, the role of altered plant-herbivore interactions and effects of changes to trophic control under global change is poorly understood. This is because both coralline algae and grazers themselves may be affected by global change, making changes in their interactions hard to predict. Here, we compare grazing damage and intensity to coralline algae *in situ* over 4 decades characterized by changing seawater acidity. While grazing intensity, herbivore abundance and identity remained constant over time, grazing wound width, but not depth, increased together with significantly weaker skeletal structure in two species of coralline algae (*Pseudolithophyllum muricatum* and *Pseudolithophyllum whidbeyense*) coincident with seawater acidification. Grazing wounds to *P. muricatum* had greater increases in width relative to depth than wounds in *Lithophyllum impressum* and *P. whidbeyense*, potentially due to differences in grazing pressure or by mineralogic differences in algal skeletons. We suggest coralline algae may be more prone to grazing damage in the future ocean, causing changes in trophic control.

Keywords: herbivory, mineralogy, ocean acidification

*Speaker

An experimental comparison of bacterial diversity and function in the maerl Lithothamnion glaciale Kjellman (Corallinales, Rhodophyta) from southwestern Greenland

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Seaweed bacterial communities, or microbiomes, serve many functional roles in 'holobiont' physiology. This close relationship provides the seaweed host with a diverse, protective boundary layer that may provide nutrients while bacteria within the microbiome gain algal exudates and substrate. Microbiome community composition can be used as an indicator of stress in response to climate change, but the bacterial cohort naturally varies across temporal and spatial gradients. Consequently, it is important to investigate the natural diversity and function of bacteria in the environment and associated with algal hosts before assessing host response to stress events. In this study we investigated the diversity of bacterial communities in the fjord environment outside Nuuk, SW Greenland, on multiple algal hosts from the region, and evaluated shifts in microbiome composition under high melt water runoff and iceberg calving from an outlet of the Greenland Ice Sheet (GIS). In 90d mesocosm experiments we focused on the Arctic maerl species, *Lithothamnion glaciale* (Kjellman), which is rare in the fjord system outside Nuuk and negatively affected by low salinity. Axenic and xenic cultures of *L. glaciale* were maintained for 6m to evaluate biofilm function with microsensor technologies. The diversity bacteria within the water column increases from the GIS to marine habitats in Kangersunneq- Godthåbsfjord and Ameralik fjords. Bacterial diversity on algal substrates is highest on Chlorophytes and lowest on Phaeophytes in this region. In experiments, we observe a significant reduction in bacterial diversity of *L. glaciale* and innate substrate in experimental conditions with low salinity. Oxygen microsensors highlight microbiome contribution to primary production in *L. glaciale*. NOx sensors indicate the biofilm is not a nutrient source for the algae. We are just beginning to understand the role bacteria plays in polar coralline algae ecophysiology, and future research will focus on microbiome composition after 9m and 1yr mesocosm incubations.

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Assessment of maerl beds structure and vitality by image analyses across a dredge-fishing pressure gradient in the Bay of Brest (Brittany, France)

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Maerl beds used to cover up to 30% total surface of the Bay of Brest seafloor, and are mainly composed by the two species *Lithothamnion corallioides* et *Phymatholithon calcareum.* These complex habitats, sheltering high biodiversity, have been demonstrated to be key for the ecosystem functioning of the Bay. However, among the multiple human-induced environmental changes they are facing, the maerl beds in the bay of Brest are strongly affected physical disturbance caused by dredge fishing activities.

We conducted a field study in April 2017 in the bay of Brest aiming at assessing spatial changes in maerl morphology and bed structure along a physical disturbance gradient defined through quantified station-scale dredging intensity. In 10 stations located along this gradient, we characterized the structure and the thali morphology of maerl beds through semi-automatic analyses of (1) sectional view images taken using Sediment profiles imaging (SPI) and (2) photos of thali sampled using Plexiglas cores by scuba divers and thereafter sliced, and (3) photos shot from above of quadrats placed on the seafloor.

By doing so, we were then able to quantify several habitat features such as the heterogeneity of the water-maerl interface, maerl layer thickness, the proportion of live/dead thali across the maerl layer, the depth profiles of thali morphology (size, complexity, roundness) and vitality (dead/live), or the maerl surface coverage as well as the relative proportion of live/dead thali at the seafloor.

In order to investigate the nature of the pressure-impact relationship across the gradient, so-measured changes in the beds characteristics amongst stations are statistically tested and correlated with dredging intensities measured at the same stations during the last 5 years.

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More species, more functions? The influence of maerl beds on polychaetes assemblages

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Maerl beds are ecosystem engineers that profoundly modify the living conditions of benthic species. Despite their recognition as species-rich and highly productive habitats, there is little information available on their associated communities other than at a taxonomic level. Here, we used a Biological Trait Approach (BTA) to assess the influence of maerl on the diversity and redundancy of the functions performed by macro-benthic species. Specifically, we analysed the traits expressed by the polychaetes species found in 13 maerl beds lying in contrasted environments. We compared these traits compositions to samples from adjacent habitats (*i.e.* subtidal and intertidal bare sediments as well as intertidal *Zostera marina* meadows) at the scale of the Brittany region (France), to deepen our understanding of: (1) how maerl beds shape the traits of their associated polychaetes assemblages and how their effects compare to other ecosystem engineers (such as eelgrass), (2) how their effects vary with environmental conditions and (3) how their presence affects the mechanisms governing macrofauna community composition in soft bottoms. Overall, maerl beds appear as the richer habitat, both in terms of taxonomy and functional traits. Unlike the other habitats, high functional richness was maintained in maerl beds regardless of the environment. This large functional space appeared evenly filled and dominant species expressed substantially different traits combinations. This was not the case in seagrass beds, which, on the other end, showed higher functional redundancy. This highlights that the effects of these ecosystem engineer on polychaetes differ and potentially act through different mechanisms. Maerl beds seem to favour higher niche differentiation, thereby promoting more diverse sets of functions than other habitats. Hence, they enhance not only species diversity but also the functionality of soft sediments in general. This effect was consistent regardless of the environmental settings, which reinforces the conservation value of this fragile habitat.

Keywords: Functional traits, Beta diversity, Regional scale, Monitoring

*Speaker

Macroinvertebrates associated with the rhodolith beds from euphotic and mesophotic zones in the South Atlantic: Fernando de Noronha Archipelago, Brazil

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Rhodolith beds are threatened by anthropogenic factors such as mining (calcareous exploitation and the indirect effects of oil and gas production activities), fishing and variations in water quality. Understand distributional pattern and define the main variables promoting the biodiversity is essential to conciliate conservation measures and economic interests. Therefore, we compare the macroinvertebrate community associated with rhodoliths from mesophotic and euphotic zone in the northeastern Brazilian mainland (i.e. Fernando de Noronha Archipelago) and propose to identify predictor variables this diversity. We randomly sampled 20 rhodoliths in two depth zones (15m and 45m depths) that were individually and carefully inserted in nylons bags (500μm mesh). All vagile macroinvertebrates (> 500μm) were quantified and identified at the highest taxonomic resolution possible. Volume, average diameter, depth, rhodolith density, biomass of macroalgae and weight of sediment were obtained for each rhodolith. Our results indicate a density of 11,378 individuals.m-2 in euphotic zone and 9,532 individuals.m-2 in mesophotic zone. Forty eight taxa were identified: 46 and 28 from euphotic and mesophotic zone, respectively. These values are comparable with those recorded for soft bottoms, rocky shore, seagrass and coral reefs. Despite this, we show that understanding of variables predicting the biodiversity is more complex than previously thought. From six variables tested by us, four were indicative of the pattern found in the macroinvertebrate community (i.e. average diameter, depth, biomass of macroalgae and density; Monte Carlo Permutation test, $p < 0.05$). These variables were important to indicate the distributional pattern of the less abundant taxa, however, they did not explain the pattern of the most abundant taxa. Thus, we argue that while new scientific advances in providing tools to better classify more diverse rhodolith beds are not available, the precautionary principle should be adopted in order to safeguard biodiversity and ecosystem services provided by rhodolith beds.

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The abundant and diverse meiofauna from maerl beds: a first insight from the Bay of Brest (Brittany)

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The maerl beds of Brittany have long been recognized as an important biogenic, structurally complex coastal habitat, forming a unique ecosystem with a high benthic biodiversity. Although maerl beds have been relatively well studied throughout Europe, several faunal groups received less attention and this is the case of meiofauna. Meiofauna makes an important contribution to the biodiversity of benthic communities playing a significant role in ecosystem functioning. Amongst meiofaunal organisms, nematodes represent one of the most abundant and diversified group inhabiting all kind of sediments. Nematodes are a good biological indicator due to their short generation time and their low mobility.
In this study, we characterized the meiofaunal community (abundance, distribution and community structure) and nematode diversity of a maerl area in the Bay of Brest (Brittany). We compared maerl meiofauna with meiofauna from a sedimentary habitat (Anse de Dinan, Brittany). The structural (SR, ES(51),J') and functional diversity (biomass, trophic diversity) of nematodes have also been studied.
Total meiofaunal abundance characterizing the maerl station was five times higher (1988± 455 ind/10cm2) if compared to that of the sandy beach (384±16 ind/10cm2). Meiofauna community was more diversified in maerl then in sandy beach (13 and 9 higher taxa, maerl and Anse de Dinan, respectively). Nematodes were always the most represented taxon in both environments. A total of 97 species belonging 78 genera of nematodes were identified from the maerl station *vs* 27 species belonging to 21 genera from the sandy beach.
We showed that all trophic groups were equally represented in maerl nematodes while in sandy beach bacterivore nematodes were the dominant trophic group. For the first time, this study shows that maerl beds host a rich and highly diversified meiofaunal and nematode community, when compared to less complex, sedimentary habitats, similarly to what has been reported for maerl associated macrofauna.

Keywords: Maerl, Meiofauna, Nematode diversity, vertical distribution

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Conservation & Management

Maerl beds of the NE Atlantic, faunal diversity and conservation concerns

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This talk will begin with a tribute to Yvonne Chamberlain who passed away in January. She was my coralline algal mentor and allowed me to trial-run the keys in her draft of Irvine, L. M. & Chamberlain, Y. M., 1994. *Seaweeds of the British Isles,* Vol. 1. *Rhodophyta,* Part 2B *Corallinales, Hildenbrandiales.* Yvonne gave me a good grounding in how to identify coralline algae using thin section histology and SEM, for which I am eternally grateful. I will then reminisce about the first maerl conference held in Millport in 2000 and have a rant about the distinction between the terms 'maerl' and 'rhodolith'. I would then like to take this opportunity to discuss the faunal diversity of maerl habitats in the OSPAR region, work carried out in collaboration with Jacques Grall and others. Our aim is to celebrate the enormous biodiversity of maerl beds in Europe and discuss methods of monitoring this diversity. Good progress has been made with maerl conservation in Atlantic Europe but there is a need to raise their profile again, since damage from aquaculture farms and towed fishing gear continues. The talk will finish up with an overview of work on coralline algae at volcanic CO2 seeps worldwide (with Sophie Martin, Viviana Pena and others) since these algae seem to be particularly susceptible to ocean acidification.

Keywords: maerl beds, conservation, biodiversity, ocean acidification

*Speaker

Rhodolith Taxa: Agents of Benthic Community Change on Tropical Pacific Reefs?

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This case study on reef communities in Guam describes stark changes in benthic community composition and explores the role of crustose calcifying red algae (CCRA) in these transitions. Recent taxonomic investigations of CCRA on Guam's reefs have revealed a high cryptic diversity of algae belonging to the Corallinales, Sporolithales, and Peyssonneliales. Like many other molecularly-assisted alpha taxonomic studies on algae, the initial results suggest the existence of high levels of endemism at island, archipelago, and ecoregion scales. Contrary to other algae, some of these CCRA taxa cover vast expanses of reef. Here, we focus on a group of facultative rhodolith taxa that dominate reef flat communities in Guam and we evaluate their role as habitat modifiers in areas that were previously dominated by scleractinian corals.

Keywords: Rhodolths, Peyssonneliales, Corallinales, Sporolithales, Ramicrusta, Peyssonnelia, Phase Shifts, Benthic Community Change, Reef Degradation, Guam, Tropical Pacific Ocean, Western Pacific Ocean

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Heterogeneity rather than size determines faunal colonization of discrete habitat units: a case study with rhodolith-associated macrofauna

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The role of habitat complexity determining patterns in the richness and abundance of associated fauna has received considerable attention in the ecological literature. High complexity habitat traits (i.e. high heterogeneity and/or size of discrete habitat units) often promote larger abundances of fauna. Sandy and rhodolith sea bottoms are typically interspersed as mosaics within coastal landscapes. The aim of this study was to experimentally assess the effect of two complexity attributes of rhodolith (i.e. their heterogeneity and size) on the abundance and structure of epibenthic assemblages. A colonization experiment was set up, where experimental units containing rhodolith nodules of varying heterogeneity and size were deployed at two adjacent recipient habitats: a sandy bottom and a rhodolith seabed. After one month, the abundance of fauna colonizing the experimental units was similar in both habitats, but the assemblage structure (i.e. composition) notably differed. The heterogeneity, rather than the size, of rhodolitic nodules influenced patterns of faunal colonization, even though the habitat type where these experimental units were deployed considerably influenced colonization patterns.

Keywords: Key words: habitat complexity, biodiversity, soft bottoms, heterogeneity, Canary Islands

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Assessing the relative habitat value of maerl compared to adjacent sediment habitats.

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The maerl beds around the east coast of Jersey are areas of high diversity and are protected under European and UK legislation. Maerl beds are made of loose coralline red algae and are nursery grounds for many marine species, including commercially important species such as King (*Pecten maximus*) and Queen (*Aequipecten opercularis*) scallop. These habitats are created by biotic processes and their three-dimensional structure is thought to promote higher biodiversity than that of surrounding, less complex habitats, such as sediment. This study aims to test the hypothesis that maerl is different to sediment and also to look at whether there is a difference between live and dead maerl. To do this, four sites around a group of Islands off the East coast of Jersey, called Les Écréhous, were sampled using quadrats and cores. The quadrats were split into three habitats, maerl, sediment and mixed. Differences in species assemblages between different maerl coverages and also between live and dead maerl were found. Maerl was found to have both higher diversity and abundance than sediment. Live and dead maerl habitats were found to have significantly different species assemblages, but no difference in taxa or abundance. Maerl beds, live or dead, are important habitats for marine organisms and create unique habitats, they are very fragile and grow at an extremely slow rate of 1mm y-1 and are easily damaged by activities such as dredging and maerl extraction so it is vital that the value of these vulnerable habitats is understood.

Keywords: maerl, live, dead, sediment, species assemblage, biodiversity, Jersey, habitat complexity

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Depth determines structure and functioning of rhodolith habitats in Central-Eastern Atlantic

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Similar to altitude in terrestrial habitats, subtidal habitats experience abrupt environmental gradients (e.g. light, temperature, water motion, etc.) across narrow vertical (depth) scales. The spatial configuration of rhodolith seabeds in the Canary Islands provides an ideal system to assess whether environmental drivers across depth regulate the structure and functioning of rhodolith seabeds. In this study we characterized across depth through temporal (seasonal) scales the structure of rhodolith habitats (size, shape and living surface of nodules) and their associated communities (fauna and flora). A two-years (winter, spring, summer and autumn) monitoring program was performed at three different depths (18, 25 and 40 m) in a rhodolith bed at Gran Canaria Island, Central Eastern Atlantic. Rhodolith nodules were mainly spherical with bigger sizes at 25 m relative to the other depths; the percentage of living surface increased with depth. The structure and functioning of the community assemblages changed consistently with bathymetry but overall with the additional substrate provided by the seasonal epiphytic associated biota (mainly macroalgae) during summer and autumn. Our data also suggested that wave induced turbulence (in upper layer) and irradiance attenuation (in the lower layer) can be the main environmental drivers regulating the structure and functioning of rhodolith habitats across depth gradients.

Keywords: Environmental driver, vertical gradient, seasons, calcareous algae, associated epibionts

*Speaker

Brazilian rhodoliths - a world heritage under threat

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The most extensive, abundant and diverse rhodolith bed formations of the world are found off the Brazilian coast. These formations are found in depths from 5 to 200 meters. Considering the general structure and potential biological/oceanographic connectivity, Brazilian rhodolith beds can be considered a single and giant unit, with a high variability of rhodolith species composition, size and density along latitudinal and vertical gradients. In a gross estimation, considering available information and some conservative forecasts, Brazilian rhodolith beds may occupy an area of around 50,000 km2 or more. This world heritage is under threat considering global and local stressors. For example, marine and terrestrial mining activities represent important local impact sources, as mineral exploration in coastal areas produces direct or indirect plumes, thus representing high-risk activities and sites. The Doce river environmental disaster, also known as "Samarco dam disaster", called attention to an important source of environmental stress, with potentially global consequences. Besides causing increased sediment loads, the Doce river drained highly toxic metal-contaminated waters into coastal ecosystems. Here we show that despite species-specific responses, Sarmarco's mud reduced the primary production of rhodoliths and other algae. Thus, the influence of this toxic sediment plum, which extends more than 6,000 km2, represents a great potential threat to Abrolhos bank rhodolith beds and their associated flora. Considering global stressors, we evaluated the impacts of acidification and warming on the physiology of rhodolith species and associated flora. These factors compromised calcification and change primary production behavior. Recent changes in the policy, regarding mining and oil explotation in Brazil, reducing surveillance/control mechanisms and environmental exigencies add more concern about future of Brazilian rhodolith beds. We propose an articulated international action to call attention to the global consequences of these threats regarding Brazilian rhodolith beds.

Keywords: Climate Change, Pollution, Conservation, Management

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Changes in the Milford Haven maerl bed between 2005 and 2016

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The Milford Haven maerl bed is small but important as is the only true maerl bed in Wales and is part of Pembrokeshire Marine Special Area of Conservation. It is dominated by *Lithothamnion corallioides* which is comparatively rare in the UK, has an associated diverse flora and fauna and is well represented with uncommon algae which are endemic to maerl. The bed comprises a mosaic of living maerl and dead maerl on fine sandy sediments with fossil maerl found in the deeper sediments. Monitoring of the maerl bed was undertaken on behalf of Natural Resources Wales in 2005, 2010 and 2016. Data collected included *in situ* epibiota records, information on small algae living on maerl, infaunal data and granulometry. The data has been analysed in various ways, particularly employing the non-parametric computer program PRIMER-e for multivariant analyses. The results show a change in epibiota over time, particularly apparent at the three monitoring sites which historically had the most live maerl. A decline in live maerl has been accompanied by a dramatic increase in the population of *Crepidula fornicata*. The trends shown by the results are discussed with reference to published literature, particularly concerning maerl beds in Brittany which have been invaded by *Crepidula*. Factors which could have contributed to the decline of live maerl are considered.

Keywords: maerl, conservation, epibiota, endemic species, infauna, granulometry, Crepidula

*Speaker

Macrofauna community shifts in fished maerl beds in the Bay of Brest, France

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Dredging impacts from the Bay of Brest clam fishery are examined in three maerl (rhodolith) beds from the bay's south basin. Observed to be similar in terms of macrofauna community and granulometery prior to the start of fishing in 2004, parts of the beds now differ in these characteristics. Data from AIS (Automatic Identification System) transponders on-board clam vessels was used to estimate fishing pressure and select impacted and non-impacted sites for monitoring beginning in 2015. In this study, five seasons of fishing pressure is compared with multiple macrofauna and sediment samplings. Preliminary results indicate sponges and larger crustaceans being more abundant at un-fished sites, while small crustaceans are more abundant in fished ones. Polychaetes are abundant across sites, but certain species' abundances vary with the presence or absence of fishing pressure. Mud is substantially reduced in fished areas, however the extent of this does not correspond directly with total fishing pressure over the seasons for which AIS data is available. Spatial changes in fishing intensity over time indicates a possible source of this variability from prior seasons. Analyses focused on teasing apart influences of long-term mud loss, recent fishing pressure, and possible recovery on macrofauna communities will also be presented.

Keywords: Ais, quantified fishing pressure, secies richness, granulometry, impact gradient

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Workshop

Global status of rhodolith (maerl) research: looking back to move forward

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Research on the structure and function of autotrophic coastal marine systems has traditionally focused on kelp forests and sea grass meadows, with comparatively little attention on rhodolith (maerl) beds. We carried out a comprehensive, structured review of the primary literature on rhodoliths (maerl) since 1960 to identify historical research foci, current knowledge gaps, and areas of needed research. The _˜530 papers identified and examined were at least an order of magnitude fewer than studies on kelp and seagrass over the same period. Rhodolith (maerl) papers, from wide ranging geographic regions, fell into two main research foci, geological and biological, with many associated sub-foci. Past and present-day geological research has broadly focused on distribution, sedimentology, and paleo-environmental interpretations. Biological research has increased more slowly over the past few decades, moving from taxonomic and descriptive surveys of distributional and biodiversity patterns, to quantitative studies of ecological and physiological mechanisms contributing to these patterns. An increasing number of studies are experimental (9%), and while there is emerging research on conservation (1%) and the impacts of climate change on rhodolith (maerl) beds, these two areas require further attention from the research community.

Keywords: literature review, rhodolith, maerl, research directions

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The whole is greater than the sum of its parts: Rhodolith Ecosystem Ecology and COnservation Network (REECON)

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Global change, greater need for predictive capacity, accountability, and increasingly limited research funding require international, transparent, innovative approaches to the study of marine systems. Despite a worldwide distribution and growing recognition that rhodolith (ma'erl) beds are important CaCO3 bio-factories, relatively little is known of the factors and processes that regulate their structure and function. Understanding abiotic and biotic drivers of stability of rhodolith beds is a crucial step towards generating accurate knowledge necessary to convince policy makers, stakeholders, funding agencies, and public of the need to support and intensify research on these highly biodiverse systems. This workshop will set the stage for the establishment of an international network of collaborators to address questions of global importance about the ecology and conservation of rhodolith beds, namely the **R**hodolith **E**cosystem **E**cology and **CO**nservation **N**etwork (REECON). First, results of a review paper in the writing will educate participants on the history of rhodolith research since the early 1960s, drawing attention to those areas in which further research efforts are required. Second, objectives and structure of REECON will be explained with the hope of generating fruitful discussions about possible modifications to proposed research protocols to accommodate likely geographical differences. Third, participants will be invited to express interest in joining REECON and form a nucleus of regional co-ordinators and collaborators that can start working towards achieving the network's goals.

Keywords: Rhodoliths, Research network, International collaboration, Ecology, Conservation

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Rhodolith formation in the deep water off Marettimo, Egadi Islands, Sicily

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During the research for identification and monitoring of priority marine benthic habitats, an extraordinary rhodolith bed has been discovered at the Egadi Islands, Sicily, Southern Italy. Its exploration has been conducted, onboard the R/V Minerva Uno in July 2016, using a Multibeam Echosounder coupling with observations by ROV dive (video recording of $>$ 1 km of seafloor) and direct sampling by Van Veen grab (70 l, 3 samples). Remote data and ROV inspections have been processed in order to produce a precise cartography of the habitat extension. ROV video and grab samples have been used to describe i) main sedimentary and biological features of the bed, ii) rhodolith morphotypes, iii) dominant algal species and iv) associated biodiversity. The rhodolith bed extends up to 7 km2 southeast of Marettimo Island and extended toward Favignana Island, at depth ranging between 90 and 100 m. Living rhodoliths cover up to 95% of the explored area. Patches of mobile biogenic sediments, mainly sand and gravel, are scattered within the living bed. Sedimentary structures, like megaripples and bioturbations by *Spatangus* sp. and *Cydaris* sp. are commonly visible on ROV video frames. Pralines are the dominant rhodolith morphotype, with medium size of L axis of 1.1 cm (max 3.4 cm), and an ellipsoidal to discoidal shape. The nucleus is formed by terrigenous clasts, or rarely, by biogenic components. Living calcareous algae are *Phymatolithon lenormandii* (Areschoug) Adey 1966, *Lithothamnion* spp. and *L. valens* Foslie 1909. The algal association at the nucleus of rhodoliths is characterized by different species, namely *Lithophylloidea* and *Titanoderma* spp.. The latter are representative of a shallower setting, perhaps the one occurring when the bed started to develop. Radiocarbon dating of the nucleus are still in progress, aimed at verifying this hypothesis and place the process of rhodolith formation in the correct temporal frame.

Keywords: deep rhodolith beds, rhodolith development, nucleus, monitoring

*Speaker

Maerl Fossil, a biomarker of paleoenvironmental fluctuations for the past 2000 years in the Bay of Brest

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The characterization of fossils maerl beds in the bay of Brest allowed to assess the rhythmicity of the colonization episodes and their relation with the climatic and anthropic variations during the past 2 000 years. Sedimentological analyzes coupled with C14 dating revealed five major stages of maerl colonization. Rhodolith was developed from a central nucleus around 1800 years cal. BP from the center of the bay and then extended to the north and southto create the actual beds. Such colonization of the bay has been poncutuated by episodes of disappearances and reappearances of maerl, which is hypothesized to be linked to the increase of turbidity in the water column. Turbidity would be a reflection of depressed climatic conditions as well as of human impact associated with intensive deforestation on the watersheds of the bay of Brest since the Gallo-Roman era. This work has only recenty been initiated and would surely benefit from discussion with the workshop participant.

Keywords: fossil maerl beds, Climate variability, Palaeoenvironments, sedimentation, Estuarine dynamics

*Speaker

Poster session

Evidence of Coralline White Patch Disease in a rhodolith bed of the Egadi Islands

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Coralline algae are among the most important marine calcifiers on a global scale, and are sensitive to rising temperatures and ocean acidification from the ongoing global climate change. Although diseases of coralline algae are known since the nineties in the Pacific Ocean, still few observations and studies are available on this topic. In the Mediterranean, similar events have been reported starting from 2015, in the north-western Mediterranean Sea, within 30 m of water depth. One of the commonest disease is the *Coralline White Patch Disease* (CWPD), that shows the bleaching of thallus patches due to cell necrosis. The CWPD is temperature-dependent, and it is suggested a relationship with the effects of global climate change. This contribution is aimed at describing CWPD in a rhodolith bed of the Egadi Islands (western Mediterranean). Two sites at a distance of 3 km have been sampled, at 86 and 103 m, by Van Veen grab, 60 l, three replicates each. Living rhodoliths have been selected and analysed for the occurrence of CWPD. A one-way ANOVA has been elaborated to test the difference in percent occurrence of diseased rhodoliths at the two sites. Rhodoliths affected by CWPD ranging in size between 1 and 4 cm are 5% and 5,7% of the total live rhodoliths, with no statistically significant difference between the two sites. At the depth of sampling, the influence of the rising temperature should be negligible, and other factors should be explored to explain the cause of the CWPD.

Keywords: Coralline disease, Egadi Islands, deep rhodolith beds

*Speaker

Quantifying the contribution of coralline species in rhodoliths as a tool for paleobathymetric reconstructions

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Coralline algae are a powerful proxy of paleo-bathymetry because their distribution is controlled by light penetration, along the gradient of water depth. Although they are among the most abundant marine carbonate producers, especially in Cenozoic carbonates, they are relatively underexploited in paleoecological reconstructions, because of time-consuming material preparation, difficulties in identification, and nomenclatural issues. As a consequence, coralline algae have been reported in open nomenclature in a large number of recent scientific contributions. However, dealing exclusively with supraspecific taxa is a strong limitation to coralline potential as paleoecological and paleobiogeographic tool. In the early Miocene Sommières Basin (southern France), rhodoliths were sampled along an obvious bathymetric gradient, reconstructed on the basis of sedimentological proxies. A group of distinctive and easily recognizable coralline species was studied along the paleo-depth gradient, and the contribution of each species was quantified by a new method based on the digitalization of thin sections. The association revealed a clear pattern when analyzed at the rank of species: *Mesophyllum roveretoi* and *Lithothamnion ponzonense* peak at middle depth; *Phymatholithon* sp. A dominates in deep-water rhodoliths, while *Lithophyllum* sp. A and *Spongites fruticulosus* are preferentially distributed in shallow water. *Sporolithon* sp. A is restricted to shallow water, contrarily to most of the modern records of *Sporolithon*. Nonetheless, shallow-water species of *Sporolithon* also occur in present-day oceans, especially at the transition between the tropics and the temperate realm, which is a climatic situation probably very close to that of the early Burdigalian Sommières Basin. These results confirm that species distribution is very sensitive to environmental variations and is much more informative than the distribution based on higher taxonomic ranks would do. The digital technique employed is a user-friendly method for the quantification of coralline algae in thin section and is especially effective for the quantification of thin encrusting species.

Keywords: paleoecology, Miocene, Sommières

*Speaker

Insight in coralline composition and main morphotypes of Tuscan Archipelago rhodolith beds (Tyrrhenian Sea)

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Rhodolith beds (RBs) rank among the most important Mediterranean habitats. These habitats are constituted by engineers species fostering a high biodiversity and complex ecological interactions. The RBs represent a non-renewable resource due to their slow rate of growth and carbonate deposition. In the Mediterranean Sea, in the last decades RBs have undergone to increasing pressure linked to anthropic activity as well as alterations in environmental features, that can lead to habitat modifications and changes in the species diversity and functional relationships. In spite of their important role in marine ecosystems, the distribution and coralline composition of RBs in the Mediterranean are scarcely documented. This study aims to improve the knowledge on rhodolith species composition and main morphotypes of three RBs from the Tuscan Archipelago (Tyrrhenian Sea). The Elba Island area was characterised by the presence of boxworks, pralines and unattached branches, at Gorgona island only boxworks and pralines were found, while at Meloria, mostly pralines and unattached branches occurred. Overall, the most frequent and abundant species, occurring at almost all sites, were *Lithothamnion crispatum* and *Lithothamnion minervae* highlighting their important role in structuring the Tuscan Archipelago RBs. Some of the sampled sites were characterised by the dominance of *Lithothamnion corallioides* and *Phymatolithon calcareum,* followed by *Lithothamnion crispatum.*

Keywords: rhodolith beds, Rhodophyta, coralline algae, Tyrrhenian Sea

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†Speaker

Composition and heterogeneity of Mediterranean rhodolith beds: the case of Apulia (Italy)

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Mediterranean rhodolith beds (RBs) are characterized by a broad diversity of morphologies and algal species, both coralline and peyssonneliacean. These habitats have been recently included among the habitats of special scientific and biodiversity interest within the EU Marine Strategy Framework Directive and several other international initiatives. Italy is among the European countries that adopted these regulations and in the last three years a regional-scale detailed monitoring process is ongoing in order to cope with the still scarce knowledge about their distribution, ecology and functional role. The present study reports some preliminary results on the composition and the remarkable heterogeneity of the RBs along the coasts of Apulia Region (Italy, Adriatic and Ionian Seas). The combination of visual and sampling methods, using a hierarchical design, allowed to explore the composition of these habitats, characterized by a suite of combinations of coralline species and morphologies. The structure of the assemblages in term of morphologies, species composition, dominant species, live/dead ratio, cover of live thalli (%) and thickness of the live layers can significantly vary at different spatial scales (i.e., from 105 to 10 meters). These preliminary results confirm the multispecific and heterogeneous assemblage of Mediterranean RBs, representing one of the first applications of the recent protocols proposed for the study and monitoring of these habitats. Our results also highlight complex spatial patterns possibly driven by a combination of natural processes and anthropic pressures deserving a proper assessment.

Keywords: rhodolith beds, Rhodophyta, coralline algae, protocols, monitoring

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Mapping subtropical and tropical rhodolith seabeds using Side Scan Sonar technology

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The cartography of seabeds, using acoustic technologies for mapping marine benthic communities is increasing and highly demanded in the management of subtropical and tropical environments where rapid anthropogenic development often occurring in coastal zones. The side-scan sonar (SSS) is an effective tool with greater use in several nautical disciplines (e.g. seaweed monitoring).
In this study, the SSS was successfully employed to collect data from subtropical (Canary Islands, Spain) and tropical (Principe Island, Republic of Sao Tome and Principe) rhodolith seabeds from 3 – 40m in depth. A list of pre-characterization habitats was generated in each studied area, using post-processing software and then corroborated by ground-truthing methods (submarine video and diving). Rhodolith seabeds were distinguished from bare sediment, rocky and coral reefs and seagrass meadows.

In Gando bay (Canary Islands), two main areas were surveyed. The northern part showed extensive rhodolith beds up to 40m deep interspersed with rocky areas and sand ripples. Otherwise, sand stretches appeared combined with rhodoliths and mixed patches of macroalgae and marine seaweeds (e.g. *Caulerpa prolifera* and *Cymodocea nodosa*, respectively) from 15 to 40m. Otherwise, in Principe Island four areas were analyzed with rhodolith beds mostly concentrated at the north and west part of the island. These biogenic habitats appeared mixed with sandy ripples and colonies of Scleractinian corals in shallow waters (from 3 to 10m) becoming more homogeneous in deeper areas (30m).
The created Geo-referenced habitat maps denoted the efficiency of SSS methods (combined with ground-truthing) for similar studies involving rhodolith seabeds.

Keywords: Cartography, habitat characterization, shallow structure, acoustic technologies.

*Speaker

Ultra-morphology and phylogeny of Phymatolithon purpureum and P. laevigatum (Hapalidiaceae, Rhodophyta) based on comparison of type materials

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To elucidate the morphological boundary and phylogenetic relationship between *Phymatolithon purpureum* and *P. laevigatum,* we revised the taxonomy of the two species using anatomical observations and DNA sequencing from type materials. Although *P. purpureum* has been often confused with *P. laevigatum* because of their similar features (e.g., smooth surface and immersed tetra/bisporangial conceptacles), *P. purpureum* was distinguished by a thicker medullary system, deeply immersed tetra/bisporangial conceptacle pore plates, and buried tetra/bisporangial conceptacles. Our molecular analyses of the *psb*A and COI–5P genes indicated that sequence divergence between *P. purpureum* and *P. laevigatum* was 1.9% and 9.3–9.5%. We also found that the lectotype of *Phymatolithon polymorphum* f. *papillatum* was consistent with the features of *P. purpureum*.

Keywords: COI 5P, Hapalidiaceae, morphology, phylogeny, Phymatolithon laevigatum, Phymatolithon purpureum, psbA, taxonomy

*Speaker

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Ultra-morphology of Lithothamnion japonicum (Hapalidiaceae, Rhodophyta): A little-known species from the Northwest Pacific

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In the Hapalidiaceae, the species *Lithothamnion japonicum* was originally described from material collected in Japan by Foslie (1900). The original description of *L. japonicum* was based on simple description. Based on the general morphology and the internal structure of the identified fragments, Foslie considered them to belong to the genus *Lithothamnion*. The solitary specimen of *L. japonicum* that Foslie has seen has the shape of a small subdichotomously branched bush, short cylindrical protuberances, convex sporangial conceptacle, and buried sporangial conceptacles. During the course of this study, a species of *Lithothamnion* was found that seemed concordant with *L. japonicum*. It also compared to the holotype material of *L. japonicuam* and holotype of *L. fretense* which is already synonymized with *L. japonicum*. We also analysed DNA sequence data of the mitochondrial cytochrome c oxidase I gene (COI-5P) and plastid encoded photosystem II reaction center protein D1 gene (*psb*A) to determine their phylogenetic relationship. Here we newly report a *L. japonicum* to Korea and present more detailed morphological characters and taxonomic re-evaluation of this coralline algae.

Keywords: COI 5P, Hapalidiaceae, Lithothamnion, Lithothamnion japonicum, morphology, psbA, Rhodophyta

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May grazers influence the response of coralline algae to ocean acidification and warming?

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Coralline algae are expected to be adversely impacted by ocean acidification and warming. Most research on these algae has involved experiments on single species, which makes predicting effects on coralline algal communities difficult. This myopic view is challenging because the impact of global changes on coralline algae will depend on the direct impacts on individual coralline species and the indirect effects of altered interactions with other species. We tested the influence of grazing on the response of the coralline alga Lithothamnion corallioides to near-future ocean acidification and warming. Two three-month experiments were performed in the winter and summer seasons in mesocosms under crossed conditions of pH (ambient and -0.3 pH units) and temperature (ambient and + 3∘C) in the presence and absence of grazers. The metabolism (primary production, respiration, and calcification) of L. corallioides was significantly influenced by grazing, especially in the summer conditions, with higher rates in the presence of grazers than in their absence. An interaction between grazing and pCO2 was evidenced in the summer, with a reduction of calcification rates in the light under high pCO2 in the presence of grazers, while no effect was observed in the absence of grazers. Interactive effect of grazing and pCO2 was also found on dark calcification with a higher sensitivity to pCO2 increase in the presence of grazers. Our results indicate that grazing plays a key role in the response of coralline algae to future increase in pCO2 and temperature. This suggests the potential for grazers' activity to stimulate the metabolism of coralline algae and to reverse or exacerbate their response to global changes.

*Speaker

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Weak latitudinal but strong local effects in Phymatolithon calcareum are shaping the genetic structure of Atlantic European maerl beds

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Maerl beds are one of the world's key coastal ecosystems and are threatened by human activities and global change. This study is the first attempt at providing information about genetic diversity and structure of one of the major European maerl-forming species, *Phymatolithon calcareum*. We studied 15 maerl beds from Atlantic Europe using eight microsatellite markers. Two sampling scales (global: NE Atlantic and regional: Galicia) were analyzed. At regional-scale the sampling of sites located in the outer most zone and the middle zone within four Galician rias was performed to test the influence of water currents and seascape features on population connectivity and genetic diversity. Results suggested that clonal reproduction plays an important role in the population dynamics of *P. calcareum*. Clonal diversity was highly variable within region and even within estuaries. Curiously, the site of St Mawes -near to the neotype locality-, showed the highest level of clonality, and a possible triploid specimen has been detected. In *P. calcareum*, the level of clonality could then be related to abiotic conditions impacting the rate of maerl breakage but also to evolutionary history of hybridation and change in ploidy in some sites. A significant genetic differentiation was found among almost all the populations studied, and a weak but significant positive correlation between geographic and genetic distances showed the limited dispersal capacity of *P. calcareum*. Finally, a very clear pattern of genetic structure was revealed at the regional scale between populations located within and at the entrance of the estuaries. Genetic differentiation among estuaries was less marked for the sites located in the outer most zone compared to those located in the middle area of the estuaries. In addition, variation in clonality was also observed: populations situated in the external parts of the estuaries were less clonal that populations of the inside parts.

Keywords: estuaries, European coast, gene flow, genetic and genotypic structure, partial asexual organisms, rhodolith

*Speaker

Combined effects of global climate changes and nutrient enrichment on the physiology of three temperate maerl species

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Calcareous coralline algae forming maerl beds play a major role as ecosystem engineers in coastal areas throughout the world. They are subject to strong anthropogenic pressures at a global and local scales, which may threaten their survival. The aim of this work was to give insights on the future of maerl beds in a context of global and local changes. The effects of temperature rise (+3°C) and ocean acidification (-0.3 pH units) according to future RCP8.5 scenario, and nutrient (N and P) enrichment on the three temperate maerl species, *Lithothamnion corallioides*, *Phymatolithon calcareum*, *Lithophyllum incrustans*, were examined in the laboratory under winter and summer conditions. Physiological rates of primary production, respiration and calcification were measured on the three species. Responses were species-specific and depended on the season. Primary production under ambient irradiance was only impacted in summer. It was affected by future temperature and pH scenario in *L. incrustans*, by nutrient enrichment in *P. calcareum*, and by their interaction in *L. corallioides*. Calcification was negatively impacted by the future global change scenario but the response varied according to the species, the season and the light or dark conditions. Measurements performed at higher irradiances under low nutrient concentration displayed that near future changes in pH and temperature may enhance maximal gross primary production rates in *P. calcareum* and *L. corallioides* and maximal gross calcification rates in the three species. The consideration of the abiotic parameters other than temperature and pH prevailing in their natural environment and the response of their metabolic rates under different environmental conditions is essential for understanding the capacity of macroalgae to adapt/acclimate to global change and which management policies can be taking into account in order to reduce the negative impact of global change on marine ecosystems.

Keywords: maerl, ocean acidification, warming, nitrate, phosphate, photosynthesis, calcification, respiration

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Characterization of different rhodolith beds off the Campania Coast (Tyrrhenian Sea)

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Mediterranean rodolith beds (RBs) are coastal to offshore habitats mainly occurring at about 40-60 m of depth. They can be structured by a combination of different rhodolith morphotypes, classified as boxworks, pralines, unattached branches (also known as maerl), and coated grains, according to their morphology, size and species composition. Despite their important role in marine ecosystems, there are only few information about the distribution and description of Mediterranean RBs. In this communication, we report a preliminary characterization in terms of habitat complexity and rhodolith species composition, comparing three different RBs off the Campania Coast (Tyrrhenian Sea) in the areas of Capri, Ischia and Acciaroli.

Keywords: rhodolith beds, Rhodophyta, coralline algae, Tyrrhenian Sea

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Norways hidden marine biodiversity: the hunt for cryptic species within the coralline algae

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Despite a comprehensive historic record from 1850 to the early 1900ies, coralline algae constitute a poorly known group for Norway, both with respect to species diversity and species belonging, spatial distribution, as well as ecology. In the CoralAlg-project funded by the Norwegian Biodiversity Information Centre, we have sampled free-living and attached (on stones, rock, kelp- and sea grass plants) coralline algae from 59 stations (20 stations including maerl beds) from 4 eco-regions. The samples cover a wide latitudinal range (59.3-70.7∘N), three wave exposure classes and two depth classes (shallow-< 10 m, deep-> 10 m). CoralAlg has also performed molecular studies of historical material from Trondheim Herbarium. This material includes type specimens of maerl species and forms described for Norway, and historic specimens collected along the Norwegian coast, mostly by Mikael Foslie. The poster provides an overview of the project and it's results.

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Vermetid gastropods as associated fauna in rhodolith beds along the Brazilian coast

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Rhodolith beds are hard benthic substrates, although mobile, made up of branching crustose coralline thalli. The complex thalli may provide space, refuge, and resources through increased interbranch space. Thus provides three-dimensional microhabitats and refuge for many organisms as invertebrates and algae, playing an important ecological function as ecosystem engineers. Among the organisms rarely considered in benthic communities, the vermetid gastropods (Mollusca, Vermetidae) are usually associated with the surface of algal thalli, as rhodolith epifauna. Like many other sessile organisms, vermetid larvae need a hard and stable substrate onto which they can attach, like rhodolith nodules. The largest extension of rhodolith beds in the world is found from 2∘N to 25∘S on the Brazilian continental shelf in the southwestern Atlantic, mostly found among seagrass beds and close to coral reefs from nearshore down to 100 m depths. In this study, the vermetid fauna associated to rhodoliths along the Brazilian coast was surveyed. Vermetids are commonly found attached to rhodoliths distributed from the northeast, in the Rio Grande do Norte State (Pirambúzios) to the southeastern, in the Rio de Janeiro State (Arraial do Cabo), including the Brazilian oceanic Island Trindade. According an up-to-date survey, 8 vermetid *taxa* were found associated to 6 coralline algae *taxa* related to rhodolith beds, from the very shallow waters (2m) to 100m depth. Previous study confirmed a positive correlation in the settlement of the vermetid *Dendropoma irregulare* and live coralline algae *Porolithon pachydermum*. It seems that vermetid settlement is also triggered by the coralline algae forming live rhodolith beds. It is estimated that the present association occurs also to the southern limit of the known distribution of rhodolith bed habitat in the western Atlantic, in the Arvoredo Island. These records represent the first qualitative assessment of this association along the Brazilian coast. .

Keywords: Rhodolith, Brazil, Mollusca, Vermetidae, associated fauna.

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Deep-water coralline algal rhodoliths forming an extensive pavement on the Brazilian continental shelf

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A vast deep-water rhodolith bed has been observed on the seafloor in the area of the Campos Basin, the largest area of oil production on the Brazilian continental shelf. This predominant coralline algal community, occurring at 94–106 m depth, is located 46 nautical miles offshore from the Cabo Frio region, in the Peregrino oil-field. The coralline algae making up the rhodoliths consist of only two species: *Lithothamnion* sp. and *Mesophyllum engelhartii*. Subordinate rhodolith components are encrusting foraminifera (*Acervulina inhaerens*), vermetid tubes (*Thylacodes decussatus*), polychaete calcified tubes and bryozoans. Accelerator mass spectrometric analysis, radiocarbon age estimates show that the range in ages between the living outer rhodolith pavements and within 3 mm from it is (*ca.* 8.301–8.533 and 8.472–8.855 Cal years B.P. respectively). The results suggest that a large proportion of the living rhodoliths in the bed consist of fossil rhodoliths, at least 8.000 years old, which are now encrusted by thin living coralline algal plants. The studied rhodolith bed has been an important habitat in this area for thousands of years and was re-colonized by corallines and associated benthic faunas in very recent time. At least from the late Holocene up today this study bed played an important ecological role by establishing a stable surface suitable for invertebrate settlement. A similar situation of long-living rhodolith beds and resurrected rhodoliths has been documented from the Middle Miocene of the Mediterranean area.

Keywords: Rhodolith pavement, Brazilian continental shelf, ecology, Holocene

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