merces

restoring marine ecosystems

NEWSLETTER02

JUNE 2017

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WELCOME

Danovaro R. – MERCES Coordinator

This second newsletter of the MERCES "Marine Ecosystem restoration in Changing European Seas" project is dedicated to the private and public industrial stakeholders and regulating authorities who wish to put their business at the heart of the Restoration Agenda. In particular, the MERCES project aims to stimulate the interest of industries (such as flood defence, coastal management, carbon trading, oil and gas, ports and harbours, deep-sea mining) and regulating authorities, belonging to the sectors identified in the EU's Blue Growth strategy, to extend business opportunities in marine restoration. MERCES will foster the development of new approaches and technologies enabling the ecological restoration of marine ecosystems.

This is a challenging task never attempted previously by the EU and spanning from coastal areas to deep-sea habitats. Through the newsletters and other communication channels MERCES will disseminate 1) information on the results of its scientific research and field studies, 2) awareness for the need to restore marine habitats and 3) know-how on best practices and tools for the development of a "marine ecosystem restoration business".

The ambition of the MERCES project is to create new employment opportunities and develop world markets for European industries related to marine restoration. The results of MERCES will provide vital information for the five objectives identified in the Europe 2020 Strategy for the coming decade: Employment, Research & Development, Education, Social Inclusion and Climate Change & Energy. At the same time, MERCES meets one of the 3 priorities defined by G7 Ministers of Science dealing with the Health of the Oceans, making a case for the global development of marine ecosystem measures.

This newsletter represents the first of a series of initiatives (including an industrial portal in the MERCES website and dedicated industry webinars) that will be carried out during the course of the project for direct communication between MERCES and industrial stakeholders and regulating authorities. Enjoy reading this newsletter. Suggestions for additions and improvements to the newsletter are welcome.

Prof. Roberto Danovaro
MERCES Coordinator
Università Politecnica delle Marche, Italy

EDITORIAL INTRODUCTION

Billett D., Ojaveer H., Ramirez E.

Welcome to this business-focussed newsletter by the MERCES project on marine ecosystem restoration. We hope you enjoy it. We have focussed mainly on case studies of active restoration projects provided by businesses and companies MERCES has contacted. In addition, we have highlighted some projects where scientific research groups and businesses are working together to drive innovation and Blue Growth. We hope MERCES will succeed in stimulating these sorts of partnerships. We are particularly grateful to those businesses which have taken the time to contribute to this newsletter.

We have also featured ongoing research in our sister Horizon 2020 projects for Blue Growth, ATLAS and SponGES, and how these programmes are addressing the needs on industry. While MERCES, ATLAS and SponGES are very different in nature, and the industries we serve, it is encouraging to see the level of cooperation which has been achieved already between the projects.

In addition, the Newsletter contains some information on MERCES research and a 'regional seas corner' where we feature information from the Baltic Sea. We are hopeful that other regional seas in Europe will join us later on.

The MERCES Business Club is now up and running through the MERCES project's website. Through the website we will provide timely reviews of the latest research being reported in marine ecosystem restoration. Regular updates will be sent to MERCES Business Club members. The MERCES Business Club will also respond to individual enquiries on marine ecosystem restoration issues through the dedicated portal merces@deepseasolutions.co.uk. Expressly we will put coastal zone managers around the world in touch with companies that can address their particular needs. If you like what you see in the newsletter sign up to the MERCES Business Club today. We look forward to featuring your work in our next edition.

The editorial team,

David Billett, Deep Seas Environmental Solutions Ltd (merces@deepseasolutions.co.uk)
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Coral transplantation to mitigate dredging impacts on coral reefs for a port development

Thorin S. - Créocéan

Setting the scene

A port extension project at Pointe-à-Pitre, Guadeloupe, French West Indies (building a new terminal for Panamax-specification vessels ships with a draught greater than 16m) required the dredging of an access channel (removing almost 7 million cubic metres of sediment over an 11-month period). The work included preserving a coral reef area by moving a substantial part of it to a new location.

The main impacts on marine biodiversity were:

- Destruction of coral reefs through rock breaking (0.8 ha of a 3 ha area where corals were located).
- Destruction of marine seagrass meadows (10,000 m^3 backfilled or dredged).
- High turbidity during dredging, dumping, rock breaking and backfilling.
- Wildlife disturbance (e.g. on marine mammals and turtles).

Coral transplantations

Various surveys and mitigation measures were implemented including coral and seagrass transplantations. The French company CREOCEAN was in charge of all coral transplantation operations including preliminary studies assessing the feasibility of the project, evaluating the health status of the donor coral reefs, identifying and characterizing the best recipient sites and submitting a detailed methodology to authorities for the different phases of the work.

In view of these studies the State environmental services required a coral transplantation of a minimum of 4,150 coral colonies, taken from two sites located with an area of over 3 ha that was to be impacted.

The transplantation was performed from January to March 2015. A total of 4,188 coral colonies belonging to 22 species and measuring 20 cm to 1.5 m in diameter were relocated; this included massive and encrusting corals belonging to 7 families (mainly Favidae and Siderastreidae). The project required major logistics and organization (total cost: €700,000 (0.5% of the project's cost), 20 divers and 3 vessels during a two-month period).

Monitoring of relocated and control-site corals is being undertaken and will continue over a 3-year period. The monitoring aims to gauge the success rate of the transplantation, coral growth rates, signs of bleaching or necrosis, coral recruitment, coral cover, and the status of associated fauna.

Monitoring is carried out using photoquadrats on 62 transplanted colonies selected at random and compared to reference sites. The sessile benthic community (including juvenile corals and sea urchins) and associated fish communities are being monitored as well (semi quantitative visual census).

The frequency of monitoring efforts is 1, 3, 6 and 12 months after transplantation, and then every 6 months for the 2nd and the 3rd year (from 2015 to 2018).

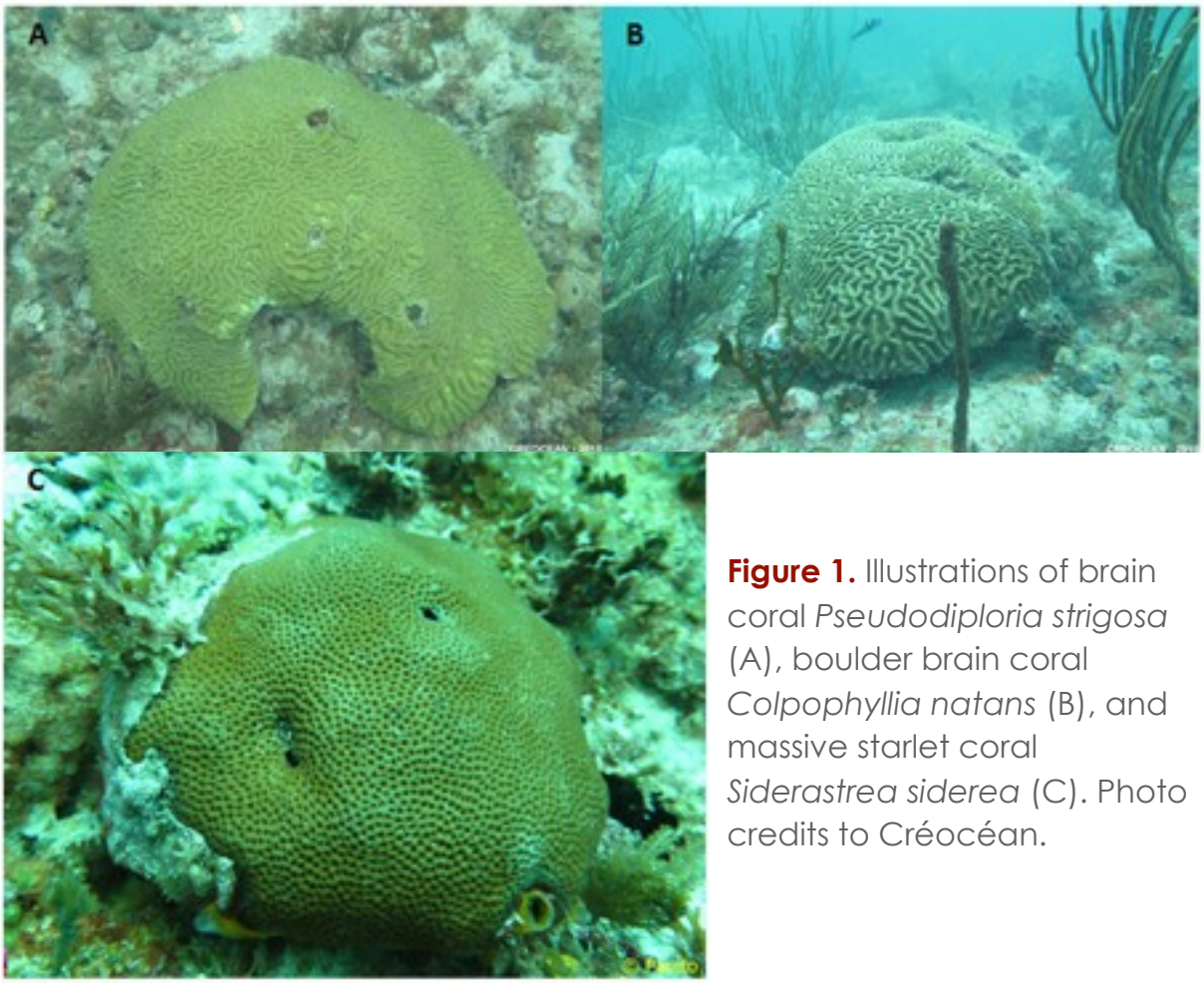

Figure 1. Illustrations of brain coral *Pseudodiploria strigosa* (A), boulder brain coral *Colpophyllia natans* (B), and massive starlet coral *Siderastrea siderea* (C). Photo credits to Créocéan.

Initial results and future perspectives

For the first year of monitoring, the survival rate of the 62 transplanted colonies chosen for monitoring was very good (98.4%). Only 1 mortality was observed one year after transplanting. Colonies showed a decline in their condition during the first 6 months post-transplant. This was mainly due to the development of small, localized tissue necrosis linked to damage from the transplanting methods. Moreover, a bleaching event occurred in October 2015 (6 months after transplanting) owing to warm waters.

During the second half of post-transplant period the majority of the colonies had recovered from the bleaching phenomenon and their state of health is improving.

These results show that the relocated corals were resilient to the stresses they experienced during relocation and the effects of subsequent seasonal warming. Boulder brain corals (*Colpophyllia* sp.), brain corals (*Diploria* sp.) and massive starlet corals (Siderastrea sp.) appear to be more resilient than others to the stresses of transplantation and the bleaching event. These observations will be refined during the continued monitoring campaigns. Future monitoring of the relocated corals during the contracted work and beyond may ascertain the resilience of these corals. Having the relocation occur during "optimal" environmental conditions would provide a buffer of time for corals to recover from any stresses during the relocation process and to acclimate to the biotic and abiotic settings of the relocation site.

For further information contact Sebastien Thorin (thorin@creocean.fr), Créocéan (www.creocean.com).

Figure 2. Harvested corals are placed in crates to be hoisted to a vessel for transportation to the recipient site (A); large boulderbrain coral being harnessed to a line from the support vessel (B); harvested corals temporarily placed seawater holding tanks during transportation (C); periodic monitoring of transplanted coral colonies (D). Photo credits to Créocéan.

Innovative eelgrass restoration techniques: the NOVAGRASS project

Kristensen E., Flindt M. - University of Southern Denmark

The project

The dramatic decline in eelgrass coverage in coastal areas during recent decades has serious implications for associated ecosystem services, such as carbon and nitrogen sequestration, coastal protection and biodiversity. The expected recovery of eelgrass in coastal areas following substantial reductions in nutrient loading has not occurred. A major reason is negative feedback mechanisms related to physical and biological disturbances that hinder the transition from seeds to established seedlings.

The objectives of the NOVAGRASS project are to 1) develop new technical tools for eelgrass seed harvest and transplanting, 2) apply and evaluate these tools at a large scale in the field, 3) provide guidelines for eelgrass restoration, including challenges related to climate change through modeling approaches, and 4) provide a socio-economic analysis and assessment of the ecosystem services gained by restoration.

The approach is to develop eelgrass seed harvest and storage procedures, and to combine these with transplanting techniques designed to alleviate effects of physical and biological disturbances. The work is based on the experience obtained from previous projects and the knowledge of widely recognized eelgrass restoration experts. Industrial partners are integrated in the NOVAGRASS research providing logistics, equipment and techniques for large-scale restoration. They enable NOVAGRASS to develop novel technologies for the expanding market of aquatic ecosystem restoration.

Some results

- The effect of seed processing on germination success. Results show that mechanically processed seeds survive and germinate less successfully than hand separated seeds. The impact of storage for periods of several months on dormancy and germination success of manually harvested seeds will be available soon.
- Eelgrass restoration. Methods based the broadcast of eelgrass seeds have shown limited success. As an alternative, shoot transplantation has been attempted at shallow and deep locations using an array of newly developed methods. The results indicate basin-scale spatial heterogeneity in transplantation success. In some locations eelgrass will not remain unless it is protected, using a variety of methods, while in other locations transplanted eelgrasses has been found to grown well irrespective of physical protection.

- A particle model of eelgrass seeds. Combined hydraulic and ecological 3D models have been used to predict the likely success of eelgrass recovery following restoration actions. The model includes a variety of key state variables, and can identify thresholds where the system feedback mechanisms respond positively to eelgrass recovery. A series of multi-year simulations is being carried out on selected estuaries (lagoons) with different eelgrass die-back history, restoration schemes and climate scenarios to identify the potential for eelgrass recovery. GIS maps are being generated of present and simulated future eelgrass coverage depending on the applied restoration actions and climate conditions. The maps will be used for subsequent ecological and socio-economic analyses.

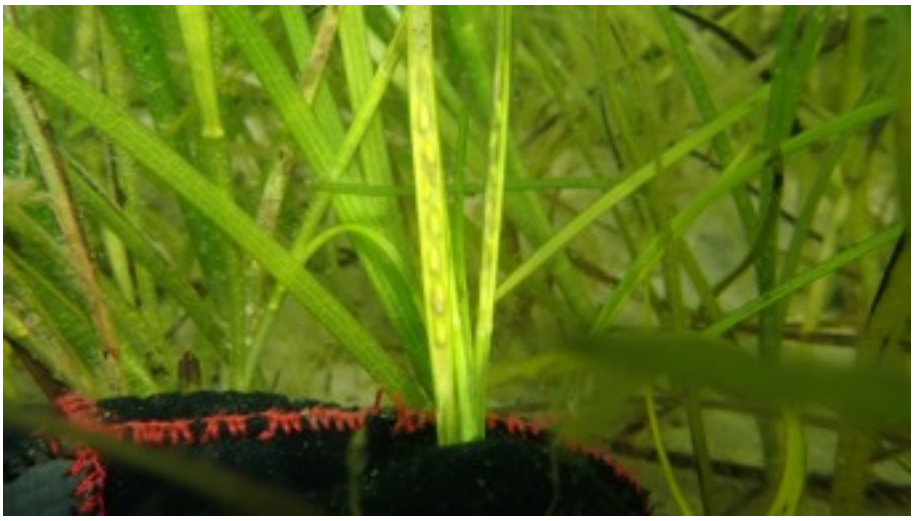

Figure 3. Seeds on mature shoot. Photo credits to Troels Lange.

- Technological developments. The collaboration of scientific and industrial partners with complementary expertise in NOVAGRASS offers the potential for successful development of innovative technologies for mass harvesting, storing and germination of seeds as well as for planting seedlings. The industrial partners' commercial interest provides the incentive for the development of cost-effective techniques that are applicable widely in water management. The systems are designed to have limited impact on the eelgrass meadows that are being harvested. The design and construction drawing for a large scale eelgrass seed harvester have been completed. In addition, a lighter second generation sowing machine has been developed while tests of a high density sowing machine have been performed. Initial tests of the seed harvester have shown successful regrowth of eelgrass after seed harvesting.

The future

The NOVAGRASS project ends in 2018. The work will instead be continued for the next 3 years in the project "large-scale transplantation of eelgrass" (TRANSPLANT) funded by the Danish Nature Agency. The main purpose of TRANSPLANT is to demonstrate the potential for eelgrass restoration by applying large-scale transplantations of shoots in a number of Danish fjords. The transplantations will be conducted in hydrographically and ecologically diverse areas where eelgrass distribution is limited. The specific test areas selected will cover the most common types of coastal areas found in Denmark. The benefits derived from ecosystem services following the transplantation of eelgrass will be assessed including N, P and C sequestration.

For further information contact Erik Kristensen (ebk@biology.sdu.dk) and Mogens Flindt (mrf@biology.sdu.dk), Department of Biology, University of Southern Denmark.

Figure 4. Automated seed harvester. Photo credits to Flemming Gertz.

Valuing multiple eelgrass ecosystem services: fish production and uptake of carbon and nitrogen

Billett D. - Deep Seas Environmental Solutions Ltd

In a recent open access paper Scott Cole (Enviro Economics Consultancy Sweden) and Per-Olav Moksnes (University of Gothenburg) have developed a framework for valuing multiple ecosystem services with relevance to the retention and restoration of eelgrass in the northern hemisphere (Frontiers in Marine Science 13 January 2016). They highlight the many complex trade-offs in the loss and/or restoration of eelgrass beds focussing on valuing nature's benefits to society in monetary terms. The work is of importance to policy-makers making decisions between competing demands in the coastal zone.

Seagrass beds are impacted by multiple stressors including nutrient pollution, sediment runoff, dredging, and coastal development (docks, marinas, etc.). The global loss of seagrass ecosystems has led to a decline in key ecological functions such as habitat provision for fish and other organisms, uptake of carbon and nutrients, sediment stabilization and storm protection. As seagrass functions decline, so too do ecosystem services resulting in the reduction of economic goods that depend on them, such as food (e.g., fish and other seafood), the protection of real estate from coastal erosion, and clearer water and stable sandy beaches for recreation and tourism.

Figure 5. Eelgrass (*Zostera marina*). Photo credits to Kaire Kaljurand.

The authors quantified the value of eelgrass beds per unit area as habitat for fish, and the sequestration (uptake) of carbon and nitrogen. They calculated that if a hectare of eelgrass is lost and the habitat transformed to unvegetated bottom where the top 5–25 cm of the sediment is eroded, a variety of losses would occur including: a reduced yield of approximately 626 kg of gadoid fish and 7535 individual wrasses, a reduction of 99,000 kg (98.6 tons) of sequestered carbon and 466 kg of nitrogen over a 20–50 year period. This produced a conservative value of economic benefits to be in the region of 20,700 US Dollars per hectare of eelgrass.

The work demonstrates the important benefits that arise from the retention and restoration of eelgrass beds with implications for commercial fishing, the mitigation of impacts from climate change and reducing eutrophication in coastal waters. Fish production, which is the most commonly valued ecosystem service in the seagrass literature, represented only 25% of the total value. Benefits of nitrogen regulation constituted 46%, suggesting that most seagrass beds have been undervalued by previous studies.

Quantifying ecosystem services provides a strong theoretical basis for valuing nature's contribution to societal well-being. Coastal managers, for example, may use the method to decide whether to allow partial losses (from e.g., dredging) or to assess the value generated by off-setting compensation projects (e.g., eelgrass restoration). Valuation estimates can support arguments for establishing Marine Protection Areas. The value associated with damaged resources is critical for implementing the Polluter Pays Principle (PPP), which underlies several EU Directives and suggests that operators, not the government, are responsible for internalizing the cost of environmental damage.

The importance of carbon budgets in marine ecosystem conservation and restoration

Crooks S., Emmer I. - Silvestrum Climate Associates

'Blue Carbon' is a recent and rapidly developing concept that recognizes the importance of the conservation and restoration of tidal marshes, tidal forests (including mangroves) and seagrasses in the global carbon cycle. Lying at the interface between land and sea these blue carbon ecosystems are prodigious removers of carbon dioxide from the atmosphere.

While the richness of these ecosystems in terms of biodiversity, biomass and ecosystem services is evident it is the carbon stored in the sediment and soils accreted by these blue carbon ecosystems that is particularly noteworthy. The gradual accumulation of organic matter in soils over thousands of years has generated rich but fragile carbon stocks. As long as blue carbon ecosystems remain undisturbed the accumulated carbon is protected from returning back to the atmosphere.

Unfortunately, these ecosystems, which are critical to the livelihoods of many coastal communities in supporting fisheries as well as providing flood protection, are being destroyed at a rapid rate. It is estimated that globally around one percent of blue carbon ecosystems are lost each year and in the process some 450 million tons of carbon dioxide are returned to the atmosphere. This is a substantial emission that is greater than that from the total economic output of a country the size of France or Italy. The social cost and economic damage of the carbon emissions from the loss of tidal marshes, mangroves and seagrasses are estimated at around 17 billion Euros each year.

Forest clearing and excavation for construction of aquaculture ponds in the tropics is one particular cause of mangrove loss. But because these ponds have a very short lifespan before being abandoned the greenhouse gas emissions footprint of consuming just a small meal of shrimp is equivalent to driving a car over one thousand miles.

Silvestrum Climate Associates are working on innovative methods to recognize and reduce these carbon emissions. Silvestrum was founded in Europe in 2008 and expanded its business to the United States in 2016 as Silvestrum Climate Associates. Silvestrum are a 'boutique' consultancy group providing specialist technical services globally in the field of international climate change policy, coastal engineering, environmental science and carbon project development.

Figure 6. Tidal marshes on the shores of Loch Kishorn, Northwest Scotland. Photo credits to Steve Crooks / Silvestrum Climate Associates.

Figure 7. Growing saplings in a replanted mangrove, Ambaro Bay, Northern Madagascar. Photo credits to Steve Crooks / Silvestrum Climate Associates.

Working with the research community Silvestrum Climate Associates have assisted the United States Government to be the first country to recognize the importance of coastal wetland management in a national inventory of greenhouse gas emissions and sinks. With the Partnership for Ecosystem Management for the Seas of East Asia (PEMSEA), Conservation International and The Nature Conservancy Silvestrum Climate Associates are releasing an assessment of blue carbon opportunities for 13 countries across East Asia. Also, as part of an International Union for Conservation of Nature (IUCN) team Silvestrum Climate Associates are preparing the launch of a 'blue natural capital facility' to serve as incubator for a long-term public-private funds.

On the ground Silvestrum Climate Associates are helping organizations and communities on four continents to connect conservation and restoration of blue carbon ecosystems to international carbon financing. We are also assisting local governments to evaluate risks to local communities to sea level rise and develop adaptation strategies including building with nature and ecosystem restoration. Besides blue carbon, we remain active in forest and peatland restoration and conservation.

For further information contact Steve Crooks and Igino Emmer at Silvestrum Climate Associates (www.silvestrum.com/contact/).

Marine ecosystem restoration and management options for port operators: the benefits of the sediment replacement

Sutherland D. - HR Wallingford

Introduction

The management of port developments is increasingly challenging because of the requirement for deeper channels for ship passage and the need to preserve important coastal wetlands and ecosystems. HR Wallingford, UK, has been closely involved in projects associated with these issues for a number of years dredging channels and restoring marine ecosystems. One particular site where HR Wallingford has been active is in and around the Port of Felixstowe and Harwich Harbour (the Haven Ports) on the Stour/Orwell Estuary (Figure 8). The estuary is internationally important for its wetland bird populations and the intertidal areas are protected under European legislation.

Figure 8. Locations of initial sediment recycling placements. Image credits to Spearman J., Baugh J., Feates N., Dearnaley M., Eccles D. (2014). *Small Estuary, Big Port - Progress in the management of the Stour-Orwell Estuary system.*

Habitat restoration and sediment replacement

Works to deepen the approach channel to the Haven Ports commenced in October 1998 and were completed in April 2000. Consent conditions included habitat and sediment replacement and the requirement "*... to avoid any impacts as a result of the dredge on the favourable conservation status of both [the Stour and Orwell] habitats*".

Predictive flow and sediment transport modelling was used as the basis for the development of a sediment replacement strategy to offset the perceived impacts on intertidal habitats.

The modelling predicted that deepening of the harbour and the approaches would lead to trapping of material in the harbour, a reduction in sediment supply to the Stour and Orwell Estuaries and an increased rate of loss of habitat of 2.5 ha/yr. To offset this 200,000 tonnes dry solids (TDS) (annual average) was replaced in the Stour/Orwell system during dredging operations between 1998 and 2007. These operations were the first large-scale mitigation of its type in the UK. Monitoring included bathymetry surveys, LiDAR measurements (for saltmarsh habitats), bird counts, benthic ecology and fish (including shellfish) monitoring.

Following the implementation of the sediment recycling, the fishing community became concerned by accumulations of silt at various locations within and just outside the estuary system. The evidence led to a modification in 2008 of the recycling strategy reducing sediment inputs to the estuaries significantly (a total of 50,000 TDS/yr). To date this modified mitigation appears to be successful in enhancing intertidal habitat whilst not causing adverse effects on fishery interests.

Figure 9. Saltmarsh in the Stour Estuary. Photo credits to Royal Haskoning (2013) *Stour and Orwell Estuaries Annual monitoring, Analysis of saltmarsh extent, February 2013*.

The benefits of the sediment replacement through dredging

Prior to the deepening of the approach channel to the Haven Ports the Stour estuary was losing intertidal area at a rate of 13 hectares per year. Since the deepening, LiDAR and bathymetric surveys in 2005, 2010 and 2015 have shown that the programme of sediment cycling has been successful in reducing both the predicted effects of the channel deepening and in offsetting intertidal erosion prior to 1998. Analysis of the extent of saltmarsh in 2005 and 2010 in the Stour and Orwell (Figure 9) was undertaken using aerial photography and site visits by Royal Haskoning DHV. After an initial loss of saltmarsh habitat between 1997 and 2005, the area of habitat has now increased following the placement of sediment in the estuaries.

The careful placement of sediment in the Stour and Orwell estuaries, supported by modelling and monitoring, has shown that this methodology can contribute effectively to restoring and maintaining marine ecosystems.

For further information contact David Sutherland, Principal Scientist, HR Wallingford, UK (D.Sutherland@hrwallingford.com).

Delivering large habitat restoration schemes

Pontee N. - CH2M and University of Southampton

A recent example of large-scale habitat restoration in the coastal zone can be found in an account by James Scott (CH2M) and co-authors (2015) on the Steart Coastal Management Project (see Coastal Management, Changing Coast, Changing Climate, Changing Minds. Institute of Civil Engineers Publishing). The project was developed by the Environment Agency, Wildfowl and Wetlands Trust (site managers), CH2M (Consultants) and Team Van Oord (Civil Engineering Contractor).

About 100 hectares of saltmarsh are being lost each year in the UK. This is due mainly to the combined effect of sea level rise and flood defence projects (coastal squeeze). In order to provide compensatory habitat a large-scale salt marsh restoration project has been initiated on the Steart Peninsula in the Bristol Channel at its confluence of the River Parrett (Figure 10). The scheme area covers around 600 hectares most of which was formerly used for agriculture. Almost 300 hectares of intertidal salt marsh and mudflats have been created together with 70 hectares of transitional brackish habitat and over 100 hectares of coastal grazing marsh and freshwater habitat. The project is one of the largest habitat creation schemes ever undertaken in the UK.

Figure 10. Steart Peninsula in the Bristol Channel. Photo credits to Sacha Dent WWT.

The project was led by the Environment Agency and took more than 16 years to set up (1998 to 2014). Through a competitive process the Wildfowl & Wetlands Trust (WWT) were selected to deliver the project and guide the scheme through all the legal and regulatory challenges. A Master Plan for the Steart Peninsula was developed by the WWT with the Environment Agency and the Bristol Port Company and the project was put into effect three years later in 2014.

Key to the success of the project was wining and retaining the trust of the local residents. A small collaborative working group was set up and major stakeholders and individuals were invited to comment on the scheme's development. The formation of strong and open relations allowed concerns or opposition to be addressed and enabled optimal plans to be developed quickly with the understanding and support of the local community. Sites of Special Scientific Interest (SSSIs), Special Protection Areas (SPAs), Ramsar Sites and Special Areas of Conservation (SACs) were safeguarded through detailed design and assessment and consultations with local authorities.

In the design of the restoration project extensive modelling was undertaken by CH2M to evaluate tidal inundation characteristics and to assess the impacts on the surrounding estuary. Multiple options were considered, including seaward breaches, multiple estuary breaches and a single breach into the estuary. Hydrodynamic modelling showed that some scheme designs produced increases in tidal levels within the estuary if implemented. Through the modelling the optimal setting for a single northerly breach into the River Parrett was chosen which avoided increases in flood risk.

3D computer modelling was used to plan the earthworks and manage risk. The model ensured that all the material excavated was accounted for, haulage routes were minimised and that special wildlife areas, archaeological features and sites important to the local community were avoided.

A 'herring bone' artificial creek system was designed for the site (Figure 11) to distribute water into the farthest parts of the site, allow the site to drain, aid the development of creeks and consequently permit the new salt marsh habitat to form. The creek network was also designed to be constructed safely, maximise the area and diversity of intertidal habitat created, minimise adverse environmental impacts, minimise whole-life costs and achieve an aesthetically pleasing landscape. Ensuring that the project did not impact on landowners or the critical drainage function of the area beyond the confines of the site presented considerable challenges. More than 100 structures were designed to manage water and access across the scheme.

Figure 11. Steart Marshes from the air . Photo credits to Sacha Dent WWT.

The artificial creeks were constructed using a 3D model combined with GPS enabled earthmoving equipment. This allowed the earthworks to be constructed accurately whilst at the same time reducing equipment movements and reducing environmental impacts.

In the last 3 years the creek system has evolved. Some creeks are cutting back and deepening and new smaller creeks are forming. The creeks are being cut back in a similar fashion to a river system eroding a hard substrate.

Additional advantages of the scheme include 1) capturing hundreds of tons of carbon in the accumulating sediments, 2) providing habitat for the breeding of commercial fish stocks, 3) restoring a natural environment for wildlife conservation and 4) stimulating tourism through new visitor car parks and informative signs. The site is now the focus of a number of long-term scientific studies by the University of Southampton, Manchester Metropolitan University, Oxford Brookes University and Plymouth University on sediment accretion rates, carbon storage estimates, fisheries, nutrient regeneration, species succession, microbial interactions and the valuation of ecosystem services to quantify the benefits of restoration actions.

For further information contact Nigel Pontee (nigel.pontee@ch2m.com), Global Technology Leader, Coastal Planning and Engineering, CH2M and Visiting Professor, Natural and Environmental Sciences, University of Southampton.

Restoration of deep-water gorgonian forests on the Mediterranean continental shelf

Gori A., Gili J-M., Linares C. - Institut de Ciències del Mar and University of Barcelona

Gorgonians are one of the main ecosystem engineers in deep Mediterranean bottoms. They generate complex three-dimensional structures that enhance spatial heterogeneity and support a highly diverse associated fauna. Gorgonians are also among the most frequently found taxa in fishing by-catch. Fishing can cause the total removal of the gorgonian colonies (in the case of bottom trawling and long-line fishing) or their partial damage (in the case of trammel net and long-line fishing). These impacts can have long-lasting effects owing to the low growth rates and slow population dynamics of Mediterranean gorgonians. Bearing in mind these life history traits, it is highly desirable to promote active ecological restoration actions in order to facilitate and accelerate their recovery.

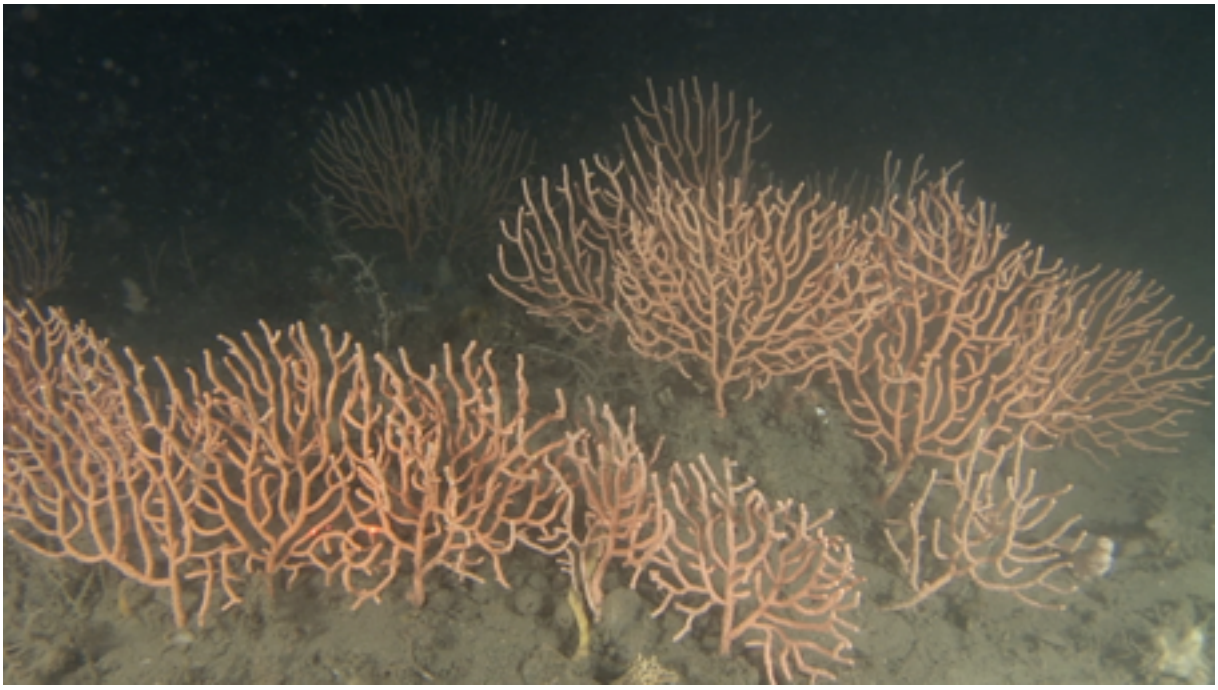

Figure 12. Gorgonians on the continental shelf in the north of Cap de Creus (Spain). Photo credits to IFM-GEOMAR - ICM-CSIC.

During the last two years, the ShelfReCover project has explored the viability of the ecological restoration of deep gorgonian populations using a novel approach: gorgonian colonies collected as by-catch by artisanal fishermen were transplanted back in their natural environment. A total of 120 gorgonians were transplanted on three steel landers, each 2 metres in diameter and 120 kg weight. The landers were deployed at 84m depth on the continental shelf in the north of Cap de Creus (Spain). Gorgonian survival after transplantation was monitored by means of the Autonomous Underwater Vehicle (AUV) Girona 500, working as Hybrid Remotely Operated Vehicle (HROV). A sonar reflector located at on each lander enabled their easy relocation using the AUV sonar. Subsequent surveys showed that most of the gorgonians had survived (100% at 6 months and 93% at 12 months after the landers were deployed).

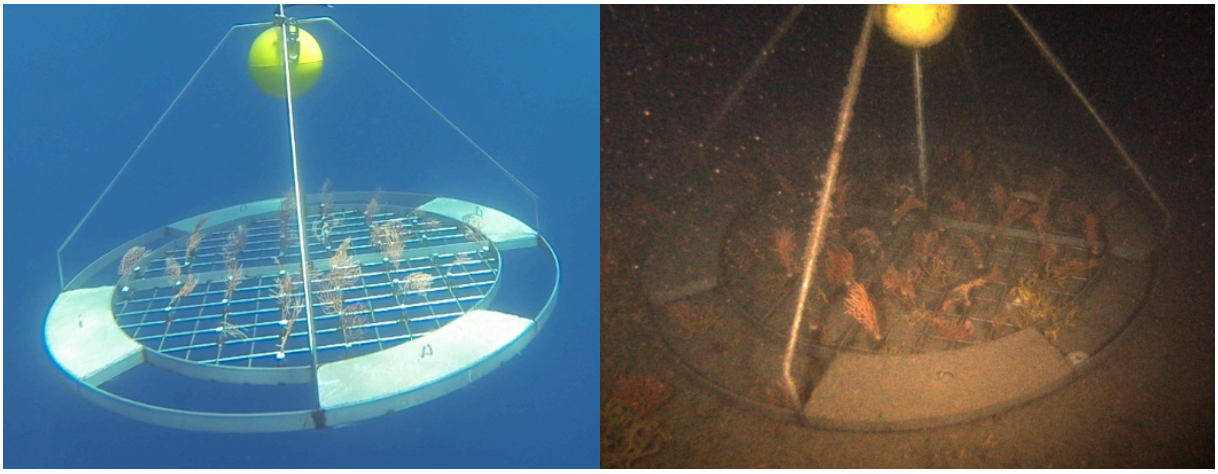

Figure 13. One of the landers with the transplanted gorgonians, during its deployment (left) and on the seabed at 84 m depth (right). Photo credits to CIRS – UB.

These preliminary results highlight the viability of deep gorgonian recovery and transplantation in their original habitat. Based on these results the Institut de Ciències del Mar (ICM-CSIC) and the Universitat de Barcelona are evaluating in the MERCES project the viability of large spatial scale actions for the restoration of deep-water gorgonians on the Mediterranean continental shelf to mitigate fishing impacts.

For further information contact Andrea Gori and Josep-Maria Gili, Institut de Ciències del Mar, Barcelona (gori@icm.csic.es), or Cristina Linares, Universitat de Barcelona, Barcelona (cristinalinares@ub.edu).

The importance of restoration actions in coastal marine habitats

Fraschetti S., Chimienti G., Cebrian E., Garrabou J. - University of Salento, University of Bari, CoNISMa, University of Girona and Institut de Ciències del Mar

Coastal areas are key areas for the economic development of our society. More than 60% of human population live near the coasts and a wide array of economic activities are developed there, such as tourism, fishing, transportation and power generation. There is a need to protect coastal marine habitats against degradation while developing economic activities in these populated areas.

A diverse array of environmental initiatives (e.g. EU Water Framework Directive, UNEP Barcelona Convention) are being implemented to reverse the current degradation trend and promote the sustainable use of marine ecosystems. However, the lack of ecological knowledge on the functioning and structure of coastal ecosystems presents a challenge: how can the recovery of degraded habitats be speeded up through marine ecosystem restoration measures?

The development of new efficient restoration protocols that can be scaled-up to large spatial scales may benefit the environment and generate economic revenues, such as from tourism. In this issue, we present two case studies on the restoration actions of key Mediterranean coastal habitats: coralligenous habitats and the macroalga *Cystoseira*.

Figure 14. *Cystoseira* on the shoreline. Photo credits to Simonetta Fraschetti.

Coralligenous habitats

There is an increasing recognition of the importance of cultural ecosystem services (CES) of marine habitats for supporting the management of marine systems. However, CES are still largely unknown compared to other ecosystem services (e.g. provisioning services) owing to the challenge of quantifying and valuing them. This is especially true when aesthetic, spiritual/cultural well-being and educational benefits are included in the assessments.

In the Mediterranean Sea, coralligenous bioconstructions are key coastal habitats because of their structural and functional importance. They exhibit high aesthetic value. Recently, a systematic mapping of the most visited diving sites across the Apulia region (Adriatic and Ionian Seas, Italy) has been carried out to understand the spatial distribution of coralligenous habitats and their ecological features. The habitats which scuba divers preferred to visit were assessed in order to quantify their economic contribution of local recreational activities. In addition, the proportion of CES that could be attributed to diving on coralligenous habitats were estimated recognising that scuba diving is closely related to cultural benefits (such as spiritual and aesthetic experiences).

Figure 15. Diving on a coralligenous reef. Photo credits to Alberto Liturri.

The results show that coralligenous habitats in this area of the Mediterranean Sea generate an economic contribution of 4.7 M euro/year. While these assessments probably underestimate the contribution of coralligenous formations, because not all ecosystem services provided by coralligenous habitats were valued, they highlight the magnitude of importance of this habitat and the recreational opportunities and tourism income they provide to local economies. The results emphasise the potential of including economic instruments in planning sustainable activities and setting priorities for conservation planning and coastal management decisions. The findings further stress that conservation is not sufficient alone and that concrete actions dedicated to the restoration of these valued habitats are critically needed.

Warning signs in the ecological health of the brown algae *Cystoseira*

The issue. Macroalgal forests such as kelps and fucoids are dominant habitat-forming species in rocky intertidal and subtidal habitats around all European coasts. They enhance coastal primary productivity and are recognized hot spots of diversity providing biogenic structure, food and habitat to diversified assemblages of understory species. In Mediterranean coastal areas species of the fucoid algae *Cystoseira* form dense canopies which maintain rich understory assemblages of sessile and vagile invertebrates and smaller-sized algae by providing shade and reducing physical stress due to aerial exposure. Two species – *Cystoseira crinita* and *C. balearica* – form underwater forests, which have a high nursery value: densities of several reef fish juveniles – particularly *Symphodus* spp. – have been found to be about 10 times greater in *Cystoseira* forests than in other habitats. The likely consequences of the alteration of this habitat are substantial with obvious consequences on the goods and services they provide.

The regression, and even disappearance, of macroalgae forest is occurring at large scale related to a variety of different stressors, such as pollution, coastal development and urbanization, outbreaks of grazer populations, species introductions and climate change. Besides global stressors, multiple local stressors, such as abandoned fishing gear (nets, trammel nets, threads) and trampling, threaten local and restricted macroalgae populations. The decline or disappearance of *Cystoseira* forests from many Mediterranean areas is leading to severe habitat transformations, with the loss of three-dimensional structures and associated biodiversity. It is surprising how little is known about most of these species and their population dynamics. The available literature suggest that the recovery of fucoid populations can take decades, probably due to their poor dispersal ability and the slow population dynamics. Clearly habitat conservation measures alone are not enough and systematic restoration actions are needed to reverse present losses.

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Rigs to reefs? How oil and gas platforms might assist biological communities to recover and connect in the North Sea: The ANChor project

Henry L-A. - University of Edinburgh

Eight international energy companies (BP, Centrica, CNR International, ExxonMobil, Marathon Oil, Shell, Talisman–Sinopec and Total) are funding scientific research projects as part of the INSITE North Sea programme. One of these, the ANChor project (Appraisal of Network Connectivity between North Sea subsea oil and gas platforms), has adopted an innovative approach studying how today's mature network of oil and gas subsea structures in the North Sea might assist regional ecological health and connectivity of dispersed biological populations. The results will allow us to understand the sensitivity of North Sea biological communities to the partial or complete decommissioning of subsea structures.

A wide variety of offshore man-made structures promote the dense growth of marine organisms such as algae, mussels, tube-building worms, hydroids, anemones and even reef-building corals. Have these man-made structures created new hard substrate reef systems? Do they play a wider role in the health of the North Sea, such as supporting more productive fisheries? How will the whole or partial removal of subsea structures during decommissioning affect the overall structure and functioning of North Sea ecosystems?

Figure 16. Original photograph courtesy of Lundin Britain Ltd. Reproduced from Roberts J.M., Wheeler A., Freiwald A., Cairns S. (2009) *Cold-water corals: the biology and geology of deep-sea coral habitats*. Cambridge University Press.

ANChor is a 2-year project (2016-2018) that combines surveys from 57 North Sea platforms with numerical models linking particle tracking simulations (such as the dispersal trajectories of eggs and larvae released by adults) with a high horizontal resolution (1.8 km) ocean circulation model of the Northwest European Shelf called NEMO. Inspired by graph theory, ANChor visualises platforms as "nodes" connected to each other by "edges" that vary in strength according to the number of connections each platform makes. The connections may be either as a donor or as a recipient of larvae of a wide variety of organisms, as estimated by the combined NEMO and larval biophysical model.

ANChor results show that there are strongly interconnected regional networks in the North Sea for most species which settle on subsea structures (such as the soft coral *Alcyonium digitatum*, the mussel *Mytilus edulis*, the barnacle *Chirona hameri*, and the anemone *Metridium senile*). CITES-protected reef framework-forming corals (*Lophelia pertusa*) which occur on platforms were highly connected in the northern North Sea, with several platforms acting as important donors to other structures and to coral reefs in Scandinavian waters.

The potential effects of decommissioning today's network of oil and gas structures on ecological connectivity are now being simulated in the model by removing the strongest donor platforms. These simulations will be used as part of the European Horizon 2020 project ATLAS (Understanding Deep Atlantic Ecosystems) to assess whether leaving subsea structures wholly or partly in place could be a viable method for industry to contribute to biodiversity offsetting and restoration measures in the North Sea.

For further information contact Dr Lea-Anne Henry (l.henry@ed.ac.uk), University of Edinburgh, ANChor project coordinator (www.insitenorthsea.org/research-projects/).

Coordinated action by HELCOM to restore the rivers and streams of the Baltic Sea region

Backer H. - HELCOM

Like blood vessels between the lungs and tissues, rivers and streams are key pathways between the Baltic, a semi-enclosed continental sea environment and its inland reaches. They may carry pollution from land to the sea, but are also paths which migratory fish like salmon and sea trout take upstream to their spawning grounds. Thus, the river and stream conditions directly influence the status of several migratory fish populations, which spend part of their life in the sea. During the last centuries, many streams and waters in the region have been subjected to intensive modifications such as straightening and dredging of streams for log driving, water level control, hydro-power developments as well as decreased water quality. In many cases such river and stream modifications have collapsed the natural fish production capacity.

The changes in energy production, timber transportation and how we spend our leisure time has created interest to restore river and stream environments and their fish populations. To follow up public interest, several municipalities in the coastal countries of the Baltic Sea have recently implemented river restoration activities.

River and stream restoration ranges from smaller interventions, such as adding gravel and riverside vegetation, to complete reconstruction of physical features, including natural meandering and removal of dams. As a fringe benefit, river restoration includes also often increased attention also to the water quality -and thus reduction of riverine pollution to the Baltic Sea.

The Baltic Sea marine environment protection commission (HELCOM) has recently started to plan coordinated actions to share the best practices on river and stream restorations for efficient use of public resources and best results for the environment. As a first step, a dedicated workshop was organised at the end of May in Demark. It is the intention of HELCOM to continue these efforts with an ultimate aim to help restoration of the degraded riverine habitats in the coastal countries, which will directly influence the Baltic Sea environment.

For further information contact Hermanni Backer Johnsen (hermanni.backer@helcom.fi), Professional Secretary HELCOM.

Figure 17. River Kiskonjoki. Photo credits to Samuli Korpinen.

MERCES research in the spotlight: two major reviews in the pipeline

Papadopoulou N. - Hellenic Centre for Marine Research

1. Identifying degraded habitats on the European margin

MERCES is producing a census of European marine key habitats in order to identify degraded habitats and their restoration potential. To do this MERCES has:

- Reviewed all existing habitat maps of European regional seas and provided source citations for all of the information.
- Reviewed degraded habitat map resources, associated habitat deterioration and reported recovery/restoration potential.
- Reviewed six key habitats and linked selected major ecosystem features to the consequences for, and likelihood of, restoration success.

2. Current marine pressures and mechanisms driving changes in marine habitats

The second MERCES report has reviewed current knowledge on major pressures impacting marine habitats and how this relates to potential restoration pathways. To do this MERCES has:

- Reviewed all existing sources and provided an inventory of maps of activities and pressures in all European regional seas, identifying commonalities and differences between regions.
- Based on six case studies, reviewed a) activities and types of pressures acting on the habitats of particular interest to the MERCES project, b) associated impacts/ consequences, and c) mitigation and restoration options.

Preliminary key conclusions of these two reviews

The second MERCES report has reviewed current knowledge on major pressures impacting marine habitats and how this relates to potential restoration pathways. To do this MERCES has:

- Most commonly reported human activities include fishing, energy, oil and gas exploitation, aquaculture and fish farming.
- Species extraction, abrasion and litter are the most commonly noted pressures, while noise and collision impacts are underrepresented.
- Deep-sea coral habitats are likely to be the most challenging to restore. In part this is due to their slow growth rates, high vulnerability and the many logistical considerations that need to be taken into account for their restoration. Coralligenous assemblages are also most likely difficult to restore due to their growth rate, low connectivity, high vulnerability and fragility to human activities and extreme structural complexity.

Figure 18. Typical activities: Coastal and marine structure and infrastructure (container terminal - above) and production of living resources (fish farming - below). Photo credits to C.J. Smith HCMR.

- From the shallow-water hard-bottom habitats, kelp forests are probably the easiest to restore owing to their fast growth rates and high levels of connectivity, while macroalgal forests are classed as "Medium" in terms of ease of restoration, owing to their higher connectivity levels and growth rates but medium to high vulnerability to pressures.
- The restoration success for seagrass meadows depends strongly upon the species in question and the location of the restoration activity. Beyond considering key ecosystem features and external exchanges, additional considerations for restoration of damaged ecosystems include: 1) a careful choice of the restoration site (restore away from problems and pressure hot spots, restore in areas that recover quickly); 2) reduction of activities/pressures and sources of degradation including working with technological solutions, employing less harmful practices and using less destructive sampling in newly restored areas.
- The restoration of the marine environment can often be seen as a cost in business planning, but recently greater awareness and creativity by businesses has led to unexpected benefits and new business opportunities from restoration activities (e.g. 'Building with Nature' in coastal management, carbon sequestration by salt marshes, seagrass beds and mangroves).
- Short term planning in the coastal zone can often lead to unsustainable economic activities with unintended consequences on local populations, such as the clearing of mangroves for aquaculture. Longer-term planning is now evident recognizing the value of a wider array of ecosystem services.

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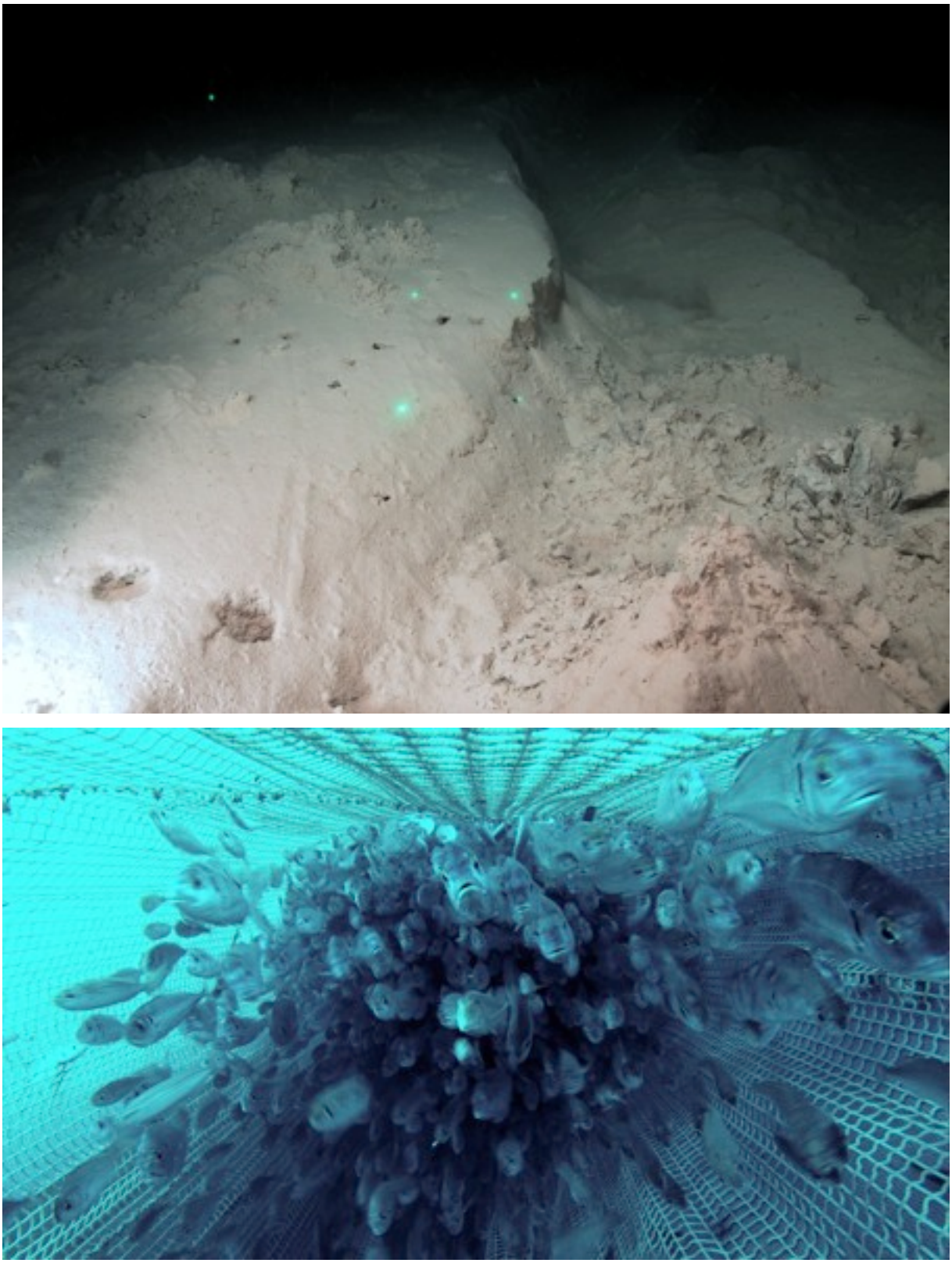

Figure 19. Typical pressures: abrasion (trawl door scarring - above), photo credits to C.J. Smith HCMR, and selective extraction of fish (fish in a trawl cod-end - below), photo credits to EPILEXIS-HCMR.

ATLAS - A Trans-Atlantic assessment and deep-water ecosystem-based spatial management plan for Europe

Roberts J.M., Simpson K. - University of Edinburgh

ATLAS is a four-year project (2016 – 2020) which brings together a unique group of European, Canadian and US scientists, policy-makers, NGOs, SMEs, and the industries working in the deep Atlantic Ocean. Funded under the European Commission's H2020 programme, ATLAS will develop the first adaptive Atlantic Maritime Spatial Plan (MSP) that will span both territorial and international waters in areas beyond the jurisdiction of any one nation. ATLAS will also bring together a wide variety of marine science datasets, which coupled with the ocean-scale MSP can transform our ability to sustainably manage Blue Growth resources.

ATLAS will exploit the vast purpose-built international sensor arrays already in place in the ocean and use these as a foundation to understand how climate and ocean variability interact with human pressures to shape the living resources in the deep Atlantic. ATLAS will scale-up our capacity to monitor and predict the functioning, biodiversity and genetic connectivity of fish stocks and ecosystems such as cold-water coral reefs, coral gardens, sponge grounds, hydrothermal vents and cold seeps. By scaling up this science, ATLAS can then scenario-test science-led, cost-effective adaptive management strategies that stimulate Blue Growth and protect sensitive ecosystems and populations at spatial scales relevant to management and industry.

An intensive schedule of 25 research cruises is planned, with 12 trans-Atlantic case studies offering opportunities for more in-depth analyses and roll-out of new spatial management plans. The existing OSNAP Subpolar North Atlantic array moorings in the Rockall Trough will be augmented with oxygen, acidity, and carbon dioxide sensors and a water sampler for nitrate, silicate and phosphate. For the first time, this will provide regular information on both ocean circulation and biogeochemical fluctuation. These new sensors will be put in place during the OSNAP 15 cruise taking place in May 2017 (Chief Scientist – Stuart Cunningham, SAMS).

Critical to the success of ATLAS is our partnerships with industry. The ATLAS project was designed with our industry partners with targeted activities taking place with each. These activities span the eastern Atlantic margin and include ATLAS scientists working with Woodside Energy in the Porcupine Seabight, with BP in the Faroe-Shetland Channel deep-water sponge belt and with Statoil on the fascinating outputs from their cabled seafloor LOVE Observatory in northern Norway.

Figure 20. ATLAS 2nd General Assembly meeting 24 – 28 April, 2017.

ATLAS will collect vast amounts of environmental data on deep-sea ecosystems and it is essential that this is not only shared with our industrial partners but applied by them to contribute to a sustainable blue economy. In the coming years industry focused workshops with key sectors including fisheries, oil & gas, cables and tourism will be used to explore data sharing opportunities as a basis to reduce the costs to business of conducting expensive environmental assessments. Additionally, the establishment of a framework for joint public/industry data collection to ensure industry Environmental Impact Assessment (EIA) compliance is achieved in a cost effective manner will be explored. We are delighted that Total joined the ATLAS industry team in 2017 in addition to the founder members BP, Statoil and Woodside Energy.

For further information contact J. Murray Roberts, University of Edimburgh (murray.roberts@ed.ac.uk), ATLAS project coordinator, and Katherine Simpson (katherine.simpson@ed.ac.uk), ATLAS project officer (www.eu-atlas.org).

SponGES - Investment into a research and innovation action for Blue Growth and the deep sea

Milanese M., Xavier J. - Studio Associato Gaia snc and University of Bergen

Sponge-dominated communities of the deep sea have been increasingly recognized as important ecosystems providing numerous goods and services such as new medicines and biotechnological products. Yet, sponge grounds have been thus far the most overlooked ecosystem of the deep sea. For instance, major knowledge gaps exist about basic aspects of their biology and ecology, their contribution to global biogeochemical cycles, their role in supporting economic activities, such as fisheries, and the impacts that human activities have upon them.

The Horizon 2020 project "SponGES - Deep-sea Sponge Grounds Ecosystems of the North Atlantic: an integrated approach towards their preservation and sustainable exploitation" brings together over 20 partners from Europe, Canada and the USA to shed light on deep-sea sponges, and bring them to the attention of policy makers, industry, research actors, and society.

SponGES will study all main types of deep-sea sponge ecosystems known to occur in the North Atlantic, all the way from the Arctic southwards to the Azores archipelago, including sites from both the western and the eastern Atlantic. In-situ observation and experimentation will be combined with novel approaches in the fields of ecology, physiology, molecular biology, biotechnology and modelling. Specifically, the project will:

- Strengthen the knowledge-base on North Atlantic sponge ground ecosystems by investigating their distribution, diversity, biogeography, function and dynamics.
- Improve innovation and industrial application by unlocking the biotechnological potential of these ecosystems namely towards drug discovery and tissue engineering.
- Improve the capacity to model, understand and predict threats and impacts and future anthropogenic and climate-driven changes to sponge grounds.
- Advance the science-policy interface and develop tools for improved resource management and good governance of these ecosystems from regional to international levels across the North Atlantic.

sisterprojects

SponGES complements the work being undertaken in other national and international initiatives, most notably MERCES and ATLAS. For instance, SponGES research will provide the underlying knowledge that is needed for the restoration of deep-sea sponge fields that have been impacted by bottom trawling on the continental slope and on seamounts (undersea mountains).

For further information contact Prof. Hans Tore Rapp (Hans.Rapp@uib.no), University of Bergen and SponGES coordinator (www.deepseasponges.org).

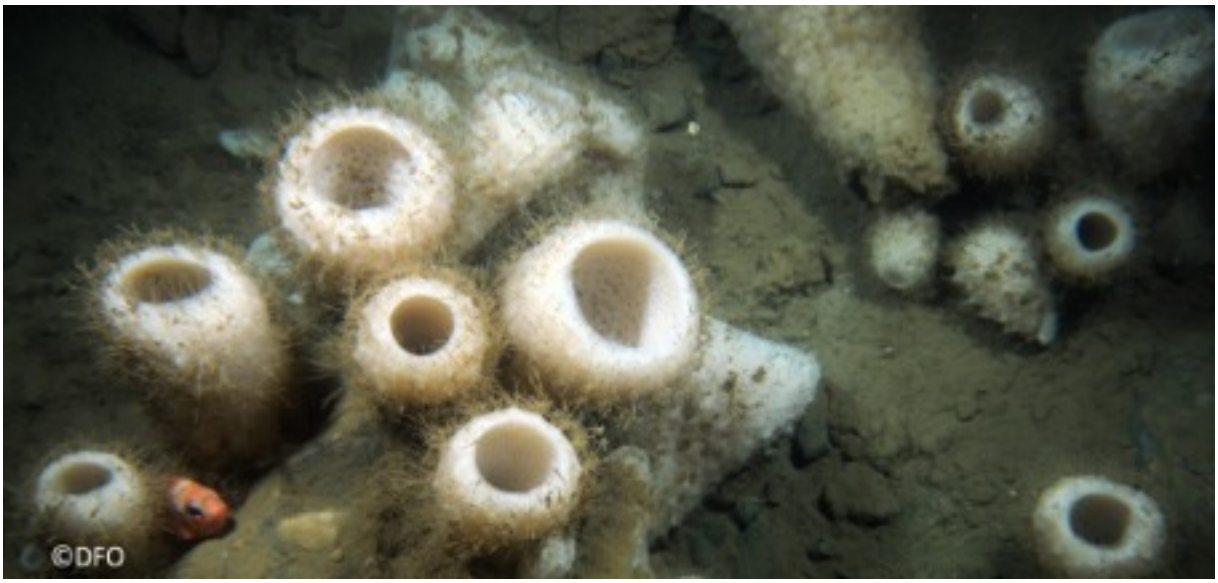

Figure 21. Sponges, like these *Vazella pourtalesi,* are an important yet largely understudied component of deep-sea ecosystems. Photo credits to Fisheries and Oceans Canada.

comingsoon

Save the date

The OECD's Directorate for Science, Technology and Innovation workshop on Innovation for a sustainable ocean economy: Linking economic potential and marine ecosystem health through innovation, hosted by the Stazione Zoologica Anton Dohrn (SZN), Naples-Italy on 10-11 October 2017.

This joint workshop between the OECD and the Stazione Zoologica Anton Dohrn, Naples, will examine how scientific advances and innovation are contributing to the development of major marine and maritime activities, while helping to protect and restore marine ecosystems. Four major issues for the future of the seas and ocean will be discussed: the greening of shipbuilding and marine infrastructures; the decommissioning of marine platforms; the pivotal role of science and technology in enhancing maritime spatial planning; and innovation as the key force driving the emergence of a marine ecosystem restoration industry. The workshop will assemble some 50 international participants from leading research centers, the private sector, and intergovernmental organizations. The event will provide participants with an opportunity to exchange national and international experiences, and will feed into current OECD research activities on the ocean economy and innovation.

Further info will be available at the Stazione Zoologica Anton Dohrn Website at www.szn.it.

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