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Seafloor Damage

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Seafloor Damage

This Thematic Issue is written and edited by the Science Communication Unit, University of the West of England (UWE), Bristol
Email: sfep.editorial@uwe.ac.uk

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EDITORIAL

The environmental cost of seafloor damage

Damage to the seafloor, due to a range of human activities, including fisheries, sand and gravel extraction and navigational dredging, has affected large areas of the seabed for over a century. Recent reports by EU Member States estimate that, in some parts of Europe, over 75% of their waters have been physically damaged. This damage has destroyed critical marine habitats and led to significant biodiversity loss.

The European Commission's work in implementing the 2008 Marine Strategy Framework Directive (MSFD)[1], in which EU Member States are required to achieve 'good environmental status' (GES) by 2020, combined with the EU's 'Blue Growth' strategy[2], should improve the quality of our marine waters. One specific aim of the MSFD is to improve the quality of the seafloor and its habitats throughout European waters.

However, our history of engagement with the oceans suggests that economic growth has often brought high environmental costs, with many areas suffering the effects of overfishing and destructive fishing practices, as well as growing amounts of marine pollution, including plastic waste. To add to these pressures, marine life will need to adapt to climate change and adjust to increased acidification of the oceans in the coming years, as well as cope with new industries, such as deep-sea mining of high-grade ores. Now, however, is the time to get our marine management right, by combining the drive for new exploitation ('Blue Growth') with a better and more sympathetic approach to environmental protection. This 'ecosystem-based' approach to management of human activities and uses of our seas is an integral part of the MSFD and vital for the achievement of GES. Improving the quality of the environment brings many benefits to our society, through the provision of ecosystem goods and services.

We are developing a better appreciation of how we have affected the marine environment. Let us hope that in this latest drive to exploit the ocean we take seriously the term 'sustainable' and interpret it to mean 'sustaining ecosystems', by harvesting and exploiting at rates and with methods that will achieve this.

This Thematic Issue of Science for Environment Policy presents key pieces of research looking at physical damage to the seafloor, which explore topics such as the impacts of seafloor trawling and of dumping dredged material; the potential effects of seafloor mining and how we might develop guidelines for this new industry; the impacts of wind farms; and new tools to map sensitivity to fishing and other human influences. It focuses on physical damage to the seafloor, a key topic to be addressed by the MSFD, as other forms of environmental impact, such as chemical contamination and nutrient enrichment, already well known issues that are addressed by a number of policies.

The first article, **'Animal forests of the sea need better protection'**, examines the physical destruction of ecosystems based on structural species, such as corals and sponges, together with additional new pressures, such as climate change and ocean acidification. The example of the destruction of the North American cod fishing industry is given, where the combination of overfishing and habitat destruction led to a collapse of the fish stocks in the late 1980s. The fishery was closed in 1992 and has shown little sign of recovery since. The article, **'Estimating the true extent of damage to exploited seafloor ecosystems'**, presents a study in which researchers attempted to reconstruct the history of shellfish beds on the east coast of Scotland, UK. These were vastly more extensive in the early 1800s, with landings (the fish catch which is brought ashore) for oysters falling by 99% during the 19th century, and by a similar amount for queen scallops during the 20th century. Impacts from bottom trawling (fishing at or close to the seafloor) are known to have significant negative effects on seabed communities and more evidence of this is provided in the article, **'Impacts of seabed trawling extend further than thought'**. This presents research that showed that the sediment plumes stirred up by the impact of a trawl can travel deeper into the sea for considerable distances and smother unfished habitats, thus expanding the area affected by the fishery.

Fishermen have their favourite spots on the seabed and visit these regularly. Thus, in some areas, the seabed has been completely altered by fishing. Based on a UK study, the article **'Reductions in fishing activity in marginal areas could substantially reduce the footprint and impact of seabed fishing'**, describes three case studies where core, well-used fishing grounds are surrounded by occasionally fished margins. The research found that excluding these marginal areas, which contained only 10% of fishing activity, approximately halved the total area of fishing grounds. Such a management approach to bottom fisheries offers the potential to reduce the environmental impacts of fisheries on the seafloor, whilst safe-guarding core fishing grounds, and providing more space for other uses of the sea, such as wind farms.

Three articles in this issue discuss new methods for providing seabed information. The article **'New tool to map seafloor sensitivity to fishing'** describes a means of assessing the sensitivity of a variety of habitats to a range of fishing impacts and intensity. Of the 31 habitats assessed by a study, 23 were sensitive to some form of fishing practice. A new way of mapping seabed habitats using a variety of physical parameters is reported in the article **'New method for mapping seafloor ecosystems'**. The method works better for natural ecosystems rather than those already affected. The third method, described in **'Assessing human-driven damage to seafloor habitats'**, has been used in a Baltic Sea example to test a scoring method. Using this method, researchers found that only 37% of habitats here had good environmental status, with oxygen deficiency, trawling and shipping causing the highest impacts on the habitats.

The last set of articles addresses other uses of our seas which, although often having a smaller spatial footprint on the seafloor, are nevertheless important aspects concerning seafloor quality. One of the new pressures on marine ecosystems will be deep-sea mining, which is covered in two articles. The first relates to **'How the environmental impacts of deep-sea mining are assessed'**, concentrating on massive sulphide deposits that are formed at mid-ocean ridges in hydrothermal vents (volcanic openings on the seafloor which release mineral-rich water). Potentially these can destroy rare and complex ecosystems that exploit methane and sulphides in the vent fluids. The article outlines the key features of hydrothermal vent ecosystems and discusses the issues that would need to be taken into account during an environmental impact assessment of deep-sea mining, including studies which identify future research areas and an ecological risk assessment.

The second article **'New guidelines for the protection of unique deep-sea ecosystems'**, discusses the protection of hydrothermal vent ecosystems, by creating effective seafloor reserves based on the precautionary approach which take multiple impacts, such as fishing and mining, into account. This article stresses the need for engagement of all stakeholders in the process of protecting these important ecosystems. The article **'What are the impacts of depositing dredged sediment on the seafloor'** demonstrates how dumping dredged material not only has an impact on the seabed, but also the functioning of the whole ecosystem, reducing the amount of food available to animals such as fish. Such impacts are not currently accounted for in environmental impact studies. Finally, **'Offshore wind farm foundations could substantially alter seafloor ecosystems of the North Sea'** reveals how planned wind turbines in the German Bight could become colonised by a range of invertebrates, including mussels. Although these could radically change the local ecosystem, they may also develop into a sustainable fishery.

While this Thematic Issue shows how difficult it may be to attain good environmental status for many areas of the seabed, a wide range of research is identifying the scale of the problem and activities that have caused the greatest impact. Given the extent of damage in some parts of Europe's seas, restoration of the seafloor to good status is likely to be one of the most challenging policy issues for Member States to address in the next few years.

**Professor Phil Weaver, National Oceanography Centre, UK;
Director of Seascape Consultants Ltd, UK**

1. *See: http://ec.europa.eu/environment/water/marine/directive_en.htm*
2. *See: http://ec.europa.eu/maritimeaffairs/policy/blue_growth/*

Contact: sergio.rossi@uab.cat
Theme(s): Marine ecosystems

‘Animal forests’ of the sea need better protection

The lack of clear international regulations is putting ‘animal forests’ at risk, a recent analysis concludes. The research examined threats to these important seafloor habitats, and suggests that collective responsibility and coherent ecosystem-based management are needed to prevent their loss.

“...animal forests, which provide a diverse array of ecosystem services, are at risk of falling victim to a lack of clear regulation and responsibility for marine ecosystems.”

Exploitation of the world’s oceans has led to drastic, and in some cases irreversible, degradation of seafloor ecosystems. Human-induced impacts, such as those from bottom trawling, eutrophication, invasive species, climate change or ocean acidification, can all act, alone or in combination, to damage marine habitats.

‘Animal forests’ are living structures on the seafloor made up of corals, sponges, sea anemones and many other species, and can be as biodiverse as tropical rainforests. These habitats not only provide ‘nursery’ habitats for mobile species, such as fish and crabs, but they can also capture and store carbon, nitrogen and phosphorus in their complex structures.

The greatest threat to animal forests is bottom trawling. Along with the destruction of the animal forest, the impacts of this practice also include compacted sediment, significant reduction in biodiversity and removal of habitat for mobile species.

This research, part funded by EU project MedSeA[1], recalls the case study of the Georges and Grand Banks cod fishery off the east coast of North America. This case demonstrates how a lack of clear legal rules and inadequate knowledge of ecosystems can lead to the ‘tragedy of the commons’, whereby the unregulated use of a common resource leads to over-exploitation or even destruction.

Concerns regarding reduced catches and loss of diversity in southern Britain were raised at the end of the 19th century, being a clear example of how the warnings already existed in several places. However, fishing effort continued to increase in Britain and other areas such as Georges and Great Banks (elevated areas of sea floor off the east coast of the USA). After a lull in fishing intensity during the Second World War, large-scale fishing began once more with vast fleets from the Soviet Union, Spain, Portugal and France all bottom trawling in the North Western Atlantic area.

This intense trawling destroyed the animal forests, which had provided essential habitat for young cod and, as a result, by the end of the 1980s the fishery had collapsed and was closed completely in 1992. Twenty years later, cod populations have still not recovered and fishing remains prohibited here.

Other threats to animal forests include tourism and the collection of corals to be sold for jewellery. This latter practice can cause considerable damage, as illustrated elsewhere by the case of the Emperor Mountains in the Pacific. This area was dredged intensively in the 1960s and over 1000 tonnes of coral were extracted. Forty years later there is still no sign of recovery.

Deep-sea mining also has the potential to cause substantial damage to seafloor ecosystems; however, there are few studies into its impacts. The lack of regulation in international waters is again of particular concern, says the author of this review.

In conclusion, animal forests, which provide a diverse array of ecosystem services, are at risk of falling victim to a lack of clear regulation and responsibility for marine ecosystems. Ecosystem-based management, taking into account the ecology of the forests themselves, is also urgently needed.

Source: Rossi, S. (2013). The destruction of the ‘animal forests’ in the oceans: Towards an oversimplification of the benthic ecosystems. *Ocean & Coastal Management.* 84: 77-85. DOI:10.1016/j.ocecoaman.2013.07.004.

1. *Project MedSeA (Mediterranean Sea Acidification in a changing climate) is supported by the European Commission under the Seventh Framework Programme. See: http://medsea-project.eu/*

Contact: r.thurstan@uq.edu.au
Theme(s): Marine ecosystems

Estimating the true extent of damage to exploited seafloor ecosystems: a UK case study

Some marine ecosystems have been altered over long periods of time, resulting in a loss of knowledge of their true healthy state, new research suggests. In this UK study, researchers used historical records, samples of sediment and present-day diving surveys to reconstruct the true history of shellfish beds on the east coast of Scotland.

"...degradation has occurred over such long time scales that knowledge of the true healthy state of such seafloor ecosystems is lost. Without a baseline to refer to, conservation managers may consider some areas as unsuitable for restoration when in fact they could recover, given the right measures."

Healthy oyster, scallop and mussel beds provide a number of valuable ecosystem services including water filtration, habitat for juvenile fish and sediment stabilisation. However, it has been estimated that, worldwide, 85% of oyster beds have been degraded or destroyed, often by destructive fishing methods.

One particular concern is that such degradation has occurred over such long time scales that knowledge of the true healthy state of such seafloor ecosystems is lost. Without a baseline to refer to, conservation managers may consider some areas as unsuitable for restoration when in fact they could recover, given the right measures.

In this study, researchers describe the history of oyster beds in the Firth of Forth, a sea bay on the east coast of Scotland. To provide a comprehensive overview, they combined three different sources of information: historical literature (mainly nautical charts and government reports), samples of the seabed and diving surveys.

Historical records showed that, in the 1800s, oyster beds in the Firth of Forth extended up to 20 miles (32.2 km) long and 6 miles (9.7 km) wide, with fishing boats able to dredge 6000 oysters in a single day. However, by the end of the century, oyster populations were in serious decline, with records showing that landings had reduced by 99% over 60 years. A survey conducted in 1895 dredged up only 7.3 living oysters per acre (4046.9 m^2) and concluded that this destruction was the result of decades of intensive fishing.

However, at this time, queen scallops became more abundant and fishers began to target these to sell as bait. This exploitation also took its toll and another survey conducted in 1957 showed that queen scallops were also in drastic decline, reduced by 99% since 1895, as were horse mussels, which had reduced by 85%.

The core samples, which were examined for shells of different species and dated by assessing sediment composition, confirmed the historical reports, showing declines in shellfish abundances and diversity throughout the 19th century. Diving surveys of the current state of the seabed, at 11 sites, found no live oysters or scallops; however, one site did contain live horse mussels.

The diving surveys also showed that the seabed at many sites was made up of thick black mud, rather than the mass of shells which would dominate a healthy shellfish bed. Shells provide habitat for young oysters to settle on, and this loss is thought to be a major reason for the failure of oyster beds.

The study's authors conclude that examining the historical changes to ecosystems can provide an all-important baseline, on which current conservation and restoration efforts can be founded.

Source: Thurstan, R. H., Hawkins, J. P., Raby, L. *et al.* (2013). Oyster *(Ostrea edulis)* extirpation and ecosystem transformation in the Firth of Forth, Scotland. *Journal for Nature Conservation.* 21: 253– 261. DOI: 10.1016/j.jnc.2013.01.004.

Contact: martin@icm.csic.es
Theme(s): Marine ecosystems

Impacts of seafloor trawling extend further than thought

The effects of seafloor trawling can extend further than the immediate fishing grounds, affecting delicate deep-sea ecosystems, new research suggests. In this Mediterranean study, the researchers demonstrated that clouds of sediment from trawling reached deeper habitats, increasing water-borne sediment particle concentrations to a hundred times that of background levels.

"...the researchers showed that fishing practices were changing the natural seasonal patterns of sediment suspended in the water."

Bottom trawling is a form of fishing, practiced worldwide, which involves dragging nets along the seafloor. Heavy equipment is used to hold the net open and in some cases is designed to actively bulldoze the seafloor. This damages species and habitats, and stirs up large amounts of sediment.

Although the damage caused by such practices in shallow coastal waters has been well documented, less is known about the effects of deeper trawls. This is a concern, since deep bottom trawling has increased in recent decades and deep-sea ecosystems are thought to be particularly sensitive to such disturbance.

In this study, partly funded by the EU HERMIONE project[1], researchers focused on the La Fonera (also called Palamós) canyon in the north-western Mediterranean. Such submarine canyons are hotspots for biodiversity, providing different habitats for a range of species.

The sides of the canyon are intensively trawled for blue and red shrimp to depths of up to 800 m, and fishers use two boards, weighing a tonne each, to hold the net open. At a depth of 980 m the researchers set up monitoring equipment to assess the turbidity (a measure of water clarity) of the surrounding water and readings were taken over the course of two years (2010 and 2011). Turbidity is important because it gives a measure of the sediment suspended in the water which may settle, smothering habitats and species and limiting the amount of light reaching seafloor habitats.

The results demonstrated frequent peaks in turbidity which were up to a hundred times greater than normal background levels, reaching more than 200 mg per litre of seawater. These high readings occurred only during work days, with levels on weekends and holidays remaining low, suggesting such peaks were driven by trawling.

Furthermore, the researchers showed that fishing practices were changing the natural seasonal patterns of sediment suspended in the water. Natural patterns would show higher turbidity in the autumn and winter as a result of storms stirring up sediment. However, the results in this study show that turbidity levels are now highest in the summer, in line with the seasonal maximum intensity and working depth of the trawling fleet.

The study's authors conclude that the influence of bottom trawling on deeper and larger areas than the fishing grounds themselves is of concern, because it may mean that even if bottom trawling is banned in deep waters, these sensitive ecosystems may still be vulnerable. These results should therefore help inform how marine protected areas are defined.

Source: Martín, J., Puig, P., Palanques, A., Ribó, M. (2013). Trawling-induced daily sediment resuspension in the flank of a Mediterranean submarine canyon. *Deep-Sea Research Part II (Special Issue: Towards a new and integrated approach to submarine canyon research).* DOI:10.1016/j.dsr2.2013.05.036.

1. *The HERMIONE (Hotspot Ecosystem Research and Man's Impact on European Seas) project is supported by the European Commission under the Seventh Framework Programme. See: www.eu-hermione.net*

Contact: simon.jennings@cefas.co.uk
Theme(s): Marine ecosystems

Reducing fishing in marginal areas could substantially reduce the footprint and impact of seabed fishing

Seabed fishing grounds in the UK are made up of intensively fished core areas surrounded by more rarely used marginal areas, new research shows. Excluding these margins, which contain only 10% of the total fishing activity, approximately halves the total area of fishing grounds. Thus reducing the fishing footprint by closing the marginal areas will disproportionately reduce the seabed impact of fishing activity.

"...any loss of fishing activity from the margins, as opposed to the core areas of fishing grounds, would lead to disproportionately large reductions in impacts on the environment and in fewer encounters between the fishing industry and other sectors such as renewables."

Marine spatial planning promotes the efficient use of marine areas in a sustainable way, and defining economically and environmentally sustainable fishing grounds is a core part of such planning. This is especially true for seabed fishing fleets, since bottom fishing (fishing at or near the seabed) is known to have significant environmental impacts, including the destruction of seabed habitats.

In this study, researchers developed and compared methods for defining fishing grounds using vessel monitoring data. The vessel monitoring system (VMS) is a satellite-based system which records the location, speed and direction of fishing boats, and has been used in the EU for all vessels of 15 m or more in length since 2005. The researchers used VMS data from the UK seabed-fishing fleet during 2006-2009 to define fishing grounds in three analyses. Firstly, they focused only on beam trawlers (which hold the mouth of a net open with a beam and drag it along the seafloor) in the south west of the UK. For the second analysis, all types of seabed fishing vessels in this region were included. Finally, they analysed data for all seabed fishing vessels by UK fleets on the Northeast Atlantic continental shelf.

The results show that in all three cases there were core, well-used fishing grounds surrounded by margins which were fished only rarely. Excluding these margins, areas with 10% or less of fishing activity, from the calculation of the fishing footprint typically resulted in a reduction of 50% in the total fished area of the fishing ground. In the event that total fishing activity was reduced by a given amount, reductions in activity on the margins of fishing grounds would provide disproportionately more space for other uses of the sea, such as conservation areas or wind farms, and for protection of the seabed habitats. In the case of beam trawlers in the south west of the UK, 90% of fishing activity took place in 39% of the area fished. When all types of seabed fishing vessels in the south west were considered, 70% of fishing activity took place in less than 25% of the total area fished. The total fishing ground area in the south west was 130 669 km^2. However, if fishing grounds were assumed to exclude the infrequently used margins, accounting for only 10% of fishing activity, this fell to 73 098 km^2. The researchers note that while margins represented 10% of fishing activity, in some cases the value of landed fish from these areas was greater than 10% of the total, although it never exceeded 20%.

At the UK level, 70% of fishing activity took place in less than 25% of the area fished. In the period 2006-2009, 69% of UK waters were fished, equalling 895 968 km^2. However, if fishing grounds excluded margins with only 10% of fishing activity, this dropped to 37% and 401 310 km^2. The authors conclude that any loss of fishing activity from the margins, as opposed to the core areas of fishing grounds, would lead to disproportionately large reductions in impacts on the environment and in fewer encounters between the fishing industry and other sectors such as renewables.

Source: Jennings, S. & Lee, J. (2012). Defining fishing grounds with vessel monitoring system data. *ICES Journal of Marine Science* 69(1), 51-63. DOI: 10.1093/icesjms/fsr173.

Contact: clare.eno@naturalresourceswales.gov.uk
Theme(s): Environmental information services, Marine ecosystems

New tool to map seafloor sensitivity to fishing

A new tool for mapping the sensitivity of seafloor habitats to fishing activities has been developed. Researchers combined data on the resistance of habitats to damage from fishing practices, and how quickly they are able to recover, to produce a widely applicable tool that can be easily understood by stakeholders and used for different locations.

"An interactive electronic web-based tool has been built which allows for illustration of recorded fishing activity and seabed sensitivity, as well as for creating scenarios."

Fishing activities, such as trawling and dredging, can damage or destroy some seafloor habitats. Adaptive management, combined with detailed spatial data, is required to ensure adequate protection of these valuable habitats.

In this study, researchers developed a tool to map the sensitivity of seafloor habitats and, as a case study, used it to assess a part of the Irish Sea, off the coast of Wales, UK. They categorised seafloor habitat into 31 broad types, including seagrass and oyster beds. Fourteen types of fishing activities which affected the seafloor were identified, including beam trawling and the use of static gear (e.g. lobster pots).

The resistance of each habitat, or ability to retain physical characteristics and species in the face of fishing impacts, was also given a score from a four-point scale, ranging from none (total removal of the habitat as a result of fishing activities) to high (no significant effect on the ecosystem).

As well as resistance, researchers examined the resilience of each habitat by collating data on the length of time taken to recover from a fishing event. Resilience ranged from very low: no recovery in over 100 years, to high: recovery in under two years. Finally, the researchers combined measures of resistance and resilience to produce an overall measure of sensitivity. These measures were based on information from a combination of scientific studies and expert opinion; the researchers add that there was a strong consensus among experts suggesting that the measures are reliable.

The results show that out of the 31 habitat types, 23 were highly sensitive to some form of fishing. Of these, 19 were highly sensitive to more than one fishing practice at more than one level of intensity. Scallop dredging was the most likely to have negative impacts on seafloor ecosystems, as the greatest numbers of habitats (18) were highly sensitive to this practice. Lobster or crab pots had the lowest impact, with the fewest habitats rated as sensitive to this practice.

The researchers conclude that this approach could provide a useful tool for marine management. For instance, if a fishing practice is found to be damaging only at high intensities, managers and stakeholders might want to consider limiting fishing effort. However, if habitats are sensitive even at the lowest level of intensity, as in the case of scallop dredging on oyster beds, then prohibiting activities is some areas may be necessary.

The researchers conclude that this method can be adapted to consider factors specific to any local area, making it widely applicable.

The approach has recently been tested around the Isle of Anglesey (Ynys Môn) in North Wales, through a European (European Fisheries Fund) funded pilot project. FishMap Môn collected fishing activity data from fishers and mapped their extent and intensity relative to the underlying seabed habitats. An interactive electronic web-based tool has been built which allows for illustration of recorded fishing activity and seabed sensitivity, as well as for creating scenarios.

Source: Eno, N. C., Frid, C. L. J., Hall, K. *et al.* (2013). Assessing the sensitivity of habitats to fishing: from seabed maps to sensitivity maps. *Journal of Fish Biology*. 83: 826–846. DOI: 10.1111/jfb.12132.

Contact: igalparsoro@azti.es
Theme(s): Biodiversity, Environmental information services, Marine ecosystems

New method for mapping seafloor ecosystems

Researchers have developed a new method of mapping seafloor habitats, which uses easily measured environmental properties to infer the type and extent of seafloor ecosystems. It could help in the effective implementation of the European Marine Strategy Framework Directive, the researchers suggest.

"...researchers developed a model designed to relate the physical properties of a seafloor environment to the habitats found there. This allows habitat distributions to be predicted from maps of physical properties, such as temperature and sediment type..."

Protecting valuable and sensitive seafloor habitats requires an in-depth knowledge of their location, extent and features. Marine spatial planning[1] and ecosystem-based management, both important aspects of the European Marine Strategy Framework Directive[2], require a good level of knowledge regarding seafloor habitats. Unfortunately, there is only limited detailed mapping of these habitats.

In this study, part-funded by the Mesh Atlantic and DEVOTES projects[3], researchers developed a model designed to relate the physical properties of a seafloor environment to the habitats found there. This allows habitat distributions to be predicted from maps of physical properties, such as temperature and sediment type, which are more widely available.

The model was tested on a case study of the Bay of Biscay. The researchers used data on 16 environmental properties, including seafloor characteristics, such as distance to the bedrock, sediment characteristics, such as grain size, and conditions near the seafloor, such as annual temperature range. Samples of species found on the seafloor were also taken. Overall, 166 of these samples were taken in areas which have undergone human disturbance, such as dredging or sewage outfall; the remaining 238 were taken from natural undisturbed areas.

The results showed that, out of the 16 different environmental properties, a combination of water depth, sediment grain size, maximum annual temperature and wave disturbance best predicted the types and diversity of species found in the samples. In general, shallower coastal areas, which also undergo greater wave disturbance, were home to fewer species, but the biomass was higher. In less disturbed deeper waters, species diversity was higher but biomass was lower.

The types and abundances of species could be more accurately predicted for natural habitats using this method, than for disturbed habitats. The researchers suggest that this is because human activities yield a range of impacts on the seafloor communities, making their prediction more difficult.

They conclude that although there are shortcomings to this method, and that detail can be lost by using environmental properties to map complex ecosystems (rather than sampling and mapping them directly), the method does provide useful information on seafloor habitats that otherwise might remain completely unmapped. They call for more research and data collection to reveal more detailed spatial maps and improve the accuracy of their model.

Source: Galparsoro, I., Borja, Á., Kostylev, V. E. *et al.* (2013). A process-driven sedimentary habitat modelling approach, explaining seafloor integrity and biodiversity assessment within the European Marine Strategy Framework Directive. *Estuarine, Coastal and Shelf Science.* 131: 194-205. DOI:10.1016/j.ecss.2013.07.007.

1. *http://www.unesco-ioc-marinesp.be/marine_spatial_planning_msp*
2. *http://ec.europa.eu/environment/water/marine/directive_en.htm*
3. *The Mesh Atlantic (Mapping Atlantic Area Seabed Habitats) and DEVOTES (DEVelopment Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status) projects were supported by the European Commission under the Seventh Framework Programme.*

Contact: samuli.korpinen@ymparisto.fi
Theme(s): Environmental information services, Marine ecosystems

Assessing human-driven damage to seafloor habitats

A new method of assessing human impacts on seafloor habitats suggests that over a third of habitats in the Baltic Sea have an 'unfavourable' status. The method is presented in a recent study which concludes that the tool can be effective in helping implement the EU's Marine Strategy Framework Directive (MSFD).

"...this tool could be of great use in implementing the EU's Marine Strategy Framework Directive and that relevant authorities should invest in collecting spatial data on human pressures to improve the method's accuracy."

The MSFD[1] states that the structure and function of seafloor ecosystems must be safeguarded against harm from human activities. To achieve this, the MSFD also requires each EU Member State to monitor pressures on the ecosystems and take actions which lead to a 'good environmental status' by 2020.

In this study, researchers set out to develop and test a method of mapping the impacts of human activities on diverse seafloor ecosystems. Using the Baltic Sea as a case study, the researchers used habitat data collected under the EUSeaMap project[2], and considered 13 different human activities that can affect seafloor ecosystems. These included, amongst others, trawling, dredging, wind farms and nutrient pollution. The intensities of the activities were scored either on a continuous scale or as presence or absence for the entire Baltic Sea.

To translate each activity into its actual impact, the scores were weighted (i.e. given more or less importance) by experts who focused on impacts on ecosystem function, resilience and recovery time after the impact. The impacts of the different activities were then added together to provide an overall measure.

The researchers caution that they have assumed that the impacts of each of the activities are 'additive', i.e. an activity will have the same impact if it occurs in isolation as when it occurs in combination with other activities. However, it is possible that an individual activity's impact could be even greater if it occurs alongside other activities, but there is currently not enough data to establish such effects.

The results demonstrated that the southern areas of the Baltic Sea suffered higher impacts than further north. Sensitive deep sea habitats are also more affected than those in shallower regions, but this was caused by oxygen deficiency, which results from nutrient enrichment, and is now a more or less continuous feature of the central Baltic Sea.

A key objective of developing the tool was to inform implementation of the MSFD. However, there is as yet no firm quantitative definition of what 'good environmental status' entails. The researchers therefore used a definition from the EU Habitats Directive[3] which states that any habitat in which more than 25% of the area is significantly affected has an 'unfavourable' or 'bad' status. They therefore considered any habitat with less than 25% of its area significantly impacted to have a 'good' environmental status, but believe that the threshold should be stricter.

Under this definition, only 37% of the habitats mapped in the Baltic Sea had a good environmental status. Of the impacts considered, wind farms and cables had the lowest impacts on the seafloor habitats of the Baltic Sea, whereas anthropogenic hypoxia (human induced oxygen deficiency), trawling and shipping were among those with the highest.

The study's authors conclude that this tool could be of great use in implementing the MSFD and that relevant authorities should invest in collecting spatial data on human pressures to improve the method's accuracy. They add that a clear definition of the thresholds for 'good environmental status' is also urgently needed.

Source: Korpinen, S., Meidinger, M. & Laamanen, M. (2013). Cumulative impacts on seabed habitats: An indicator for assessments of good environmental status. *Marine Pollution Bulletin.* 74: 311–319. DOI: 10.1016/j.marpolbul.2013.06.036.

1. *http://ec.europa.eu/environment/water/marine/directive_en.htm*
2. *The EUSeaMap project was funded by the European Commission. See: https://webgate.ec.europa.eu/maritimeforum/system/files/20110301_FinalReport_EUSeaMap_v2.9.pdf*
3. *http://ec.europa.eu/environment/nature/legislation/habitatsdirective/*

Contact: patrickcollins119@gmail.com
Theme(s): Biodiversity, Marine ecosystems, Risk assessment

How the environmental impacts of deep-sea mining are assessed

A briefing document, providing policymakers with key information on environmental impact assessments of deep-sea mining, has been published. The authors describe the Environmental Impact Assessment (EIA) process in detail to aid management and policy decisions regarding these sensitive habitats.

"Deep-sea Seafloor Massive Sulfides exploitation is a commercially attractive prospect, leading to a potential deep-sea gold-rush."

Hydrothermal vent chimneys are formed when heated pressurised seawater is ejected from fissures on the seafloor. As the hot vent fluids, which can reach temperatures of 450°C, meet the surrounding seawater and cool, they precipitate out dissolved metal sulphides, forming hydrothermal vent chimneys in tectonically active regions. Seafloor Massive Sulfides (SMS) are aggregations of collapsed hydrothermal vent chimneys. These SMS mounds may contain high-grade ores such as copper, zinc and gold. Recent technological and economic factors have converged to make the possibility of mining SMS deposits a reality, although no commercial extraction has taken place to date. Deep-sea SMS exploitation is a commercially attractive prospect, leading to a potential deep-sea gold-rush. Currently, management and conservation efforts are being developed in advance of industrial exploitation and can therefore provide an advance, rather than reactionary, assessment of the environmental impacts of deep-sea mining.

Proposed methods of exploitation include the use of large deep-sea remote operated vehicles to macerate the SMS deposits into slurries which are then pumped to a surface vessel for further processing. Hydrothermal vents typically have biologically significant ecosystems with high conservation value including endemic species and specialised communities. These communities are 'chemosynthetic'; they derive their energy from chemicals such as hydrogen sulphide or methane dissolved in vent fluid. Similar to plants which form the base of photosynthetic communities, bacteria that are able to use methane and sulphides as a source of energy, form the basis for deep-sea vent communities. This means that the ecosystem is dependent on the vent, and cannot exist elsewhere. The International Seabed Authority[1] regulates deep-sea mining activity in international waters, and has developed guidelines for an EIA process which will be used to assess applications for exploitation rights of SMS deposits and other deep-sea mineral resources, such as manganese nodules and cobalt crusts. These guidelines are informed by and inform working groups of scientists, industry and stakeholders, such as VentBase, who develop best practice approaches for EIA at deep-sea mine sites through consensus. The EIA process is part of a precautionary approach to management and may consist of three basic stages:

(1) A scoping study to assess the area to be mined, an evaluation of possible environmental impacts from mining, and proposals to address these impacts.

(2) An environmental survey composed of a number of separate assessments, including: an identification of habitats; an assessment of currents in the mining area and surveys of the seabed and the physical, chemical and biological properties of the water column. The baseline ecological survey includes attractive large animals, such as whales, that capture public attention as well as commercial fish stocks that might be affected by noise or the disturbance. Of concern are the endemic organisms to the vents that live on or in the seabed sediment adjacent to vents, which may be destroyed by the mining process.

(3) An ecological risk assessment, based on the scoping study and environmental survey and is used to evaluate risk and develop effective mitigation strategies, such as set-aside areas. It was proposed at a recent VentBase workshop that the single most significant component of a mitigation programme is the establishment of appropriate 'set-asides'. Set-asides should have similar physical, chemical and biological characteristics as the extraction site and should act as a source of recruits for recolonisation of the mining area.

Together with an environmental management plan, which describes monitoring plans for the mining areas before and after mining operations, and other aspects, such as the legal and policy framework, the EIA forms the basis for the Environmental Impact Statement, which provides an overview of the whole mining project.

Source: Collins, P.C., Croot, P., Carlsson, J. *et al.* (2013). A primer for the Environmental Impact Assessment of mining at seafloor massive sulphide deposits. *Marine Policy.* 42: 198–209. DOI:10.1016

1. *www.isa.org.jm/en/home*

Contact: clv3@duke.edu
Theme(s): Biodiversity, Marine ecosystems

New guidelines for protection of unique deep-sea ecosystems

Guidelines to establish reserves protecting deep-sea hydrothermal vents and cold seep ecosystems have been proposed. A group of stakeholders from 14 countries have put forward the Dinard Guidelines for Chemosynthetic Ecological Reserves, to help design and manage reserves for these unique ecosystems in national and international waters.

"Cooperation among all stakeholders with an interest in the seabed would be the best way forward to ensuring the protection of high diversity seafloor ecosystems, while allowing for the possibility of responsible use of these ecosystem resources."

Deep-sea hydrothermal vents occur when hot water carrying hydrogen sulphide is forced out of volcanic fissures in the seabed. Cold seeps also release hydrogen sulphide but in this case, the water issued from the seabed is of a similar temperature to the surrounding sea. Both hydrothermal vents and cold seeps support unique ecosystems which, instead of relying on sunlight, are based on specialised bacteria able to use the hydrogen sulphide as a source of energy.

Research into hot vents and cold seeps has improved the understanding of ocean chemistry and how metal ores form, and has revealed the existence of many previously unknown species. On-going research is providing insight into how life has adapted to the harsh conditions found in these environments and perhaps even how life itself originated on Earth.

However, these unique ecosystems are under threat from human activities, such as trawling for fish; exploitation of gas, oil and methane hydrate resources; and seabed mining of massive sulphide deposits. There are concerns that the progress of such human activities could outpace conservation measures designed to protect these vulnerable seabed ecosystems.

Marine biodiversity is protected by a range of international and national laws and agreements, as well as by voluntary codes of conduct. Prominent among these is the Convention on Biodiversity[1] (CBD), a global treaty concerned with the conservation and sustainable use of biodiversity. Chemosynthetic ecosystems are recognised under the CBD as being 'ecologically or biologically significant areas' requiring protection.

The International Seabed Authority[2] (ISA) manages deep-sea mineral resources in international waters, requiring organisations that have been granted exploration or prospecting licences to prevent and control harm to the marine environment.

For this study, a group of stakeholders, including marine scientists, policymakers and industry representatives from 14 countries, produced the Dinard Guidelines[3] to manage chemosynthetic environments on the seabed. The guidelines propose the establishment of reserves to protect the biodiversity, ecosystem functioning and resilience of these unique environments, while permitting reasonable use of their resources.

The guidelines outline general principles to create effective reserves that can be managed at different scales (i.e. regional, national and international), within existing governance instruments, if possible. The reserves should meet the CBD criteria for ecologically or biologically significant areas and should be established with the goal of protecting biodiversity and ecosystem function. Conservation management should take an adaptive and precautionary approach, taking into account multiple impacts including fishing and mining.

Cooperation among all stakeholders with an interest in the seabed would be the best way forward to ensuring the protection of high diversity seafloor ecosystems, while allowing for the possibility of responsible use of these ecosystem resources.

1. *www.cbd.int/*
2. *www.isa.org.jm/en/home*
3. *www.isa.org.jm/files/documents/EN/Pubs/TS9/index.html#/3/zoomed*

Source: Van Dover, C.L., Smith, C.R., Ardron, J. *et al.* (2012) Designating networks of chemosynthetic ecosystem reserves in the deep sea. *Marine Policy.* 36: 378–381. Doi:10.1016/j.marpol.2011.07.002.

Contact: Stefan.bolam@cefas.co.uk
Theme(s): Biodiversity, Marine ecosystems

What are the impacts of depositing dredged sediment on the seafloor?

Depositing dredged material on the seabed can significantly reduce the functioning of marine habitats, diminishing the amount of food available for fish and other animals further up the food chain, new research suggests. The author of the study calls for inclusion of this effect into environmental impact assessments of dredging.

"One key function of seafloor species is to provide food for other species, such as fish. In this study, the researcher focuses on this aspect, examining whether the total weight of all seabed animals, and therefore overall food availability, is altered by the deposition of dredged material."

To ensure that waterways and harbours remain navigable, they are often dredged, with the sediment that builds up over time, removed and deposited elsewhere on the seabed. In the EU, approximately 140 million tonnes (dry weight) of dredged material is disposed of in coastal areas every year. It is therefore vital to assess the effects of this practice on marine ecosystems.

The impacts that dredged material can have on the seafloor are diverse, ranging from physical differences in sediment structure to significant reductions in the numbers of species that live there. One key function of seafloor species is to provide food for other species, such as fish. In this study, the researcher focuses on this aspect, examining whether the total weight of all seabed animals, and therefore overall food availability, is altered by the deposition of dredged material.

Fourteen disposal sites off the coast of the UK were selected for this study. They represented different disposal regimes, including variation in frequency and amount of material deposited. Samples of seabed sediment were taken at each site, as well as from another site outside the disposal areas for comparison, to provide a reference for the impacts of the disposed material. The number of years over which the sampling took place varied between sites, ranging from one to eight.

To assess the amount of food available to animals higher up the food chain, the researcher measured the weight of all the animals found and converted this into a measure of energy. The results showed that, at seven of the 14 sites, the amount of energy was significantly reduced in the disposal area, compared to the reference area. The researcher notes that the seven sites which did not show significant decreases in energy production were those at which relatively small amounts were deposited.

The results also showed that changes in the amount of energy produced did not always coincide with changes in the relative abundances of different species, a measure which is often used to assess the impact of disposal. This suggests that to effectively inform policy, such measures should incorporate the amount of food available to the next level of the food chain.

Although the researcher cautions that there was a large amount of variation in the data, both over time and between areas, he concludes the results do show that disposal of dredged material on the seabed can disrupt sediment-dwelling animals, with potential knock-on effects further up the food chain.

Source: Bolam, S. G. (2012). Impacts of dredged material disposal on macrobenthic invertebrate communities: A comparison of structural and functional (secondary production) changes at disposal sites around England and Wales. *Marine Pollution Bulletin*.64: 2199–2210. DOI:10.1016/j.marpolbul.2012.07.050.

Contact: Roland.Krone@awi.de
Theme(s): Biodiversity, Marine ecosystems

Offshore wind farm foundations could alter seafloor ecosystems of the North Sea

The planned expansion of offshore wind farms in the German Bight of the North Sea will provide hard surfaces in what is currently a soft-bottom habitat. This could see a significant increase in the numbers of some species, such as mussels, which attach themselves to these hard structures, in turn, leading to increased numbers of fish and crabs specialised to this habitat, new research suggests.

"The researchers estimated that the construction of the planned wind farms could increase numbers of edible crabs by 1.1 million, the number of velvet crabs by 970 000 and the number of sea-scorpions by 200 000."

Offshore wind turbine foundations provide a surface for some animals, such as mussels, to grow on, and foraging grounds or shelter from predators for larger animals, including fish and crabs. In areas such as the North Sea, where the seafloor is mainly soft sand or mud, the provision of such 'hard' habitats changes the type of species able to survive there, potentially having an effect on the wider ecosystem.

This research was carried out in the German Bight, where the construction of 5000 wind turbines is planned over the next 20 years. Researchers undertook two separate studies; one of marine invertebrates, such as mussels and sea anemones, and another of larger, more mobile animals, such as fish and crabs. In the first study, during 2005-2007, divers studied species on the foundations of a research platform. This platform was purposely built to measure biological and physical factors relevant to the construction of wind farms and its foundations were very similar to those of wind turbines.

The three most common types of invertebrate found were the blue mussel (*Mytilus edulis*); anthozoans (a group of animals including corals and sea anemones) and the amphipod Jassa (tube-building, shrimp-like creatures). At 1 m depth, the foundations were thickly covered by blue mussels; at 20-28 m depth, anthozoans dominated, together with Jassa and the pink-hearted hydroid *Tubularia* (an anthozoan).

The researchers estimate that a yearly average of 4300 kg of biomass accumulated on the underwater structure. Furthermore, about 75% of the colonising invertebrates were blue mussels. As the mussels die, the shells fall to the seabed, creating additional hard surfaces for colonisation, increasing numbers further still. Five thousand wind turbines could turn this area into a biomass hotspot, the authors conclude.

In the second study, undertaken during 2007-2009, the researchers focused on larger animals and compared species found on the soft seabed, on shipwrecks and on the research platform. Fifteen different groups of species were found on the research platform, 16 around shipwrecks and 11 on the soft seabed. The types of species on the platform and shipwrecks were similar; the most common species was the edible crab (*Cancer pagurus*). However, the species found on the seabed were substantially different from both the wrecks and the platform.

Three species were found only on wrecks and the platform; these were the edible crab, the velvet crab (*Necora puber*) and the sea-scorpion fish (*Taurulus bubalis*). The researchers estimated that the construction of the planned wind farms could increase numbers of edible crabs by 1.1 million, the number of velvet crabs by 970 000 and the number of sea-scorpions by 200 000. The researchers conclude that the planned developments may have a large effect on seafloor ecosystems. However, they concede that many facts remain unclear, for example, working wind turbines will vibrate slightly, whereas the trial platform does not, and it is not clear how this might affect seafloor species.

Source: Krone, R., Gutow, L., Brey, T. *et al.* (2013). Mobile demersal megafauna at artificial structures in the German Bight – Likely effects of offshore wind farm development. *Estuarine, Coastal and Shelf Science.* 125: 1-9. DOI: 10.1016/j.ecss.2013.03.012.

Krone, R., Gutow, L., Joschko, T.J., *et al.* (2013). Epifauna dynamics at an offshore foundation - Implications of future wind power farming in the North Sea. *Marine Environmental Research.* 85: 1-12. DOI: 10.1016/j.marenvres.2012.12.004.