Bund für Umwelt und Naturschutz Deutschland
BUND
FRIENDS OF THE EARTH GERMANY

APOC
Anthropogenic impacts on particulate organic carbon cycling in the North Sea

The seafloor, a climate miracle

Newsletter on cutting-edge research and policy developments

ISSUE 2 • DECEMBER 2022

Welcome to the second newsletter of the project APOC. In this issue, we take you on a journey to a mysterious hotspot for marine mud, explore the carbon budget of the North Sea as well as the carbon effect of two extensive human activities. We share our experience from the (only) second Oceans Conference of the United Nations, introduce our research brief on how to protect sedimentary carbon pools and provide an example for its political transfer. As usual, an overview of current research highlights and an update on the political backdrop complete this newsletter. We hope you enjoy reading it!

- the APOC team

BACKGROUND | APOC (Anthropogenic impacts on particulate organic carbon cycling in the North Sea) is an interdisciplinary project funded by the BMBF as part of the MARE:N Coastal, Marine and Polar Research for Sustainability program. It combines the expertise of four marine research institutes and one organisation for environmental conservation. We are investigating the influence of environmental and climatic changes as well as anthropogenic pressures on the transport, cycling and storage of particulate organic carbon (POC) in the North Sea – today, in the past century and in the future.

The fish, a climate hero

Hardly any other group of animals is as numerous and diverse in our oceans as fish. But it is not only their diversity that is often underestimated, but as well their key function in the marine carbon cycle. Fish are carbon engineers that help reduce the amount of CO_2 in the atmosphere and preserve it in form of organic carbon on the seabed. The activities of bottom-contacting fisheries not only directly threatens the sedimentary carbon stores in our oceans, but also indirectly disturb the carbon cycle through overfishing. **Find out more on the role of fish in the carbon cycle!**

ABOVE – Drawing of a herring. © Pixabay

AWI BUND Friends of the Earth Germany GEOMAR Helmholtz-Zentrum hereon UHH

News from the APOC project

Follow the current activities, events and progress in our interdisciplinary project – from research cruises in the North Sea to first laboratory results and modelling efforts to joint workshops with project network and cooperation partners.

2nd APOC Workshop

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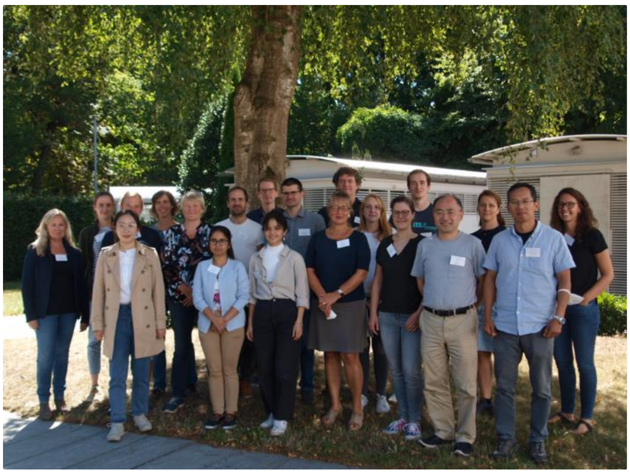
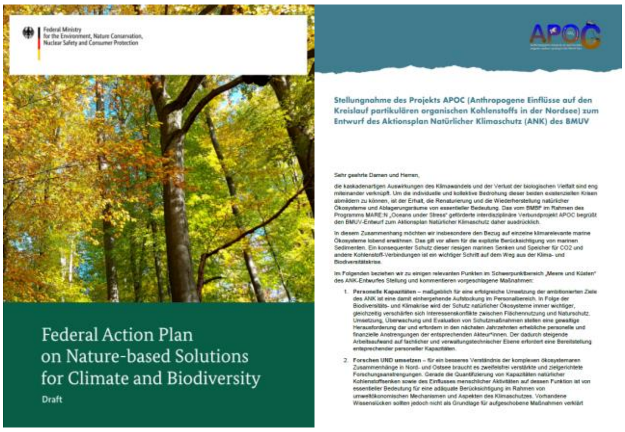
The time had finally come: to the delight of all 20 participants, the second annual APOC meeting could take place in person for the first time since the project launched in April last year. At the beginning of September, the APOC community enjoyed the opportunity to get to know each other, share their latest work and engage in fruitful discussions in the excellent venue of the Hanse-Wissenschaftskolleg (HWK) in Delmenhorst. In addition to the outstanding organisational support, this also enabled the scientific exchange to continue during the breaks and at dinner with a delightful culinary catering and beautiful sunshine. The hybrid setup allowed our new project manager from Project Management Jülich (PtJ), Tobias Höfig, to join the event online. The exchange was especially substantial for our APOC postgraduates and other early-career scientists – but it also strengthened the cooperation between the various work packages and the collaborative partners. We are looking forward to the coming research months!

BELOW – Participants of the 2nd APOC workshop. © HWK





ABOVE – German Action Plan on Nature-based Solutions for Climate and Biodiversity (© BMUV) and APOC statement.

Bridging the gap between science and politics

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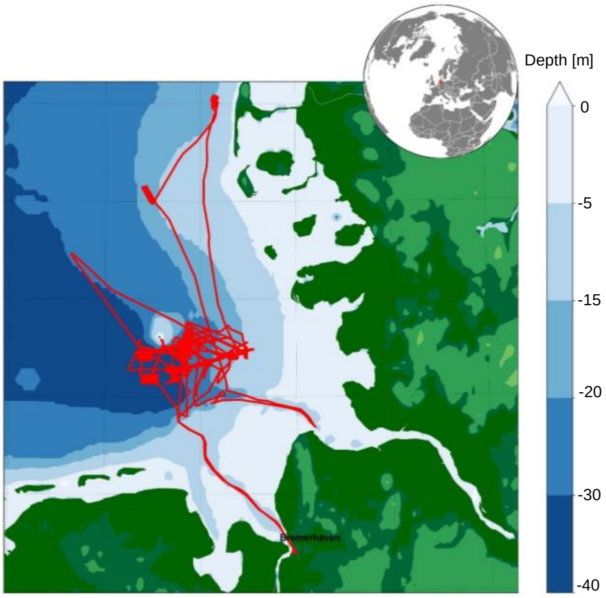
Fostering bidirectional exchange between science and politics is a key aspect of the APOC project. A good example of how such a transfer can be implemented in a proactive and constructive way is the participation in public consultations for new policies. Under the lead of the BUND Marine Conservation Office, APOC took the opportunity to provide a joint statement on the German Federal Action Plan on Nature-based Solutions for Climate and Biodiversity (ANK). Proposed in early September by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), the ANK will play a substantial role in achieving the German government's climate and biodiversity goals. In a collaborative effort, we critically assessed the ministerial suggestions for marine measures and provided guidance and feedback on far-reaching actions aiming at the protection of sedimentary carbon pools and the transition to sustainable fisheries.



ABOVE – Cruise track of research cruise HE595 of the RV Heincke (17.03. – 03.04.2022).

The Helgoland mud area: a mysterious hotspot for carbon

AWI

The Helgoland mud area (HMA) extends over a size of about 500 km² SE of the island of Helgoland in the German Bight. Influenced by tides and storms and with a mean water depth of 20 m only, it resembles a high-energy environment naturally promoting turbidity from suspended material. Yet, it is known as a hotspot for the deposition of sedimentary carbon. With an organic carbon content of about 1.5 %, the area is one of the few mud depocenters in the North Sea. During the last 10.000 years, the HMA has piled up sediment layers of up to 30 m in thickness that continue to grow with up to 2 cm per year. It is still largely unknown, which processes are responsible for trapping such large amounts of suspended material in these rough waters. A research cruise on the RV Heincke set out to shed light on the unresolved mystery of the HMA. Chief scientist Moritz Holtappels and his team collected sediment cores and over 400 samples of suspended material and measured water characteristics through the entire water column to help solve the puzzle.

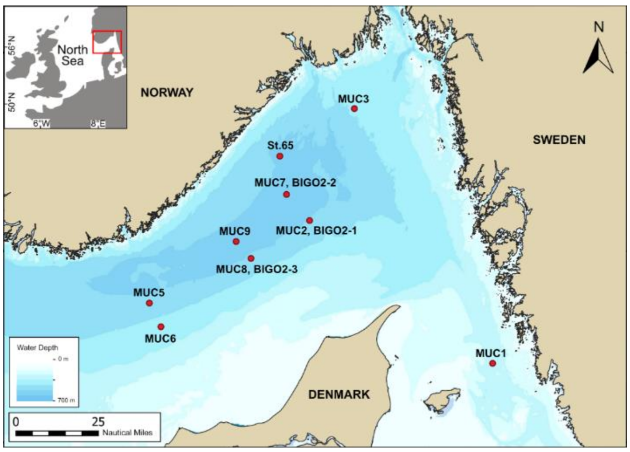
➢ RV Heincke HE595 | Map | Event list | Data

Have human impacts altered carbon cycling?

GEOMAR

During the last century, extensive human activities have changed and continue to change the vulnerable sedimentary system of the North Sea – and along with it the cycling of particulate organic carbon (POC). But how big is the human impact on POC cycling actually, can we reconstruct its extent? To answer this question, we utilize the idea that depocenters may reflect any variabilities in POC cycling. Depocenters are locations to which most of the POC suspended in the water column is transported and where it ultimately deposits on the seafloor. Naturally, this includes POC that has been resuspended by human activities such as bottom trawling or dredging. The general hypothesis is simple: if human activities affected the sedimentary system and POC cycling in the North Sea, this effect should be seen in its depocenters in form of changes in POC deposition rates. At GEOMAR, we focus on the area of the Skagerrak, the largest depocenter for POC in the North Sea. With a maximum water depth of 700 m, its basin is the deepest part of the North Sea. Here, sediments are less impacted by natural and human influences. They thus serve as a promising archive to study the variability of POC cycling since the industrial Age. We therefore try to reconstruct POC deposition rates from sediment cores collected during research cruise AL561 on the RV Alkor in August 2021.

BELOW – Sampling sites in the Skagerrak during research cruise AL561 on the RV Alkor (02.08. – 13.08.2021).

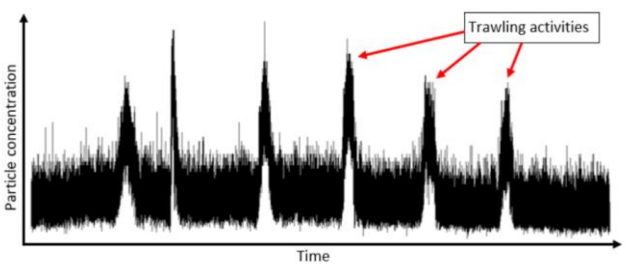


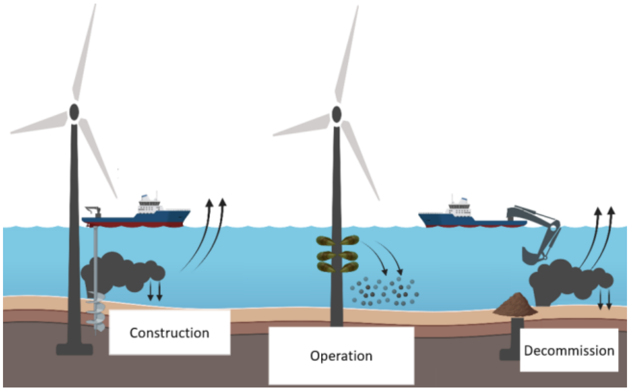
How much carbon can be released through trawling activities?

AWI

Fishing with mobile bottom-contacting gear has extensive and destructive effects on marine life and the integrity of the seafloor. Especially the disturbance of sedimentary carbon and release of CO_2 into the water column and atmosphere is of major concern in the face of the climate crisis. But what exactly happens during trawling activities? How much sediment is stirred up and entrained into the water column? And how much of the sedimentary carbon is converted back into CO_2? Answering these questions is essential in assessing the climate impact of mobile bottom-contacting fisheries. We conducted a beam trawl experiment with the RV Uthörn in the Helgoland mud area and measured changes in turbidity upon the repeated passage of the trawling equipment. First results show that each trawl stirred up an average of 12 kg of sediment per meter of track and generated a sediment plume of about 3.5 m height and 70 to 90 m length. This is in line with similar experiments in the Baltic Sea.

BELOW – RV Uthörn. © Folke Mehrtens, AWI | Enhanced particle concentrations during trawling activities.



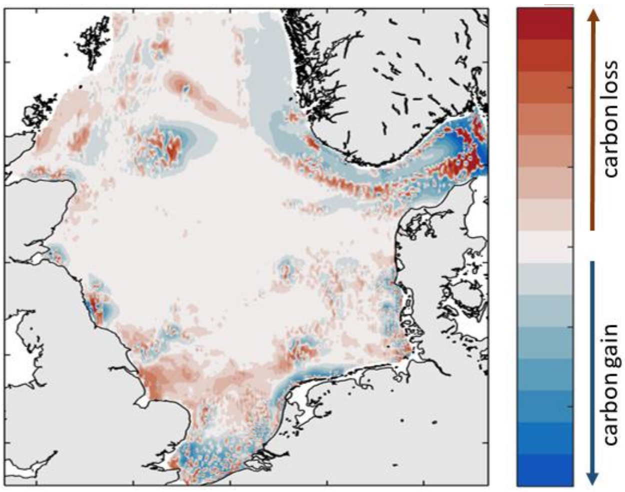


ABOVE – Schematic representation of the impact phases of an offshore windmill on sedimentary carbon stores. © Knut Heinatz, UHH.

The net carbon effect of offshore wind farms

UHH

Countries of the EU have outdone each other in recent years with their plans for the expansion of offshore renewable energies. Driven by the current energy crisis and the pursuit of energy diversification and improved sustainability, there currently is a strong political focus on offshore wind. Germany is no exception to this and intends to obtain at least 70 GW from offshore wind farms by 2045. In an effort to reach the ambitious targets, marine spatial planning now considers opening protected areas for the development of wind farms. This threatens to put even further pressure on marine ecosystems, which have already been deeply stressed by human activities. The impact of offshore wind farms on the functioning of the marine carbon cycle and the sequestration potential of its ecosystems is still unclear. While there are first estimates on the footprint on sedimentary carbon stores, the effect over the entire life cycle of a wind farm is not yet clear. To address this knowledge gap, we estimated the net carbon effect over the construction, operation and decommissioning phase of the offshore windfarms in the southern North Sea. Initial results suggest that offshore wind farms could trap more sedimentary carbon than they release within their development area and are currently under review in the journal Frontiers of Marine Science.



ABOVE – Simulation of changes in sedimentary carbon pools of the North Sea due to bottom trawling activities.

Modulation of sedimentary carbon pools through bottom trawling

Hereon

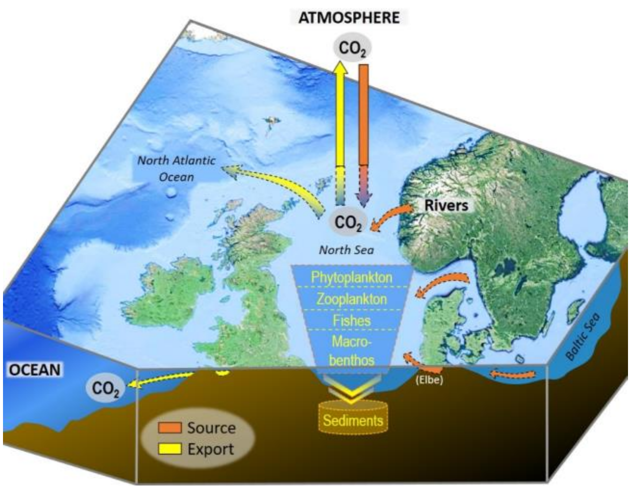
The continuous burial of organic material in seafloor sediments of the North Sea has created large standing stocks of sedimentary carbon. Shaped by natural processes such as riverine input, currents and storms, the carbon content of these stocks is locally highly variable. Mobile bottom trawling activities add another layer of complexity to this mix. They introduce both physical and biogeochemical disturbance to the ecosystems, thus modulating the sedimentary carbon stocks. To quantify these effects, we modelled the enhanced resuspension and lateral transport of organic matter from bottom trawling considering gear types, vessel speed, size and engine power as well as mud content in the seafloor sediments. Our model also accounts for feedback mechanisms that result from physical mixing by the penetrating trawling gear as well as introduced mortality of organisms. We identified strong local changes in sedimentary carbon content after one year of trawling (see above). Overall, the modelled Greater North Sea area shows a net loss of carbon and local erosion and deposition rates in the order of millimetres to centimetres. In a next step, we will add changes in nutrient and oxygen availability as well as turbidity to the model.

Understanding the carbon budget of the North Sea ecosystem

Hereon | UHH

The marine carbon cycle is a highly complex mixture of processes that constantly exchange carbon between various pools and transforms carbon between non-living (inorganic) and living (organic) matter. Organic carbon for example can take various pathways through the entire food web, from plankton to fish to the organisms on and in the seafloor. It may for example sink to the sediment, be eaten by predators or recycled to start the cycle all over again. Due to this complexity, estimating carbon budgets and fluxes is burdened by a high variability and large uncertainties. Sparse data, spatial and temporal heterogeneity along with high annual as well as seasonal variability complicate their quantification. In order to better understand changes in the carbon budget of the North Sea ecosystem, we pair a thorough literature review with an advanced 3D physical-biogeochemical model (SCHISM-ECOSMO) to address knowledge gaps in the seasonal, spatial and temporal variability and sensitivity of carbon fluxes and stocks. We are further using our model results on trawling-induced resuspension to quantify the impact on nutrient cycling, productivity and carbon uptake – and to assess the effect of potential trawling bans on the carbon sequestration capacity.

BELOW – Schematic representation of the carbon budget of the North Sea ecosystem. © Hagemann, Hereon.



Size matters: the importance of protecting sedimentary carbon

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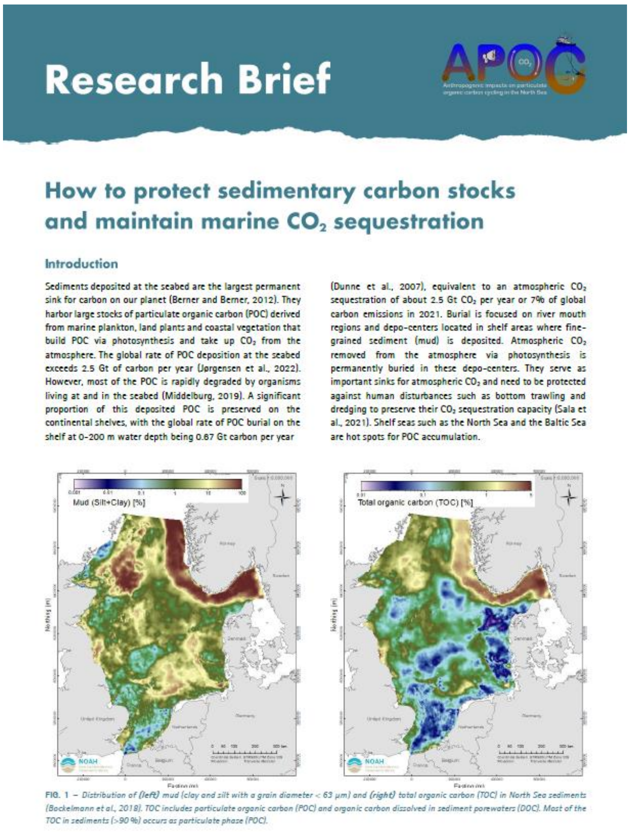
In the fight against global warming, coastal vegetated ecosystems such as seagrass beds and salt marshes are increasingly protected due to their disproportional contribution to CO_2 sequestration. However, the extent of such ecosystems is rather limited in the shelf seas – and, thus, is their sequestration potential. Muddy shelf sediments instead have been demonstrated to act as efficient long-term carbon sinks and offer a much higher CO_2 sequestration potential. Still, they remain virtually unprotected from disruptive human activities such as bottom trawling and dredging. In a research brief on the sedimentary carbon stores in the North and Baltic Sea, we address the climate value of muddy depocenters and the potential of protective measures to preserve their CO_2 sequestration capacity. Ocean protection is climate protection!

BELOW – APOC research brief on sedimentary carbon stocks in the North and Baltic Sea and how to protect them.



Research Brief

APOC

How to protect sedimentary carbon stocks and maintain marine CO_2 sequestration

Introduction

Sediments deposited at the seabed are the largest permanent sink for carbon on our planet (Berner and Berner, 2012). They harbor large stocks of particulate organic carbon (POC) derived from marine plankton, land plants and coastal vegetation that build POC via photosynthesis and take up CO_2 from the atmosphere. The global rate of POC deposition at the seabed exceeds 2.5 Gt of carbon per year (Jørgensen et al., 2022). However, most of the POC is rapidly degraded by organisms living at and in the seabed (Middelburg, 2019). A significant proportion of this deposited POC is preserved on the continental shelves, with the global rate of POC burial on the shelf at 0-200 m water depth being 0.67 Gt carbon per year (Dunne et al., 2007), equivalent to an atmospheric CO_2 sequestration of about 2.5 Gt CO_2 per year or 7% of global carbon emissions in 2021. Burial is focused on river mouth regions and depo-centers located in shelf areas where fine-grained sediment (mud) is deposited. Atmospheric CO_2 removed from the atmosphere via photosynthesis is permanently buried in these depo-centers. They serve as important sinks for atmospheric CO_2 and need to be protected against human disturbances such as bottom trawling and dredging to preserve their CO_2 sequestration capacity (Sala et al., 2021). Shelf seas such as the North Sea and the Baltic Sea are hot spots for POC accumulation.

FIG. 1 – Distribution of (left) mud (clay and silt with a grain diameter < 63 µm) and (right) total organic carbon (TOC) in North Sea sediments (Bockelmann et al., 2018). TOC includes particulate organic carbon (POC) and organic carbon dissolved in sediment porewaters (DOC). Most of the TOC in sediments (>90 %) occurs as particulate phase (POC).

ABOVE – Nadja Ziebarth and Bettina Taylor from BUND at the UN Ocean Conference 2022 in Lisbon, Portugal.

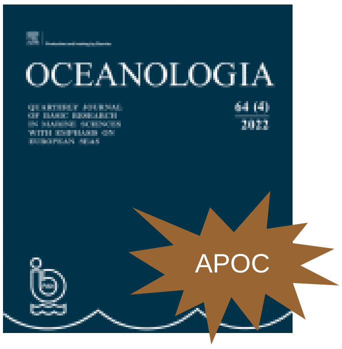
Missed opportunities at the UN Ocean Conference 2022

BUND

With the establishment of the Ocean Conference, the UN wanted to initiate a global process for the protection of the world's oceans – and thus advance the implementation of the 2030 Agenda, in which the member states agreed on Sustainable Development Goals (SDG). Nadja Ziebarth and Bettina Taylor from the BUND Marine Conservation Office set out to join an impressive 7,000 participants in Lisbon, Portugal. Their goal: placing sedimentary carbon on the agenda of government representatives, politicians as well as members of civil society joining the event. The link between climate protection and marine conservation, as well as references to the key function that healthy oceans have for climate regulation, were only represented to a limited extent at the conference. However, we were able to highlight the important issue of sedimentary carbon sinks and their integrity at many events and discussions and thus drew attention to the topic. Unfortunately, the UN conference did not produce any binding decisions. Other international marine agreements will show how serious the UN states really are about marine protection issues. BUND therefore continues to advocate in various (inter)-governmental bodies for the protection of muddy depocenters for climate protection.

In brief – current research highlights

In this section, we spotlight selected literature with high relevance around the APOC-specific topics of the marine carbon cycle and human activities. In addition to our own research, this also includes external results from peer-reviewed studies and reports.



Natural and anthropogenic influences on the development of mud depocenters in the southwestern Baltic Sea

Porz et al. (2022) | Oceanologia | DOI: 10.1016/j.oceano.2022.03.005

Investigation of the morphological evolution of two mud depocenters in the southwestern Baltic Sea. A simulation of seabed resuspension by bottom-contacting fishing gear revealed that sediment transport in the study area increases by up to 40% due to these anthropogenic activities when compared to seabed resuspension by natural processes.

Value wild animals' carbon services to fill the biodiversity financing gap

Berzaghi et al. (2022) | Nat. Clim. Change | DOI: 10.1038/s41558-022-01407-4

Wild animals could provide substantial climate benefits through their effect on carbon storage in ecosystems. However, they are not widely recognized in existing carbon markets. This comment explores the feasibility, caveats and challenges of including wild animal services into financial markets. The large-scale implementation of nature-based Solutions could bridge the funding gap to combat biodiversity loss and climate change.

Assessing the potential vulnerability of sedimentary carbon stores to bottom trawling disturbance within the UK EEZ

Black et al. (2022) | Front. Mar. Sci. | DOI: 10.3389/fmars.2022.892892

Introduction of a carbon vulnerability ranking (CVR) to identify areas of the UK seabed where preventative protection from trawling activities may be most beneficial to help maintain current stocks of organic carbon. Results indicate that the sedimentary carbon at the west coast of Scotland is potentially at greatest risk from anthropogenic activities.

The impact of mobile demersal fishing on carbon storage in seabed sediments

Epstein et al. (2022) | Glob. Chang. Biol. | DOI: 10.1111/gcb.16105

Literature review on potential drivers of change in sedimentary carbon stores due to mobile bottom-contacting fisheries. 61% of the reviewed studies found no significant effect, while 29% reported on a reduction of organic carbon due to lower production of flora and fauna, the loss of fine flocculent material, increased sediment resuspension, mixing and transport as well as increased oxygen exposure.

Sedimentary carbon on the continental shelf: Emerging capabilities and research priorities for Blue Carbon

Graves et al. (2022) | Front. Mar. Sci | DOI: 10.3389/fmars.2022.926215

Review on the methods that can be applied in marine sediments to provide the evidence needed to establish where and when marine carbon in offshore sediments could contribute to climate mitigation, focusing on continental shelf sediments. The aim is to enable an improved assessment of the role of the seabed in climate change regulation.

Exploring changes in fishery emissions and organic carbon impacts associated with a recovering stock

Martin et al. (2022) | Front. Mar. Sci. | DOI: 10.3389/fmars.2022.788339

Case study on the organic carbon impact of fisheries and the potential in moving from traditional single-stock management towards a climate-based ecosystem approach. Fisheries management should consider emissions from fuel, disturbance to organic carbon in sediments and living pools, and the carbon functions of the ecosystem.

There and back again, a journey of many pathways: conceptualising the marine organic carbon cycle

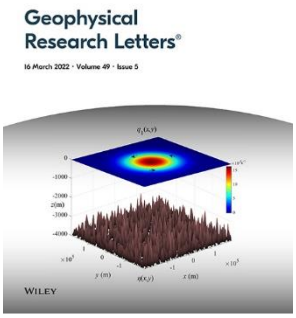
Scheffold & Hense (2022) | Ocean Sci. | DOI: 10.5194/os-18-437-2022

Where carbon ends up and for how long has implications on atmospheric CO_2 levels and our climate. The authors present a qualitative concept of organic carbon pathways and their structure. This concept helps identify pathways, compare ecosystems and assess how human actions and environmental changes can alter these pathways.

Ecosystem-based fisheries management increases catch and carbon sequestration through recovery of exploited stocks: The western Baltic Sea case study

Scotti et al. (2022) | Front. Mar. Sci. | DOI: 10.3389/fmars.2022.879998

A mass-balanced ecosystem model for the western Baltic Sea showing that ecosystem-based fisheries management promotes ecosystem resilience to ocean eutrophication and warming. Through rebuilding of commercial fish populations, these joint measures can increase carbon sequestration by more than three times compared to "business as usual".



Quality not quantity: prioritizing the management of sedimentary organic matter across continental shelf seas

Smeaton & Austin (2022) | Geophys. Res. Lett. | DOI: 10.1029/2021GL097481

Investigation of the reactivity of sedimentary carbon in the Scottish part of the UK EEZ. Inshore and coastal carbon stores were found to be most vulnerable to disturbance and potential conversion to CO_2, highlighting the need to align future management interventions with the variable spatial reactivity of sedimentary carbon.

The transition of marine environmental policy

How does the political framework in the North Sea change? What influence does this have on marine anthropogenic pressure and the state of marine carbon sinks? This section summarises important events at national, regional and international level.

EU Nature Restoration Law (NRL)

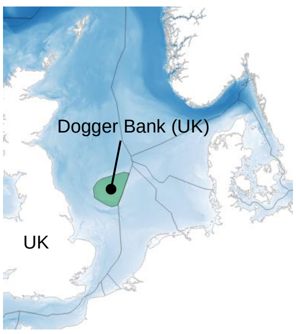
NRL proposal | NRL factsheet | EU Brochure on Nature Restoration

On June 22, the European Commission proposed a new law to restore ecosystems, habitats and species across the EU's land and sea areas – the Nature Restoration Law (NRL). It is the first continent-wide, comprehensive law of its kind and a key element of the EU Biodiversity Strategy, which calls for binding targets to restore degraded ecosystems. The NRL will restore at least 20% of both EU land and sea ecosystems by 2030, and all ecosystems in need of restoration by 2050. Particular focus lies on ecosystems with the most potential to capture and store carbon and to prevent and reduce the impact of natural disasters. Other than the existing EU nature laws (Birds and Habitats Directives or Natura 2000), this will include all natural habitats, including soft sediments as valuable sedimentary carbon stores.

Energy Hub North Sea: the German struggle in expanding offshore wind energy

German Marine Spatial Plan 2021 | German Site Development Plan (draft)

In their hunger for renewable energies, EU countries are turning their attention to the seas on their doorstep. Germany provides a good example of the increased competition for space that this strategy entails. Policy plans call for at least 70 GW of energy to come from offshore wind power by 2045. The spatial basis for this expansion in the German EEZ is provided by the Marine Spatial Plan, which came into force on 1 September 2021. Additional development areas for offshore wind energy are to be defined within the scope of an amendment to the Site Development Plan. Although the second draft for this plan is now available, existing development areas cannot provide for more than 60 GW. In order to meet the policy plans for the remaining 10 GW, development areas would have to displace competing uses and use existing marine protection areas – thus contradicting the concept of sustainability on which renewable energies are based.



A huge ecological experiment: UK bans trawling and dredging in the Dogger Bank

Most of the officially designated marine protected areas are "paper parks" – protected in theory, but in practice impacted by, e.g., destructive fisheries. This largely stems from an unhelpful conflict in the EU law between nature conservation and the common fisheries policy (CFP). The Brexit and the end of the CFP in UK waters finally opened the door to enforce nature conservation acts: in June this year, the UK banned dredging and trawling activities in the British part of the Dogger Bank. This way, it started a huge ecological experiment in an area of 12,000 km² or almost the size of Northern Ireland.

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