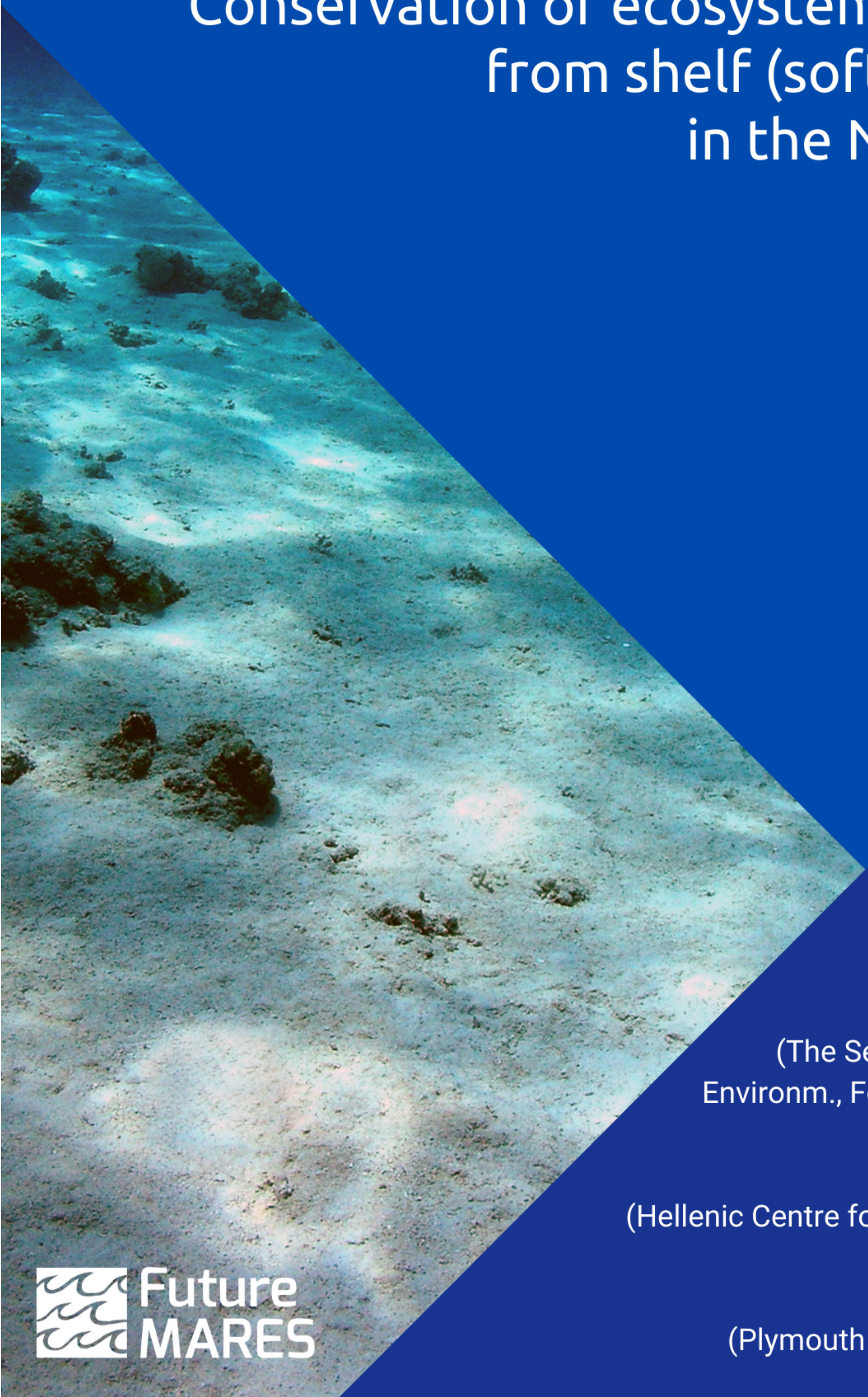
# NE Atlantic and North Sea: Conservation of ecosystem services from shelf (soft) seabed in the North Sea

Storyline 13

NBS 2
EFFECTIVE CONSERVATION



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Future MARES

## Introduction

The EU Horizon project FutureMARES (2020-2024) was designed to develop science-based advice on viable actions and strategies to safeguard biodiversity and ecosystem functions to maximise natural capital and its delivery of services from marine and transitional ecosystems in a future climate. The program investigates effective habitat restoration, conservation strategies and sustainable harvesting at locations across a broad range of European and other marine and transitional systems. The restoration of habitat-forming species (plants or animals) and habitat conservation (e.g. marine protected areas, MPAs) represent two nature-based solutions (NBS) defined by the EU as "resource efficient actions inspired or supported by nature to simultaneously provide environmental, social and economic benefits that help to build resilience to change". A third action that will interact with these two NBS and have positive effects on marine biodiversity is nature-inclusive harvesting (NIH) such as the sustainable farming of plants and animals at the base of marine food webs and ecosystem-based management practices for traditional (artisanal) and commercial fisheries. FutureMARES will advance the state-of-the-art forecasting capability for species of high conservation value, explore new and less carbon intensive aquaculture production methods, perform modelling analyses geared towards informing the development of climate-smart marine spatial planning approaches, and provide an assessment of ecosystem services based on scenarios of climate change and the implementation of NBS and NIH.

This document provides a multi-disciplinary summary of activities conducted in FutureMARES in a specific area on specific NBS and/or NIH. The activities include work across various disciplines including marine ecology (analyses of historical time series and experiments performed in the field and laboratory), climate change projection modelling (future physical, biogeochemical and ecological changes), economic analyses, social-ecological risk assessments. Many of these components and analyses, including NBS / NIH scenarios tested, were co-developed with local and regional stakeholders through regular engagement activities. The work presented in these Storylines represent activities conducted by a large number of FutureMARES project partners. Broader comparisons and syntheses (across regions and/or topics) are provided in the FutureMARES deliverable reports (www.futuremares.eu) submitted to the European Commission.

## NBS regional context

The continental shelf sediments constitute around 8% of the global seafloor (Harris et al. 2014) but is supporting many ecosystem services to society including support for biodiversity and food-web, carbon cycling and storage, waste remediation, nutrients recycling, recreational activities and renewable energy resources (Culhane et al. 2018, Galparsoro et al. 2014). The relative value of these benefits provided by the seabed is thought to rival most of the global ecosystem (Le Quéré et al. 2018, Liquete et al. 2013), yet until recently it was largely only viewed as supplier of food for higher trophic levels or as host for charismatic species worth protecting. It is however now known that the shelf seabed is a net carbon sink, capturing the $CO_2$ from the atmosphere through the water column and down to the deeper part of the bed, and controls a large proportion of nutrient recycling thereby supporting a significant part of new primary production and contributing to mitigate eutrophication event (Kroeger et al. 2018). The mechanisms underlying these functions are controlled by a complex and interlinked set of physical, biogeochemical and biological processes – above, at the surface and within the sediment – which vary regionally and seasonally and include the specific properties of the overlaying water column. Understanding how these underlying factors vary in space and time, what this variation means for the relative rates of these diverse seabed properties and how they are linked with each other is critical to enable the provision of evidence to support decisions regarding maximising benefits of specific utilisation of the seabed functions whilst simultaneously minimising trade-offs and negative feedbacks.

The Greater North Sea (GNS) ecoregion is a temperate coastal shelf sea of 766, 624 $km^2$ predominantly characterised by soft sediments (from mud to gravel beds) which is impacted by multiple and contrasting anthropogenic activities (ICES 2019). GNS benthic habitats have a long history of extensive bottom trawling, aggregate extractions and, more recently, offshore renewable energy structure which has led to various degree of habitat destruction or loss, abrasion, or smothering. Designed to protect the marine life, the MPA network currently covers 27.1% of the ecoregion (European Environment Agency 2018). MPA designation has to date, however, overwhelmingly been based around (structural) biodiversity, largely ignoring rationale linked to ecosystem functioning, which inherently limits MPA capability to ensure the sustainable provision of the services supported by the seabed.

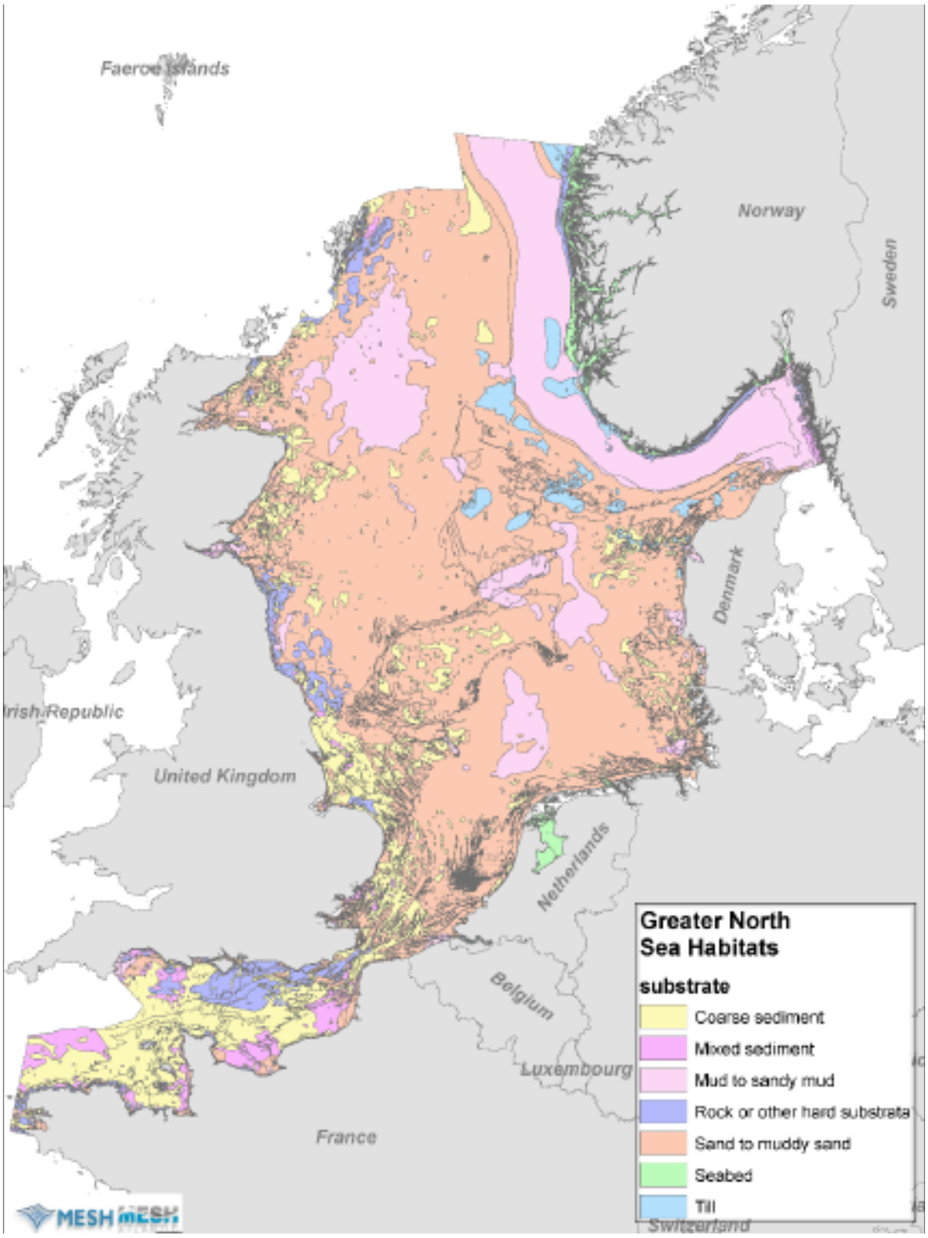


**Figure 1:** Major substrate types from the Greater North Sea shelf.
Credit: compiled by EMODNET seabed habitats

## Projected impacts of climate change

Changes in standing stock, productivity and biogeochemical (carbon and nutrient) processes of the Northwest European shelf seabed in response to climate change remain relatively poorly understood and many projections are based on first principles or theory. Still, seabed processes controlling carbon and nutrient cycles (including carbon sequestration and processes supporting new production) result from the interplay between physical (temperature, sediment), chemical (carbon supply, oxygen) and biological (micro to macrofauna) parameters and climate change is expected to have some degree of impact on all of these aspects. In the water column, a temperature-driven increase in metabolic rates and nutrient cycling, coupled with an overall projected decrease of primary production in the Northwest European shelf is expected to decrease the carbon (and food) supply to the seabed (Kay et al. 2018, van der Molen et al. 2013) resulting in a restriction of the core combustible on which the most important seabed functions are based upon. In parallel, area of low oxygen occurs naturally in bottom waters during the summer and can dramatically impact the community yearly dynamic, levels are currently above the critical threshold but are projected to decrease further potentially due to a change in the balance of production and consumption, vertical mixing and solubility (van der Molen et al. 2013).

Diminution of carbon export to the seabed combined with increased metabolism and possible lack of oxygen are expected to decrease the organisms biomass of the seafloor both overall and at individual level (van der Molen et al. 2013, Jones et al. 2014). In turns, biomass strongly relates to ecosystem functioning (Norkko et al. 2013, Séguin et al. 2014), which means that climate change impacts on the seafloor biology are expected to further disturb processes of carbon sequestration and new primary production and to propagate through the food-web as both the biomass and the available energy source per benthic prey for higher trophic level is expected to decrease.

Ocean acidification (OA) is likely to further impact the ability of the seabed biology to sustain ecosystem functioning since organisms with structures composed of calcium carbonate, such as molluscs, are likely to be negatively impacted. These organisms tend to also be keystone species in the food web, either as major filter-feeder or as important prey, which will further risks to the sustainability of services delivered by the seafloor community. These changes will potentially propagate to the whole marine ecosystem and may disrupt major biogeochemical cycles and as seabed production decreases, the total commercial catch of bottom-feeding fish species that is sustainably harvested should also decrease.

Shelf seas are subject to many other human impacts. The significance of some of these (e.g., pollution by microplastics), has only recently been recognised. Although impacts are usually investigated separately, important interactions can occur. Trawling impact and climate change both have ubiquitous impacts on the Northwest shelf seabed and the management of fishing efforts (through MPA or Highly Protected Marine Areas - HPMA) need to account for the multiple services that the seabed provide and the likely impact of climate change on these services.

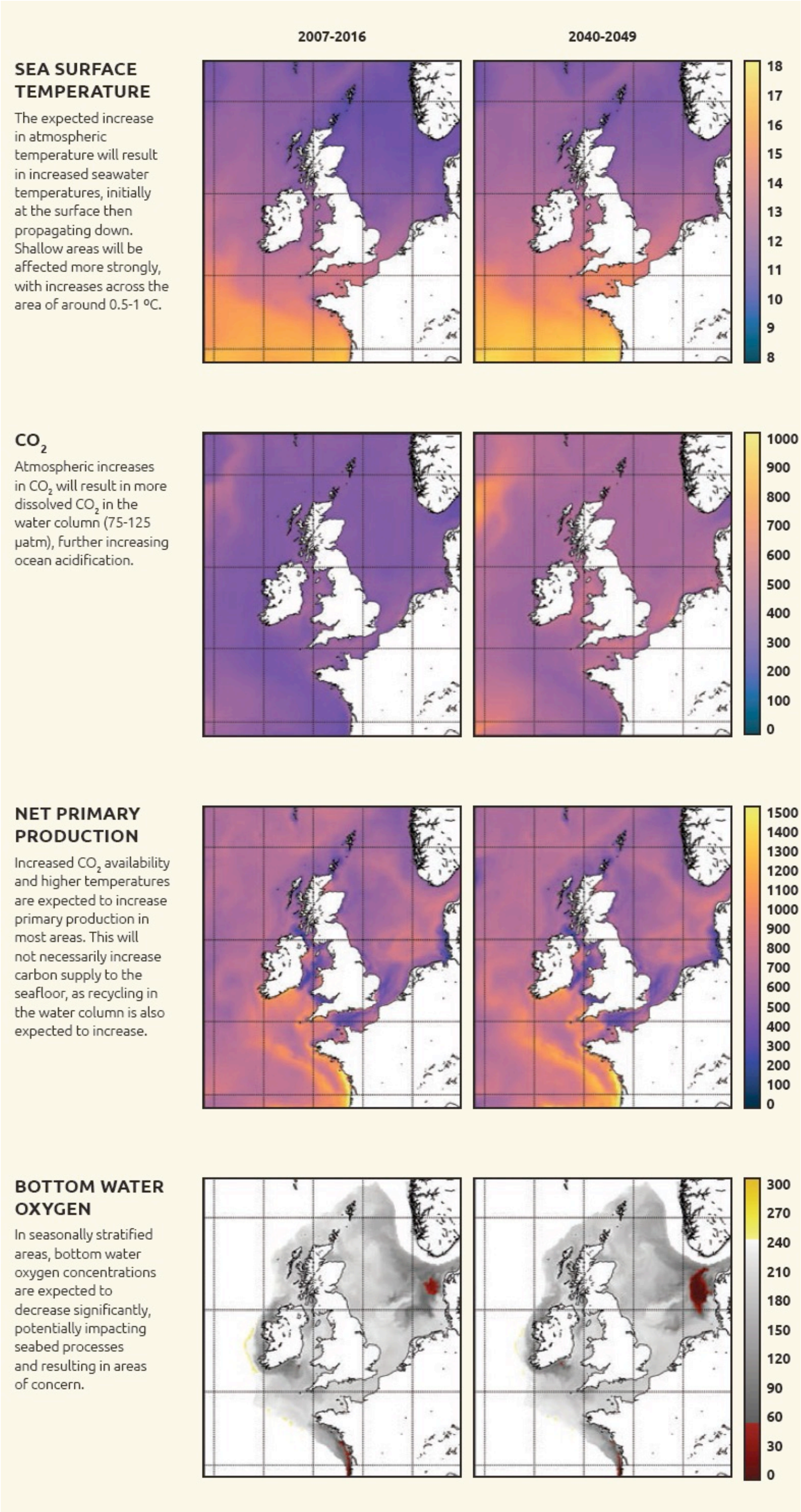


**Figure 2** How climate may alter the North Sea shelf seabed based on recent conditions (2007 - 2016) and near future (2040 - 2049) projections. Credit: taken from (1))

## Scenarios describing future society and economy

FutureMARES will develop policy-relevant scenarios based on commonly used IPCC frameworks including SSPs and RCPs. These broad scenarios are regionalised based on stakeholder perspectives to guide activities such as model simulations in specific Storylines. Each of these scenarios has implications for the three NBS examined in this program (effective restoration, effective conservation, sustainable seafood harvesting):

**Global Sustainability (SSP126) -** Low challenges to mitigation and adaptation

The world shifts gradually but pervasively to a more sustainable path, emphasising inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, investments in educational and health accelerate lower birth and death rates, and the emphasis on economic growth shifts to an emphasis on human well-being. Societies increasingly commit to achieving development goals and this reduces inequality across and within countries. Consumption is oriented toward lower material growth, resource and energy intensity.

**National Enterprise (SSP385) -** High challenges to mitigation and adaptation

A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to focus on domestic or regional issues. Policies shift over time to be oriented more on national and regional security. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialised countries and high in developing ones. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

**World Markets (SSP585) -** High challenges to mitigation, low challenges to adaptation

The world increasingly believes in competitive markets, innovation and participatory societies to produce rapid technological progress and train and educate people for sustainable development. Global markets become more integrated and strong investments in health, education, and institutions are made to enhance human and social capital. The push for economic and social development is coupled with exploiting abundant fossil fuel resources and adopting resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

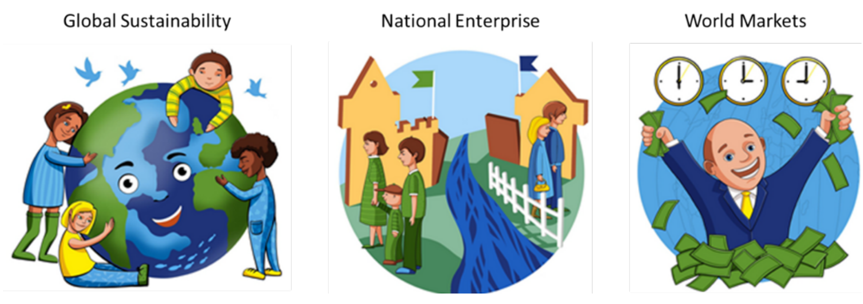


**Figure 3:** Representation of three, broad scenarios to be regionalised to guide activities such as model simulations in FutureMARES project. Credit: FutureMARES

**FutureMARES research needs**

The shelf seabed is responsible for most of the global benthic biogeochemical cycles, is an important host of biodiversity, is a key supplier of energy for higher trophic web, and contributes to pollution remediation. Climate change threatens these ecosystem services, and it is critical to predict the magnitude of climate-driven changes and the consequences of these changes to implement successful management measures to maintain a healthy and diverse seabed system. In order to do that, further work is critically needed to incorporate multiple service provisions from the seabed (beyond biodiversity) to identify key areas and describe more accurately the mechanisms that sustain those services, especially "keystone pathways" that support multiple services and assess the relevant links and relative contribution to the benthic parameters, specifically the functional contribution of the biology.

Develop statistical tools and measure relationships between benthic parameters dynamic and relative levels of ecosystem service bundles provided, identification of key parameters for evaluating human impact and climate change on benthic functions and services.

Develop "response models" of the key benthic parameters to human activities and climate change and propagation through change in ecosystem service delivery, including spatial projections of areas where service conditions are altered due to human activities, highlighting co-benefits and trade-offs.

Integrate those response linked to the relationships assets – services into interactive tools for testing management scenarios with various degrees of protection (MPA, HPMA), decisions, and service outcomes across various policy objectives.

**FutureMARES research** (T = Task – see program structure at futuremares.eu)

- **T1.1** Extend the spatial extent and length of local time series (based on field experiments and monitoring data) with emphasis on main bioturbators, carbon (B, P/B) and important prey species for benthivores;
- **T1.2** Compile and explore functional traits (response/effect) & environment-trait relationships for key macrozoobenthic species defined in T1.1;
- **T2.1/2.2** Compile regionally downscaled climate model runs for projections of change in seabed physics & biogeochemistry;
- **T4.4** Test scenarios of climate change and MPA design on changes of in seabed biota and their impacts on the wider food web and seabed bioturbation;
- **T5.1/5.2** Perform a climate risk analysis for the main infauna species examined in T1.1/1.2 (bioturbators, main prey, P & P/B) including multiple ecosystem services;
- **T6.1** Spatial comparison of layers of services, climate risks and current and planned MPA to inform a climate-smart MPA tool for the North Sea;
- **T6.2** Inform on economic change of carbon storage following the methods of Luisetti et al. (2019)
- **T7.1** Inform and integrate finding in the regional policy landscape, especially OSPAR and ICES for cumulative effects of multiple pressures;
- **T8.1** Engage stakeholders to compile views on the change in the MPA paradigm for the North Sea ecosystem.

## Storyline Contact

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## References

Culhane FE, et al. (2018) Linking marine ecosystems with the services they supply: what are the relevant service providing units? Ecol Appl. 28(7): 1740–51.

European Environment Agency (2018) Marine protected areas [Internet]. EU publications. Available from: https://op.europa.eu/en/publication-detail/-/publication/47a135d3-0731-11e9-81b4-01aa75ed71a1/language-en#document-info

Galparsoro I, et al. (2014) Mapping ecosystem services provided by benthic habitats in the European North Atlantic Ocean. Front Mar Sci. 1 (July).

Harris PT, et al. (2014) Geomorphology of the oceans. Mar Geol [Internet] 352: 4–24. Available from: http://dx.doi.org/10.1016/j.margeo.2014.01.011

ICES (2019) Greater North Sea Ecoregion – Ecosystem overview. Report of the ICES Advisory Committee, 2019.

Jones DOB, et al. (2014) Global reductions in seafloor biomass in response to climate change. Glob Chang Biol., 20(6): 1861–72.

Kay S, et al. (2018) CERES Deliverable D1.3 Projections of physical and biogeochemical parameters and habitat indicators for European seas, including synthesis of Sea Level Rise and storminess. Climate change and European aquatic RESources.

Kroeger S, et al. (2018) Shelf Seas: The engine of productivity, Policy Report on NERC-Defra Shelf Sea Biogeochemistry programme. Lowestoft.

Le Quéré C, et al. (2018) Global Carbon Budget 2017. Earth Syst Sci Data. 10(1): 405–48.

Liquete C, et al. (2013) Current Status and Future Prospects for the Assessment of Marine and Coastal Ecosystem Services: A Systematic Review. PLoS One, 8(7).

Luisetti T, et al. (2019) Quantifying and valuing carbon flows and stores in coastal and shelf ecosystems in the UK. Ecosyst Serv [Internet], 35: 67–76. Available from: https://doi.org/10.1016/j.ecoser.2018.10.013

Norkko A, et al. (2013) Size matters: Implications of the loss of large individuals for ecosystem function. Sci Rep., 3: 1–7.

Séguin A, et al. (2014) Body size as a predictor of species loss effect on ecosystem functioning. Sci Rep., 4: 1–5.

van der Molen J, et al. (2013) Modelling marine ecosystem response to climate change and trawling in the North Sea. Biogeochemistry, 113(1–3): 213–36.