Interreg North Sea

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Norsaic REPORT

CLIMATE CHANGE PARAMETERS FOR MSP

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1. Introduction

The implementation of marine spatial planning, the process by which human activities at sea are coherently managed at an international scale, is mandatory for all Member States of the European Union. The Greater North Sea area is a densely populated, widely used, heavily industrialized sea region shared by many countries in and outside of the European Union. Various busy ports are located on these shores, e.g. Rotterdam, the busiest port in Europe, as well as Antwerp or Hamburg, and thus its shipping lanes are among the busiest in the world. Beyond transportation of goods, this sea region is heavily used for diverse activities such as fisheries, oil and gas exploration, sand extraction, offshore wind energy production, and tourism.

However, due to climate change and increasing human activities and needs, Marine Spatial Planning in the Greater North Sea is currently facing the challenge of maintaining a healthy, sustainable, future-proof sea basin while accounting for the disturbances to human uses and ecosystems caused by climate change both today and in the future. To tackle this challenge, an adapted MSP approach needs to be jointly developed by decision-makers, researchers and maritime actors, for an improved cooperation governance on every level.

The Interreg project Norsaic (co-funded by Interreg North Sea Region) aims to improve cooperation and governance in marine spatial planning (MSP) by adapting and advancing crucial MSP elements, establishing innovation capacity and building joint cooperation capacity.

Within Work Package (WP) 1 "Adaptation - Planning for the Future", the project aims to develop visions and strategies for the adaptation and advancement of crucial MSP elements to generate future proof MSP processes and plans in the North Sea region responding to a changing climate.

Activities in this WP1 include the development of parameters and visions for the topics of Climate Change, Land-Sea-Interaction, Cumulative-Impacts (local, regional and transnational) and Multi-Use.

2. Objective

The objective of the activity 1.1 "Climate Change – Parameters" is to identify relevant parameters representing what is at stake in the North Sea in terms of expected impacts of climate change on ecosystems and uses, from a spatial planning point of view. It will be the basis for the production of maps (for existing data) and will help formulating demands for further research. Raising awareness about the reality of climate change impacts also requires to present at least some already observed changes.

As activities in Work-Package 2 "Innovation capacity for governance", we will look for innovation in the representation of the proposed information, in order to make it impactful, dynamic, interactive and connected to other spatialized information currently used in maritime spatial planning.

In the second phase of WP1, we will share the representation of the climate change information for MSP with stakeholders and decision-makers at different governance scale. They will be proposed to take advantage of for developing strategic visions for the future.

Climate change is considered as an umbrella topic impacting the other topics which will be developed by Norsaic: land-sea interactions, multi-use and cumulative impacts at local and regional scales.

3. General approach

The method consists first in identifying key issues already dealt with by maritime spatial plans as well as forthcoming challenges, with a restrictive focus on what is related to spatialized information. This is very discriminatory as most of the challenges are policy or governance oriented and do not have a spatial dimension. The three main sources are:

- MSP-GREEN project: deliverables 2.1 [1]
- eMSP-NBSR project: policy brief on cross-cutting issue climate change[2]
- *Quante, M.E. & Colijn*, F. E. (2016): *North Sea Region Climate Change Assessment*

Additionally, a webinar gathering experts from the project partners and invited speakers (see in Annex 4) allowed to explore the challenges for maritime spatial planning associated to climate change and test ideas about how to structure the information.

Climate Change Parameters for Maritime spatial planning are defined here as a list of spatial information necessary and relevant, at the scale of the North Sea, to cope with climate change issues in MSP. They should consist at least in maps covering the whole sea basin.

The logical framework adopted to inventory the parameters of climate change in MSP distinguishes 3 types:

- baseline: current status of climate change and its impact (raising awareness)
- scenarios: further and future impacts caused by climate change (being informed)
- mitigation and adaptation levers: challenges and opportunities from a sectoral point of view, key features for mitigation and adaptation measures through maritime spatial plans (deciding)

Within this activity, a long list of key issues related to climate change for maritime spatial plans have been developed (see Annex 1). Based on this list, additional information was gathered to estimate feasibility and practicability of the map in the framework of the project, by expert judgement: does a synthetic map of the topic exist already, what is the availability of the necessary data to create a map, how difficult and how long does it take to process the data?

Starting from this feasibility assessment, priorities were attributed to the parameters, chosen through various factors, including the time it would take to create a map and the information provided on the related map. This has been the basis for the chosen topics and parameters taken as examples in the following chapter. It is important to stress, that this report is no scientific paper and does not contain all topics in completeness. The aim of this report is rather to provide information being practical summary for MSP planners.

[1] https://mspgreen.eu/results/
[2] https://www.emspproject.eu/wp-content/uploads/2024/01/Climate-smart-MSP-Policy-Brief-eMSP-NBSR-January-2024.pdf

4. First interim results

Following the general approach, we have identified several topics and parameters to continue with in this part:

- Synthetic map of intensity of meteo-marine evolution
- Fish distribution shifts due to climate change
- Which areas and infrastructures are currently affected or threatened by physical landscape evolutions and risks such as coastal erosion and evolution or floods?
- Blue Carbon storage capacity
- Sensitivity of maritime spatial plans zoning to climate change

In the following sections, all these topics and parameters will be presented and described with examples of either existing maps, or maps designed within the framework of the project.

4.1. Synthetic map of intensity of meteo-marine evolution

One of the most distinct consequences of climate change is the projected increase of the air temperature. This also has an effect on the calculated sea surface temperature, as it is displayed in Figure 1.

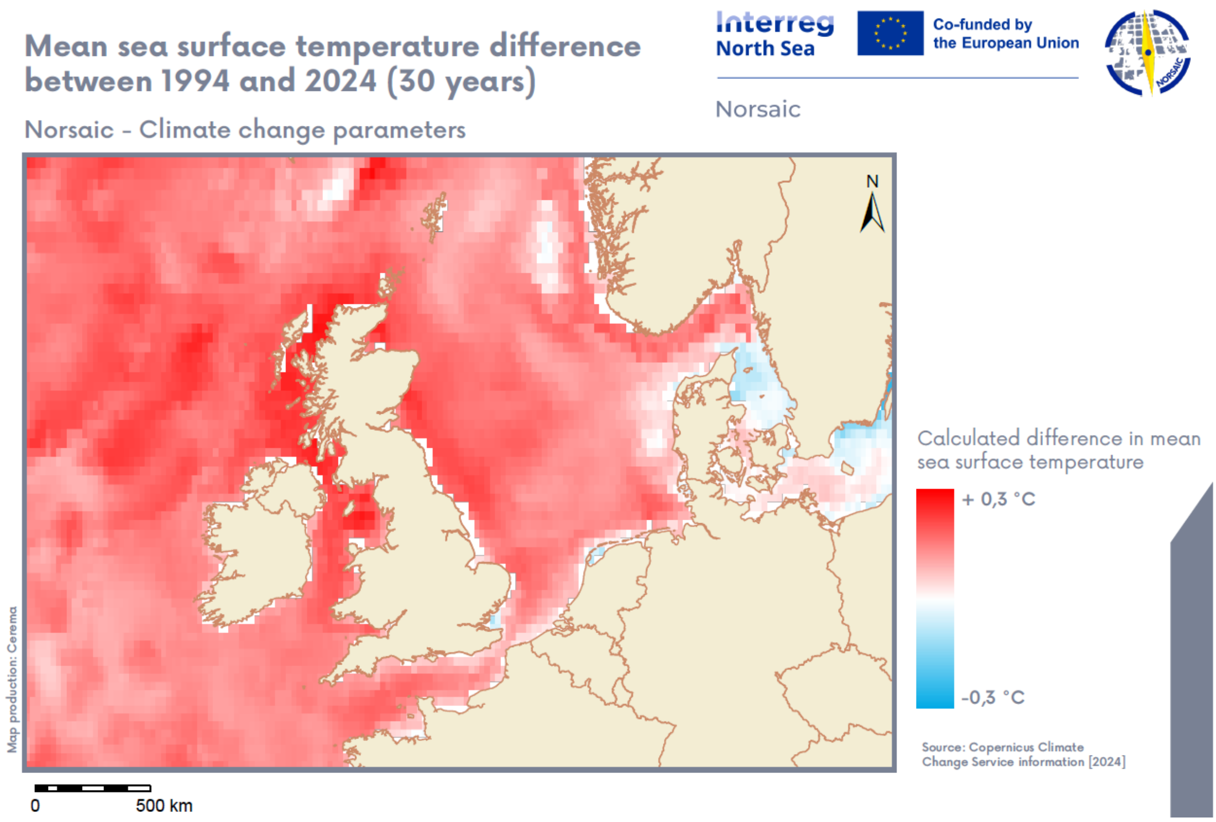

Figure 1: Mean sea surface temperature difference between 1994 and 2024 (30 years).

Figure 1 shows the mean sea surface temperature difference between 1994 and 2024 in the North Sea. The difference was calculated using sea surface temperature values from the Copernicus Climate Change Service, averaged across monthly values in years 1994 and 2024.

This 30-year period indicates an increasing temperature nearly in the complete North Sea area, only locally some smaller areas seem to not experience changes in the sea surface temperature.

Following the latest CMIP6 models (EEA 2023), it is likely that this trend will continue until 2100 (see Figure 2). The European Environment Agency used this climate model and several Shared Socioeconomic Pathways (SSP) scenarios to project the sea surface temperature anomalies for several sea basins until 2100.

For the North Sea, the model project an increase of the sea surface temperature between 0,5°C to 3,5°C depending on the scenarios (numbers referring to the 25th and 75th percentile; see Figure 2).

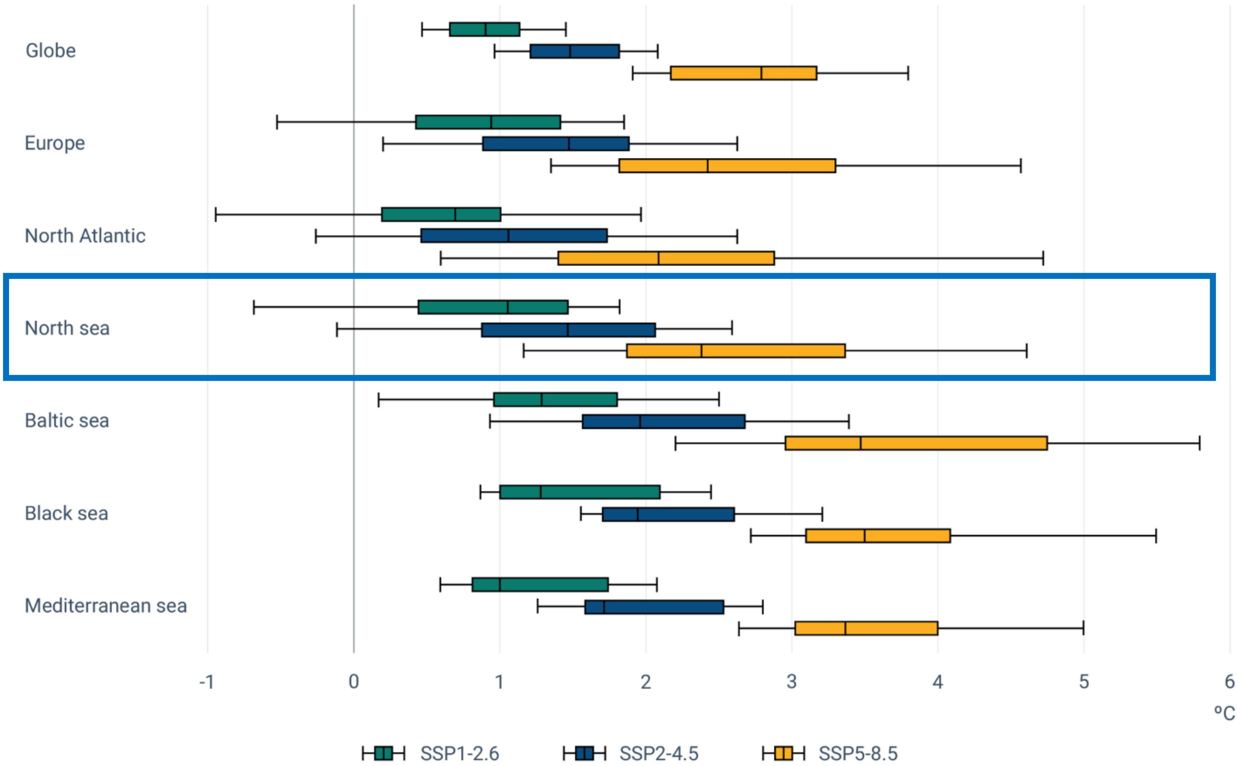

Figure 2: Projected sea surface temperature anomalies under different SSP scenarios for European seas and global ocean[3]. The climate models also project an increase in frequency, duration, spatial extent and maximum intensity of marine heatwaves (EEA 2023).

Conclusion for MSP:

In summary, both the likely increases of the sea surface temperature and the marine heatwaves could lead to significant ecological impacts and result in increased risks to human health and ecosystems (EEA 2023).

[3] https://www.eea.europa.eu/en/analysis/indicators/european-sea-surface-temperature?activeAccordion=ecdb3bcf-bbe9-4978-b5cf-0b136399d9f8

Therefore, it is crucial for MSP planners to be aware of the potential climate change effects and consider them in the planning process. Due to an increase of the sea surface temperature or marine heatwaves, a change or the reconfiguration of marine ecosystem might lead to changes in MSP, e.g. new areas for nature protection or for introducing protective measures in relation to other human activities.

4.2. Representations of changes in fish distribution due to climate change

With fishery being a human activity conducted throughout the whole North Sea, though in various spatial intensity, changes with regard to abundance of target species due to climate change effects, may require fishery adaptation to steering of the utilisation of space in the framework of Maritime Spatial Planning.

With rising water temperatures geographical abundance of a wide variety of fish species, including commercially exploited fish stocks in the North Sea is changing: e.g. the distribution area of cod and plaice has already been observed moving towards the northwest, "traditional" cod spawning grounds in the southernmost North Sea reaching temperature limits for successful spawning (best below 10°C). Some research on potential positive effects of further deployment of offshore wind energy indicate a certain chance of mitigating climate change effects on e.g. cod stocks in the southern North Sea.[4], providing some shelter for spawning and nursing.

With more thermophilic species such as mackerel or sardines moving further North other commercially viable fish species are gradually finding suitable environment. Other effects may result in earlier spawning of certain fish species which might also have an impact on the fish stock, e.g. sole, in the North Sea. (Quante, Colijn 2016).

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4 Gimpel et al., 2020

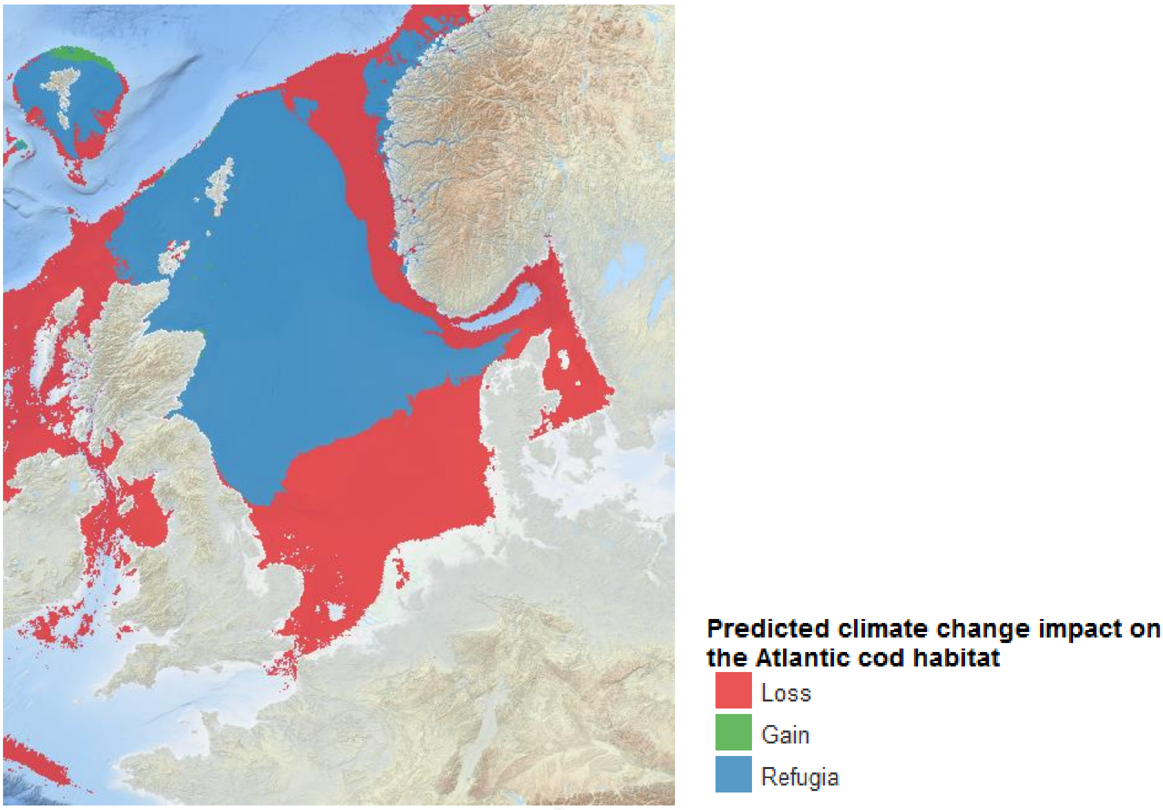
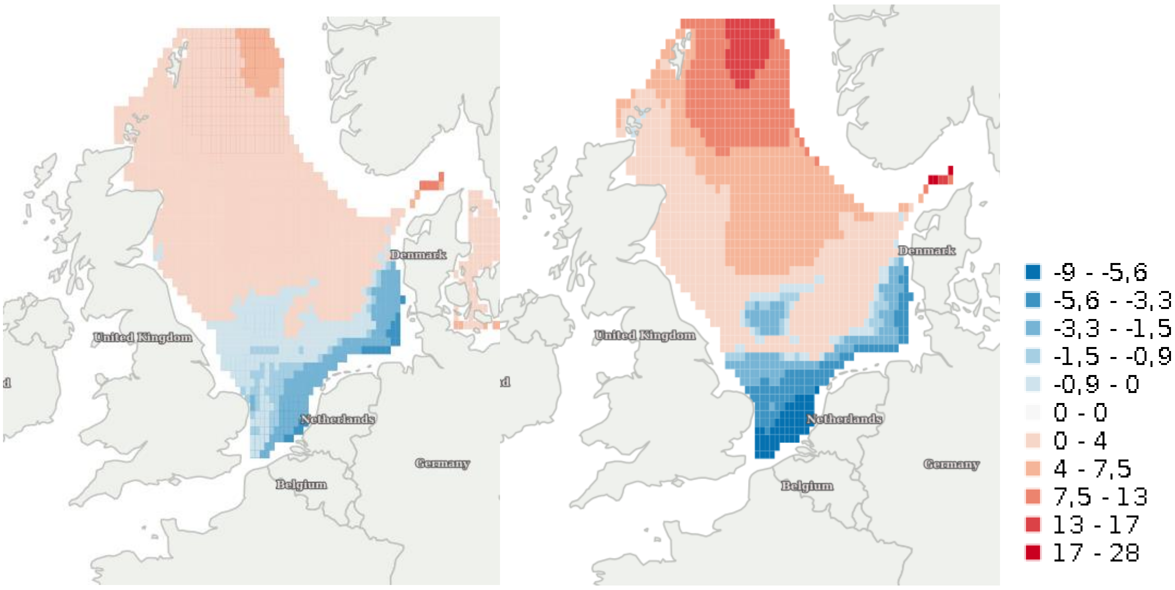


Figure 3: predicted loss, preservation (refugia) and gain in habitat for the Atlantic cod (Gadus morhua) in the future (2081-2100) under a business-as-usual climate change scenario.The study providing these data is part of the Horizon 2020 ATLAS project, a transatlantic assess-ment and deep-water ecosystem-based spatial management plan for Europe).[5]

[5] https://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;bkgd=1;theme=382:0.75;c=-379006.2284979576,7869681.194834028;z=5)



1970-2010 changes in HS
(difference in %)

1970-2050 changes in HS
(difference in %)

Figure 4: changes in habitat suitability (given in %) for Cod from 1970 to 2050 (observed / estimated using a species distribution model (TIMoFiD) within the scope of the project CoastalFutures[6]; Detailed information about the method can be found in Annex 5.

[6] https://atlas.thuenen.de/catalogue/#/map/286

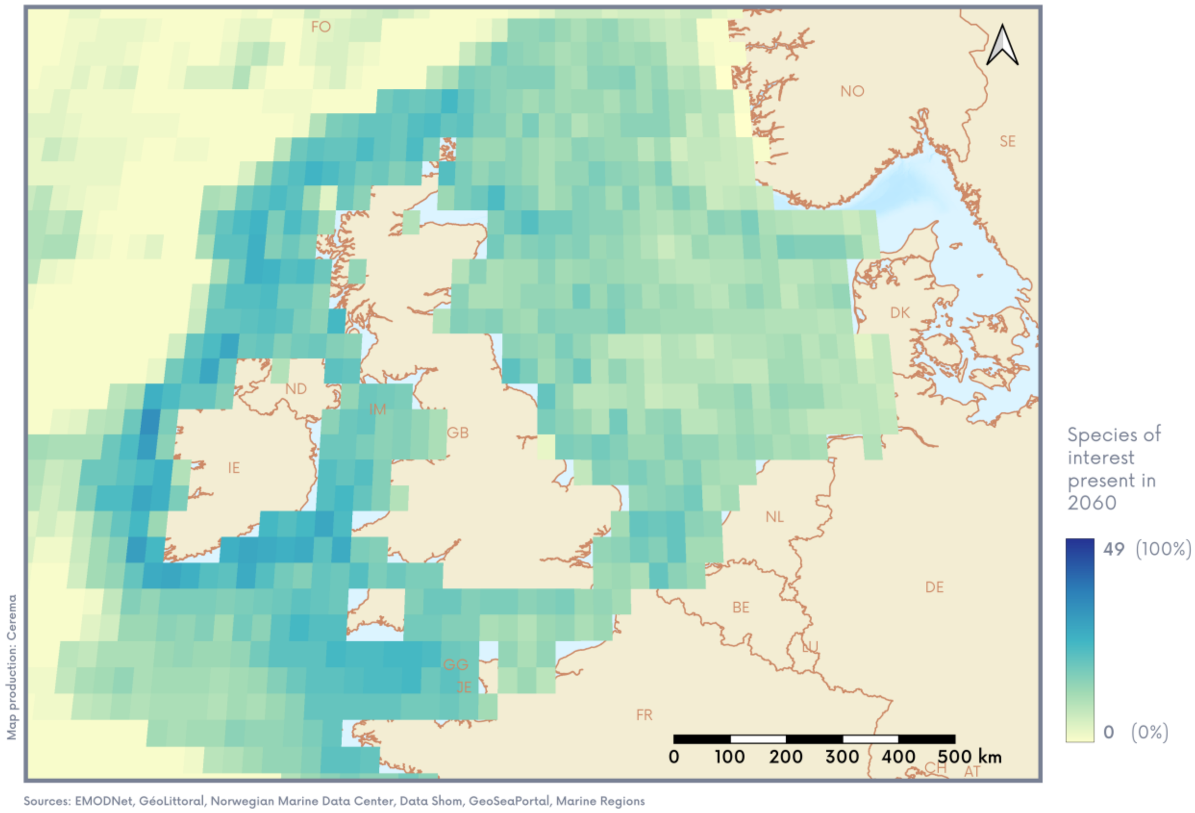


Figure 5: Modelled presence of commercial fish species in 2060. Detailed information about the method can be found in Annex 5. Source: EMODnet.

All in all, the predicted spatial developments of currently exploited fish stocks in the North Sea show high potential for significant climate change induced changes, though fish stocks may be affected to various extent. E.g. coastal fishery on brown shrimp[7] which is significantly economically important in the Southern North Sea seems to be more resilient to temperature changes, so it is expected that brown shrimp will stay more or less in the current distribution area, but with eventually some expansion in peak abundance to the North[8].

SEAWISE

The EU project SEAWISE (https://seawiseproject.org/) has investigated on how to assess the distribution of fish species across European seas[9]. They developed, also based on the ICES WKFISHDIS2 workshop, guidelines on how to appropriately pre-process such data, analyse them with state-of-the-art species distribution models (SDMs), and define metrics on how to compare species distributions. This is essential for exploration on how species distribution may change under different scenarios of climate change.

[7] https://www.weser-kurier.de/ratgeber/klimawandel-vertreibt-nordsee-arten-doc7e42qznf9qeo8jjs2eb
[8] R. Saborowski, K. Hünerlage 2022
[9] Sys et al., 2022

The general conclusion of the report was: "In general, there was good agreement between the distributions generated by different models that were applied to four different reference species with different characteristics in terms of spatial distribution. Differences between models were mainly related to the configuration of spatiotemporal processes, and the extrapolation, mainly in areas with few observations, or where correlates extend to values outside the observed range.

Trends in species distribution were species specific. Some species have shifted in a northward direction, while the distribution of other species was static, or characterized by a southward trend. It is difficult to have a mechanistic understanding, e.g. migration due to climate change, local outbursts, and/or local depletion of fish stocks, of these changes based on survey data that does not allow tracking of individual fish. Potential climate related shifts were instead investigated by linking the survey data with oceanographic variables generated through coupled hydrodynamic-biochemical models. This allowed us to explore how species distributions may change under different scenarios of climate change." (Sys et al., 2022).

Conclusion for MSP:

Concluding from this rough forecast into the potential development of fish stocks in the North Sea implications for MSP may be the need:

- To develop reliable stock take of currently commercially exploited fish stocks' distribution (e.g. SEAWISE; Sys et al., 2022)
- Fish stock distribution changes due to temperature changes are really species and area specific, which make it complex for considering changes in fishery socio-economics in MSP.
- To develop plausible change scenarios within and beyond MSP planning cycles including socio-economic impact assessments
- When planning for fixed infrastructure such as offshore wind energy and subsea cables, adequately balanced measures should be developed for securing access to current and future important fishing grounds while also catering for nature protection needs.

4.3. Representation of threats caused by physical landscape evolutions, coastal erosion and floods on areas and infrastructures

The evolution of the coast can be approached through 3 problematics strongly linked to climate change: the sea level rise, the increase of storms frequency and violence, the evolution of the coastline due to hydro-sedimentary movements.

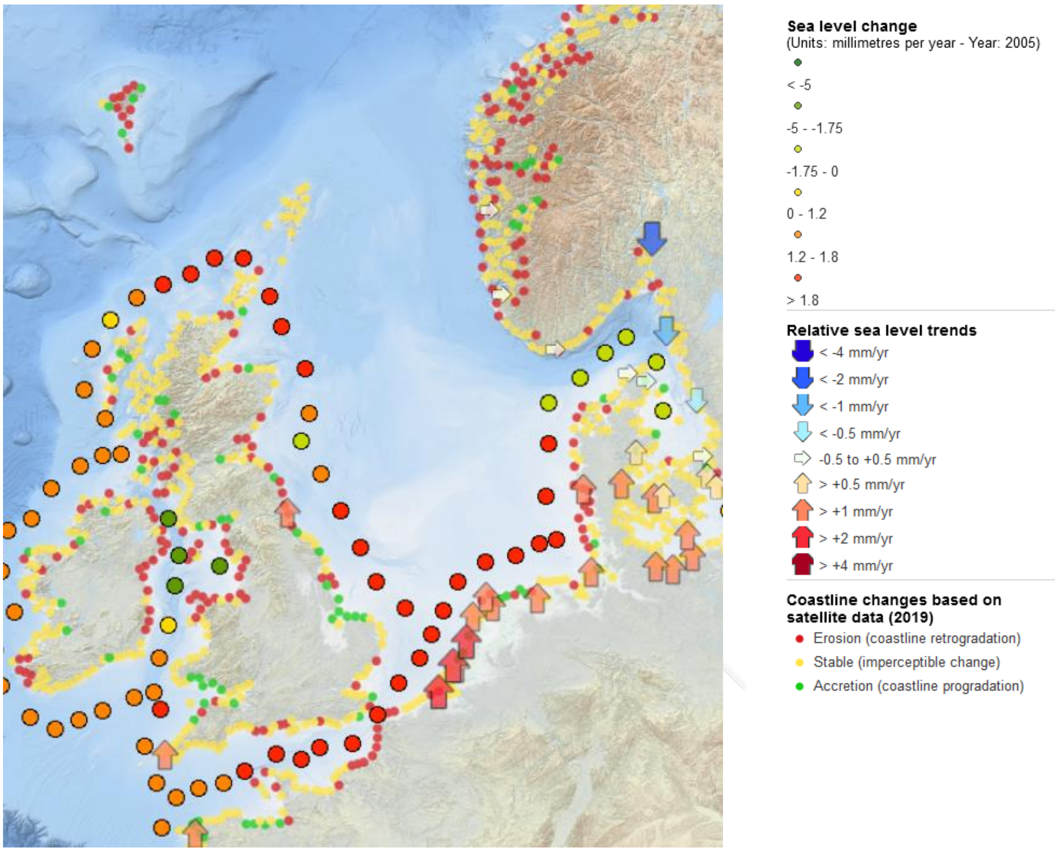


Figure 6: Overview of sea level change, relative sea level trends and coastline changes based on satellite data in the North Sea

Figure 6 shows an overview of sea level change, relative sea level trends and coastline changes based on satellite data in the North Sea[10]. The intensity of the sea level change slightly varies locally. Nevertheless, the relative sea level trend seems to increase in great parts of the North Sea. The coastline changes are stable in most parts, while some regions have erosion and some other regions have accretion.

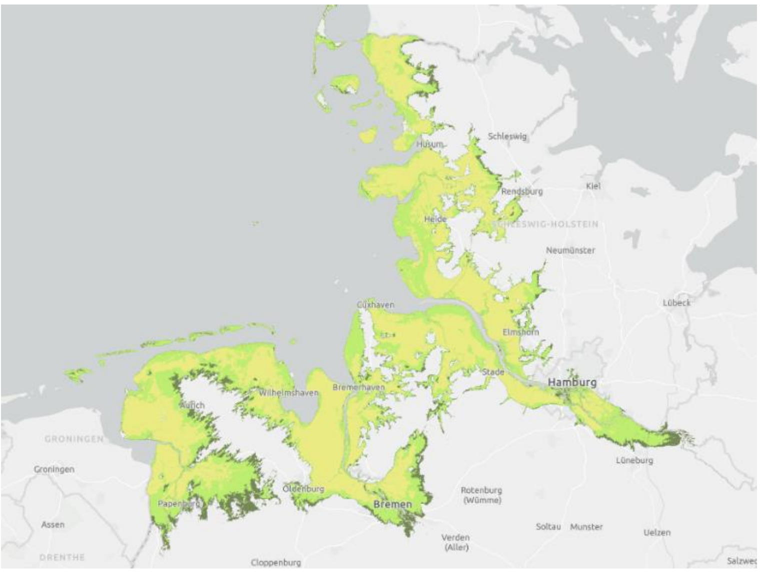
[10]https://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;bkgd=1;theme=195:0.75,298:0.75,13:1;c=-232986.85661528283,8166108.9774330165;z=5

Local Case Studies (France, Belgium and Germany)

In addition to the North Sea wide overview, we also focused on two local examples. In the maps presented here, we show the local influence of the rising sea level (figures 7 and 8), the impact of storms (figure 7) and of the coastline evolution (figure 9).

In principle, the mean sea level determines the starting level for the development of storm surges. The higher the mean sea level, the less wind is required to raise water levels to storm surge level.[11]

Scientists predict a mean sea level rise in the German Bight until the end of the century of up to 1,20 m (current worst-case scenario), with additional 0,30 m wind jam added storm surges could be 1,50 m higher than today[12] . Figure 7 showcases the areas in Germany where coastal protection might not be sufficient or even not feasible to maintain any more.



yellow: coastal protection needs – normal tides
light green: coastal protection needs – storm surges (storm surge 1962)
dark green: potential coastal protection needs by 2100 (storm surge 1962 + 1,50 m)[13]

Figure 7: areas and infrastructures currently affected or threatened by physical landscape evolutions and risks such as coastal erosion and evolution or floods.

The approach is quite identical in the French Case Study, without the implication of the storm evolutions (Figure 8).

[11] https://hereon.de/imperia/md/assets/main/transfer/norddeutsches_klimabuero/documents/nordseesturmfluten_klimawandel.pdf
[12] https://hereon.de/imperia/md/assets/main/transfer/norddeutsches_klimabuero/documents/nordseesturmfluten_klimawandel.pdf, p. 32

[13] https://kuestenschutzbedarf.de/portal/apps/sites/#/kuestenschutzbedarf/pages/kuestenschutzbedarf-an-der-nordseekueste

Prediction of the coastline evolution due to hydro-sedimentary movements (Figure 8) can also show very different evolution, with areas highly threatened by the rising of the sea level currently in progression.

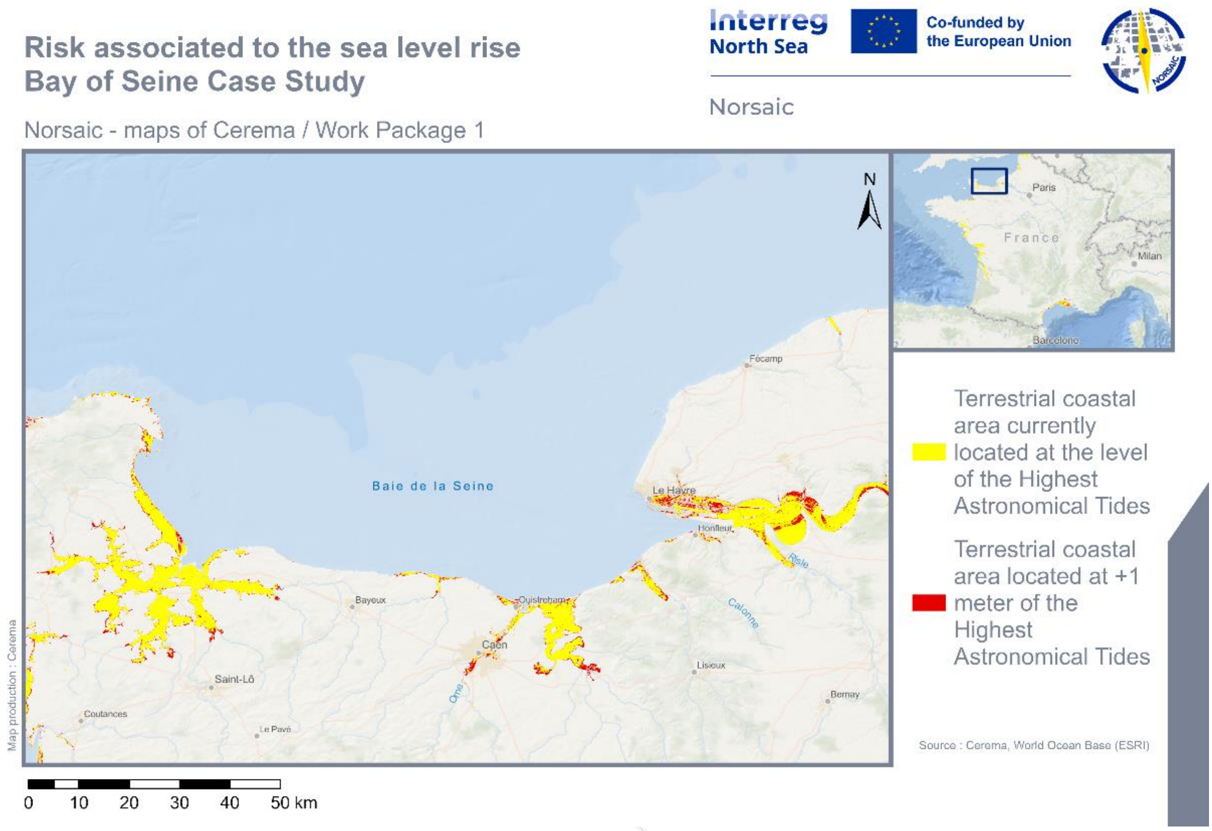


Figure 8: Recession or Progression of the coastline in the Bay of Seine.

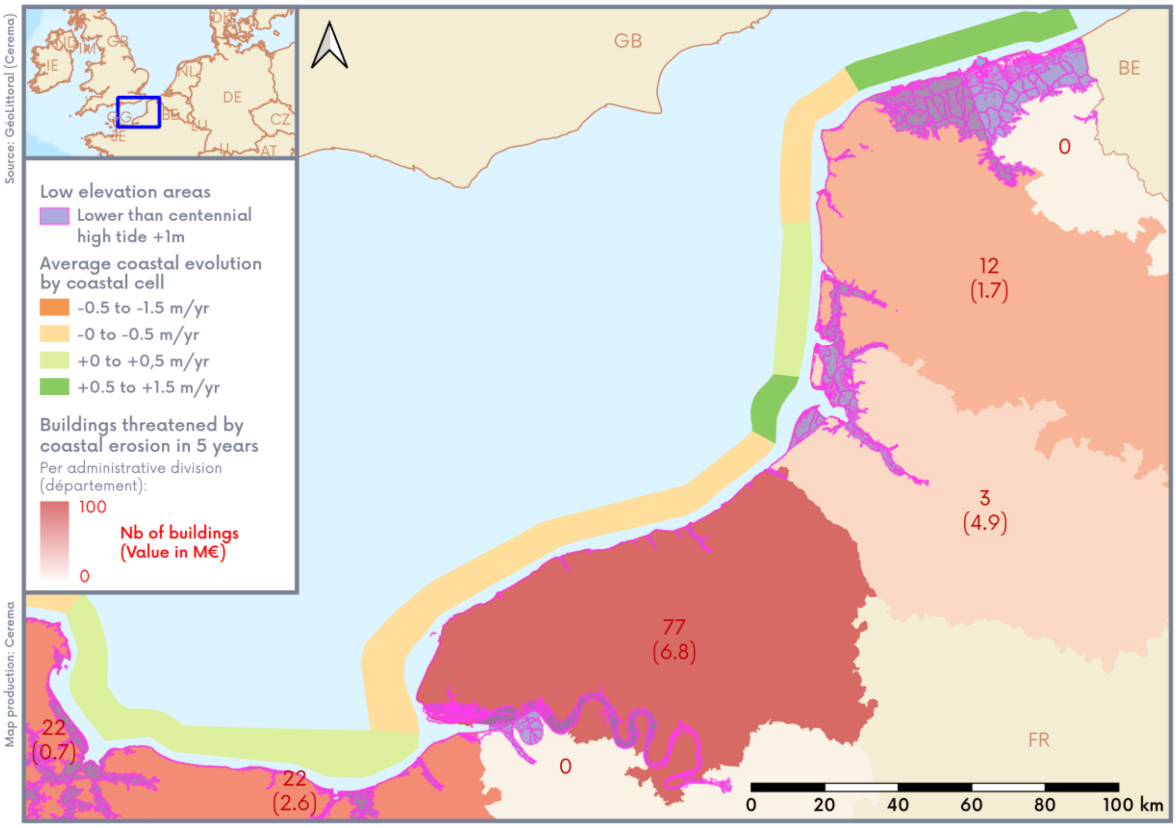


Figure 9: coastal risks on the French coasts of the North Sea and English Channel.

Various coastal risks were studied on the French Channel and North Sea coasts (figure 9): low elevation areas less than 1 m above centennial tide levels, but also the number of buildings directly threatened by coastal erosion in the next 5 years per département (French administrative unit of NUTS level 3) and the total value of these. In the most threatened département, a total value of 6.8 million euros was identified as directly threatened in the next 5 years.

Finally, these studies can be compared with an existing study conducted by the services of the Flemish Government in Belgium. In this study, the risks of coastal flooding in case of storms are estimated on the Belgian coast (through hydraulics and hydrodynamics modelling) considering the projected climate conditions in 2050. The estimated risk of coastal flooding is further divided into three levels of risk based on different storm conditions used in the model:

- A storm with a return period of 10 years is used to define areas with a high risk of flooding
- A storm with a return period of 100 years, for areas with a medium risk of flooding
- A storm with a return period of 1000 years, for areas with a low risk of flooding.

No area was found with a high risk of flooding.

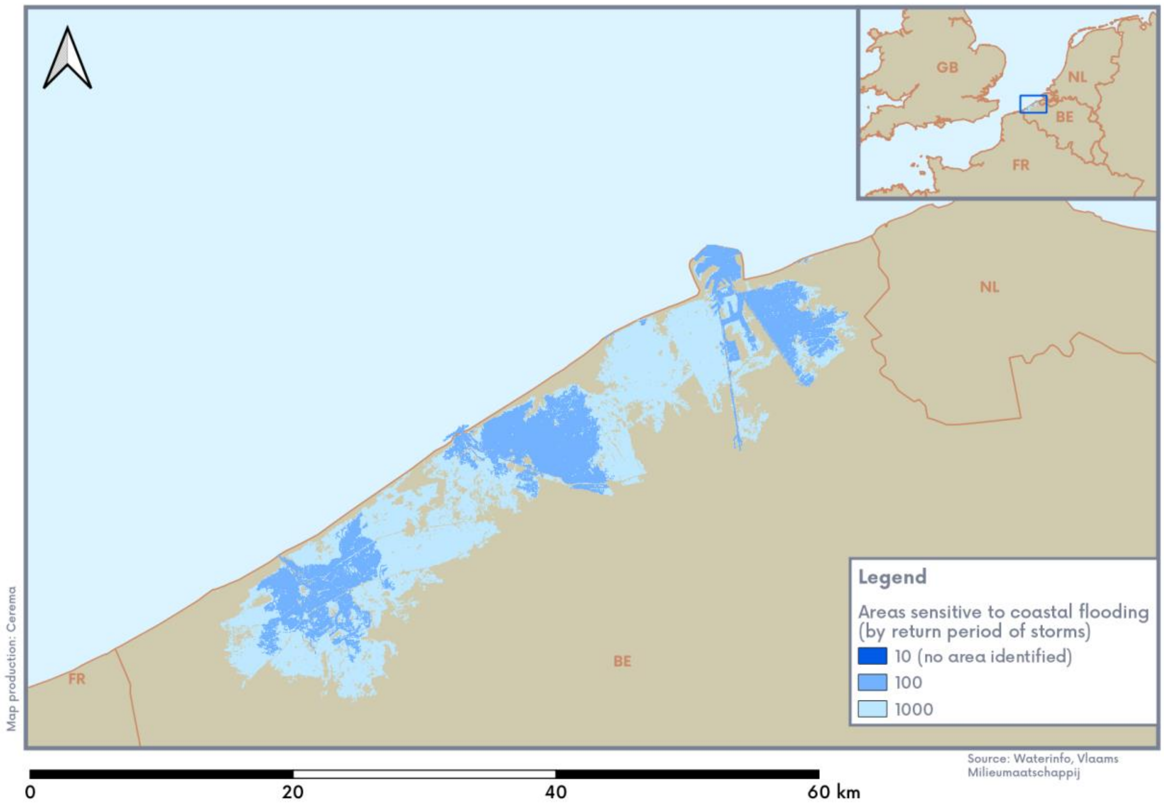


Figure 10 : Coastal flooding risks in Belgium

In the Netherlands, the approach is quite different from the examples provided here, therefore the methodology adopted to provide maps is not appropriate: as there is a unique approach due to continuous sand nourishment, the extent of the coastline is being continuously monitored, in order to adapt the sand nourishment strategies accordingly.

Conclusion for MSP:

Considering the combine effect of multiple factors contributing to the evolution of the coastline (storms, hydro-sedimentary, sea level rise) can adjust the correct knowledge of the climate change impact. However, the response by human societies (increasing protection, relocation of activities and assets for example) are very few planned through MSP, and more with much more from other institutions strategies.

On a long-term perspective however, the need for a more and more precise knowledge of coastal risks will also impact MSP through the adaptation of maritime activities inland.

4.4. Representation of Blue Carbon storage capacity

Blue Carbon refers to the potential of specific marine and coastal ecosystems to naturally absorb carbon dioxide (CO2) and store it (IOC, Unesco). The ecosystems with a confirmed ability to store carbon are mangroves, tidal marshes, salt marshes, and seagrass meadows.

Other ecosystems, like kelp forests and other macroalgae, phytoplankton, and seashell beds, are suspected to have a potential to store carbon as well. However, due to the complex mechanisms by which carbon is stored in these habitats, the duration of carbon storage and its efficiency are not yet completely understood by the experts. Therefore, these specific habitats are often excluded from Blue Carbon related projects, until an agreement is reached within the scientific community.

Using ecosystem maps and data, coastal and marine ecosystems suitable for, or with potential for carbon storage, can be identified.

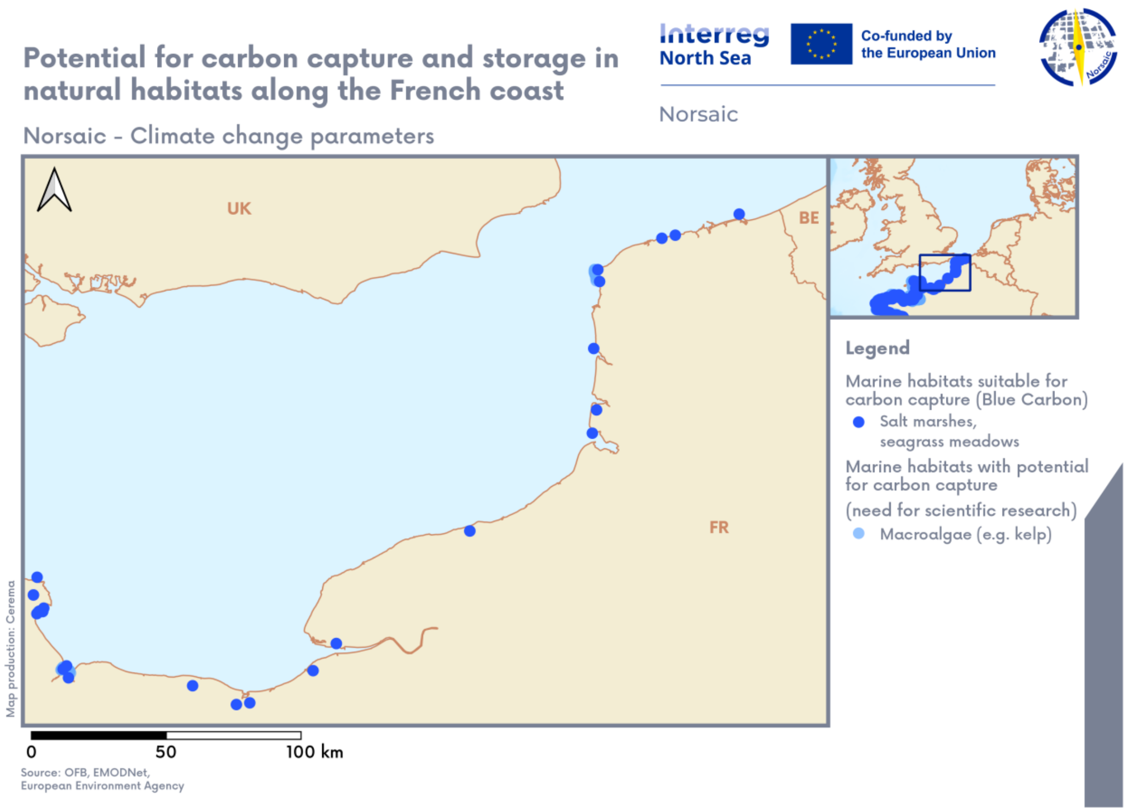


Figure 11: Ecosystems and potential ecosystems along the French coast and in the French North Sea and Channel suitable for carbon storage and natural carbon absorption (Blue Carbon).

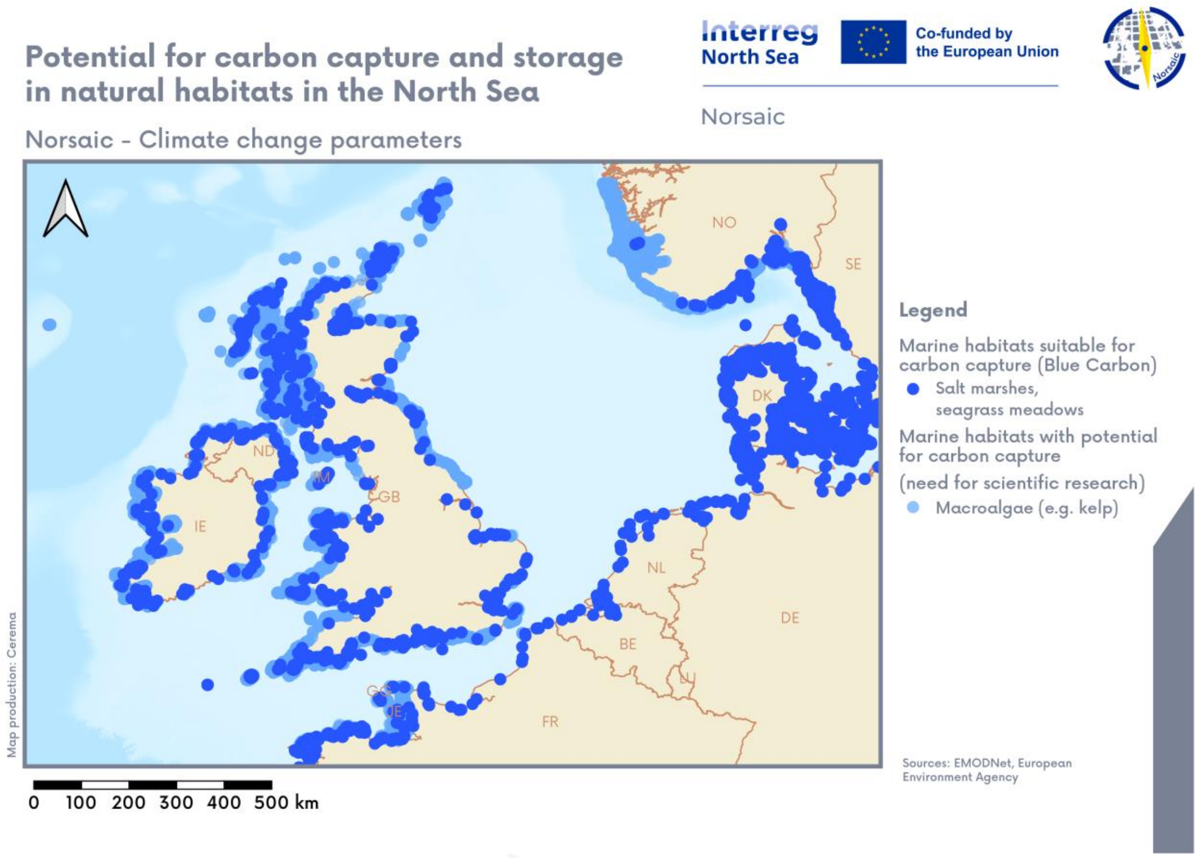


Figure 12: Identified coastal and marine ecosystems in the North Sea, the Channel, the Celtic Seas and the Danish Straits suitable for, or with potential for, carbon storage and natural carbon absorption (Blue Carbon).

The figures 10 and 11 above represent maps of ecosystems with confirmed or suspected potential for carbon capture, along the French coasts and in the Greater North Sea basin. As appears on the maps, there is a great number of sites suitable for carbon storage.

Scientific literature for carbon absorption in temperate conditions (UK) provides estimates of CO_2 absorption per surface unit. It is estimated that saltmarshes absorb 235 to 804 tCO_2e/km^2/year, and seagrass meadows absorb 42 to 370 tCO_2e/km^2/year. Using these values and the surface of identified Blue Carbon habitats in the French "Eastern Channel and North Sea" sea basin, estimates of total absorption of carbon by Blue Carbon habitats in this area of the French EEZ (table 1). Similarly, UK's blue carbon ecosystems are estimated to sequester 11 million tons of CO_2 per year (Norris et al., 2021) for the entire UK EEZ.

	Surface of habitat (km^2)	Estimated absorption (min) (tCO_2/yr)	Estimated absorption (max) (tCO_2/yr)
Salt-marsh	42,59	10009,43	34245,02
Seagrass	12,58	528,40	4654,99

Table 1 : Minimum and maximum estimates of total carbon absorption by Blue Carbon habitats in the French "Eastern Channel and North Sea" administrative sea basin.

Conclusion for MSP:

Highlighting such « carbon storage » sites in national plans may allow marine planners to include the management and protection of these important sites in future spatial plans, not only for nature conservation but also as a way to mitigate climate change effects. Moreover, restoration sites could also be designated through the MSP process, in order to increase the ecosystem services of these ecosystems.

4.5. Representation of sensitivity of maritime spatial plans to climate change

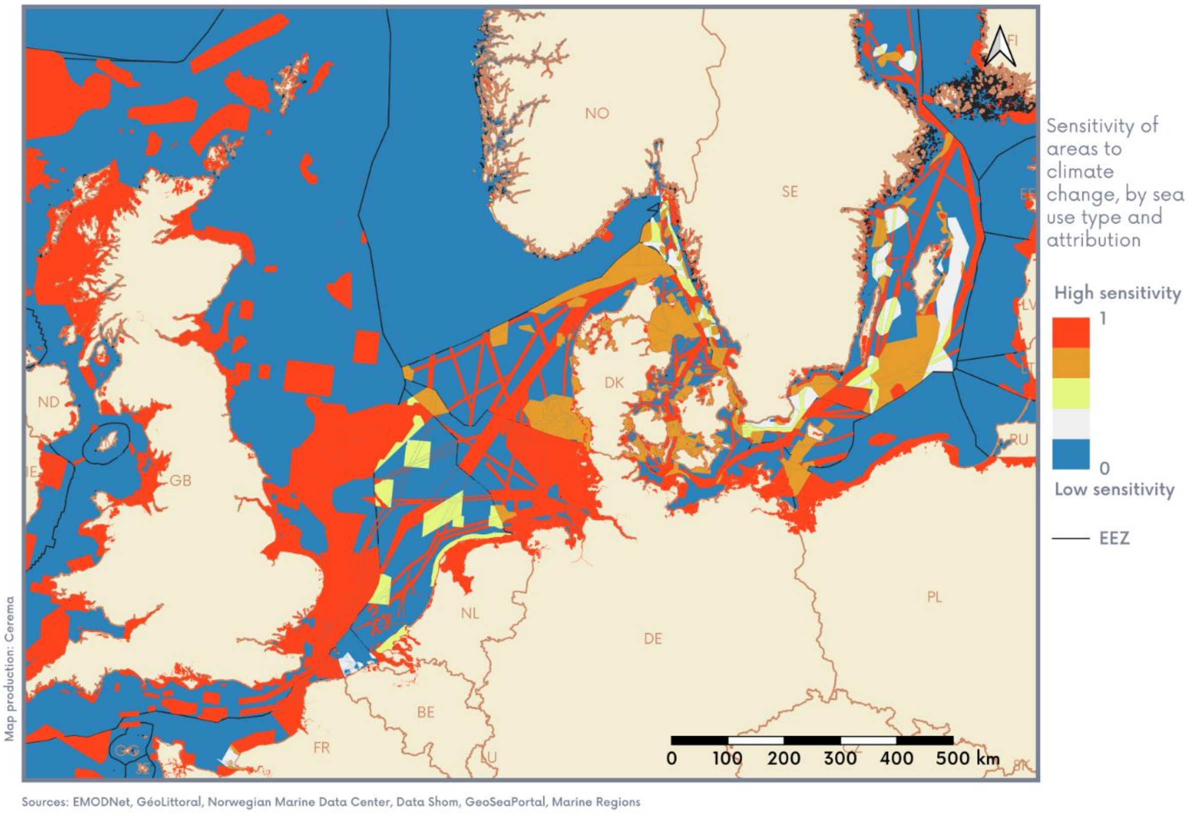


Figure 13: sensitivity of the maritime spatial plans to climate change. Detailed information about the method can be found in Annex 5.

The meaning of sensitivity here refers to the way climate change could call into question the zoning of the plans.

The map in Figure 12 is a first approach to define and represent the sensitivity of maritime spatial plans to climate change. The methodology used is based on EMODNet data model. This model assigns at a place a function to each sea-use, whether it is “Reserved”, “Priority”, “Allowed”, “Potential”, “Restricted” or “Forbidden”. The sensitivity of the planning is the sensitivity of this choice, it depends on the nature of the sea-use (notably mobile or not) and of the sensitivity to climate change of the sea-use itself. For example: aquaculture is fixed, it is sensitive to climate change, so reserving an area to aquaculture is highly sensitive to climate change. At one point, the sensitivity of the spatial planning will be the average of sensitivity of sea use functions weighted by the sensitivity of sea uses.

Conversion into numerical values of the two parameters relies on internal expert judgement, for the testing, on a scale from 0 to 1, and could be adjusted. The model is then applied on a x*x grid for the extended North Sea and the map obtained represents five sensitivity classes. The full methodology is described in Annex 5.

Particular cases:

In some cases, sea uses were attributed a null value as sea use function. These null values were attributed a function sensitivity of 0. For instance, in the Netherlands, a majority of sea uses were attributed a null value as sea use function; as such, the entire EEZ of the Netherlands appears to have low sensitivity to climate change.

Conclusion for MSP:

Having in mind that marine spatial plans are revised every six to ten years, we may consider that climate change should not have a major impact on MSP results as such, but it is likely to be considered on a longer term, in order to anticipate future choices. The sensitivity of the spatial planning is important at least as a warning to consider the most sensitive zones for the monitoring of the plan and the next revision.

The nature of the spatial planning influences the result. The vocation map in France is at a scale for which choices are less constraining, resulting in less sensitivity to climate change (but no planning is not an option). The exception concerns the Marine Nature Park, where nature protection is a priority. The next generation of plans is coming soon. It will be interesting to extend the test to them. In Germany, the orange and red areas for a high sensitivity are the result of several overlapping designations (nature protection, diver and harbor porpoise).

5. Conclusions

The initial inventory of issues identified in previous works as well as the analysis above indicated that most questions at stake when looking for “Climate-smart MSP” are not spatially explicit. Additionally, on the wish list of the maps that could raise awareness, inform about the future or support decision for mitigation and adaptation measures, very few are available or feasible. There is a lot to do, which means that it is necessary to be selective and focus on the more appropriate developments: the interim results will enable to discuss it with practitioners and stakeholders.

The question of the time scale of climate change compared to the revision cycle could lead planners to minimise the necessity of taking it into account right now. This feeling is increased by the difficulty of providing evidence for spatial decisions. If spatial planning to mitigate and adapt to climate change is not operational, impactful maps about the reality of climate change and its probable consequences in the future should counterbalance it. Most recommendations about climate smart planning are not about spatial planning, but rely on this awareness.

In future developments our opinion is that priority is to give evidence to support the following objectives:

- Designations to consider long-term impact of climate change with regard to changing environmental conditions (Hydrography, Meteorology, Biology …)
- Environmental assessment of designations to include resilience with regard to climate change
- Designations to include measures to mitigate negative impact and adapt to changing environmental conditions on human activities
- Provide elements for targeting the spatial design of monitoring programmes.

The geographic scale is also of importance. We established among our criteria that we were looking for maps covering the whole sea basin. Nevertheless, we had to admit that coastal areas had specific issues when it comes to biodiversity, natural hazards or blue carbon for example.

With respect to coastal risks, some connexion will probably be possible later in the project with the topic about land-sea interactions, when terrestrial centres influence activities at sea and at the same time could be threatened by the sea.

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ANNEXES

Annex 1: Key issues related to Climate Change for maritime spatial plans

Key issues	Baseline	Scenarios	Levers
Sea basin scale			
General			
Raising awareness, giving information	• Where is meteo-marine state most impacted (currently) by climate change? Synthetic map of intensity of meteo-marine evolution compared to the 20th century	• Where will CC have the most impact? Synthetic map of predicted changes to meteo-marine state in 50 years	
How much maritime limits (defined by the coastline) are sensitive to climate change?	• Current behaviour of the coastline • Current maritime boundaries defined by international agreements	• Predicted areas under the sea level in 15, 30, 50 years and associated maritime boundaries (theoretical)	
Safety at sea related issues	• Where is climate change causing risks at the moment? Map of current safety risks (sea ice, high traffic, frequent storms)	• Map of predicted safety risks (increased storminess, increased drifting sea ice due to fragmented coastal ice, new Arctic routes with high traffic...)	• Where can planners act? Highlights of current/future dangerous areas within Member States' EEZ
Sensitivity of maritime spatial plans to climate change scenarios (impacts, threats, new economic potential, shift in maritime activities spatial distribution…)	• Are the planned activities flexible? Definition of MSP areas based on EMODNet model (i.e. Priority, Allowed, Restricted, Potential etc…[14]) • Would there be alternative space for relocation of priority / restriction areas? • Are the planned activities threatened? Map of threatened activities based on reserved or prioritized areas	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats)	• Where can activities be carried out? Maps of compatibility/suitability of activities • Where can/should planners act? Maps of easily changed plans (compared with fixed uses such as wind turbines) • Which long-term spatial changes / allocation of space with regard to the lifetime of fixed infrastructure should be proposed?
Planning areas for technical carbon capture solutions			• Map of depleted deposits where captured carbon could be stored • Potential geological carbon storage areas
Nature			
Nature Conservation facing climate change	• Map of current Marine Protected Areas • Which MPAs are currently impacted by climate change? Map of habitat change caused by CC in MPAs since the MPA was installed	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats) • In the current MPAs, which will no longer be relevant for the ecological component they protect due to climate change? (study based on CC hotspots, species' habitats and CC-driven changes)	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats) • Which areas are ecologically important? Maps of total ecological value and ecosystem services • Future MPAs currently being planned

[14] Tbc: zoning approach in national MSPs is diverse, and national MSPs do not all include these categories, focus should be set on – where available - priority areas and restricted areas; categories applied in EMODnet developed in BASEMAPS for Baltic Sea MSPs

Key issues	Baseline	Scenarios	Levers
Ecosystems weakened by climate change	• How are current ecosystems and habitats impacted by CC? Synthetic map of changes compared to the ecosystems • Map of current habitats • Synthetic map of current biodiversity • Synthetic maps on dead zones: current dead zones, dead zones by the end of the 20th century	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats)	
Sustainability of ecosystem services	• Map of current value of marine and coastal ecosystem services	• Where are ecosystem services threatened? Map of estimated losses due to decrease in functional ecosystem services • Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats)	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats)
Safeguarding and enhancing nature-based carbon capture (Blue Carbon)	• Locations with high carbon capture rates		• Blue Carbon storage capacity
Socio-economic			
Adaptation of the fisheries sector: targeted species, fishing techniques, sustainable levels of harvesting, longer routes...	• Synthetic map of current state of the fishing sector: distribution of commercial species, fisheries, main fishing harbors and fish markets • Fish stocks	• How will fish distribution change due to CC? • Synthetic map of predicted changes to meteo-marine state in 50 years (for safety of navigation and fishing activity)	
Impact of biophysical changes on energy systems and offshore activities	• Where are Marine Renewable Energies developed currently? • Current potential for MRE development – synthetic map (e.g. based on wind regime, extreme events and storminess, insolation)	• Synthetic map of predicted changes to meteo-marine state in 50 years • Evolution of potential for MRE development (comparing models to current situation) • Future situation of current MRE farms (threatened by storms, loss of wind power...)	
Shipping: new routes, new propulsion systems? Sailing conditions	• Synthetic map of current meteo-marine state • Where is sea ice currently found? Average sea ice distribution over the last years • Maritime traffic: current routes, TSS, traffic density	• Synthetic map of predicted changes to meteo-marine state in 50 years • Where will new routes develop in the Arctic? Predicted new routes • Areas of compatibility with new propulsion systems or larger tonnage	
Key issues	**Baseline**	**Scenarios**	**Levers**
Coastal scale			
General			
Impact on physical landscape evolutions and risks such as coastal erosion and evolution or floods	• Which areas and infrastructures are currently affected or threatened? • Frequency and intensity of extreme weather events	• What are the impacts of more regular extreme weather events and shift in average meteo-marine conditions on infrastructures? • Threatened areas in X years: Predicted areas under the sea level, areas under high risk of coastal erosion in X years • Estimated value of threatened infrastructures and housing	• Can strategic relocation be implemented? Infrastructures and housing that can be relocated (e.g. harbours need to be close to the sea anyway)
Land-sea interactions conditions and resources	• Synthesis of socio-economic data such as gross	• Predicted evolution of socio-economic data according to	

Key issues	Baseline	Scenarios	Levers
	added value of activities related to the sea per municipality, or rates of employment in activities related to the sea, etc.	several scenarios of CC management (e.g. strategic relocation, business as usual, etc.)	
Impact on the development of toxic micro-algae, bacteria, and viruses	• Areas of (current) frequent developments of toxic blooms • Synthesis on nutrient pollution (source, river discharge, pollution at sea)	• Predicted evolution of nutrient pollution (incl. predicted evolution of physical and chemical composition of seawater)	• Sources of nutrient pollution at sea • Areas of (current) frequent developments of toxic blooms
Nature			
Nature Conservation facing climate change	• Map of current Marine Protected Areas • Which MPAs are currently impacted by climate change? Map of habitat change caused by CC in MPAs since the MPA was installed	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats) • In the current MPAs, which will no longer be relevant for the ecological component they protect due to climate change? (study based on CC hotspots, species' habitats and CC-driven changes)	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats) • Which areas are ecologically important? Maps of total ecological value and ecosystem services • Future MPAs currently under planning
Ecosystems weakened by climate change	• How are current ecosystems and habitats impacted by CC? Synthetic map of changes compared to the ecosystems • Map of current habitats • Synthetic map of current biodiversity • Synthetic maps on dead zones: current dead zones, dead zones by the end of the 20th century	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats)	
Sustainability of ecosystem services	• Map of current value of marine and coastal ecosystem services	• Where are ecosystem services threatened? Map of estimated losses due to decrease in functional ecosystem services • Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats)	• Which areas will face the biggest changes? Map of predicted CC hotspots and refugia (based on predicted changes to habitats)
Safeguarding and enhancing nature-based carbon capture (Blue Carbon)	• Locations with high carbon capture rates		• Blue Carbon storage capacity
Socio-economic			
Coastal and maritime tourism at risk: sea level rise, coastal erosion and storms, alteration of coastal landscapes, decline of beaches, decrease in destination appeal, relocation in new areas, …	• Synthesis on Tourism (gross added value, number of visits, number of hotel bookings…) • Current threats to tourism: Frequency of extreme weather events, municipalities under high risk of coastal erosion... • Local coastal protection measures	• What are the impacts of more regular extreme weather events and shift in average meteo-marine conditions on infrastructures? • Threatened areas in X years: Predicted areas under the sea level, areas under high risk of coastal erosion in X years... • Estimated value of threatened infrastructures and housing • Cost of replenishing beaches	• Can strategic relocation be implemented? Infrastructures and housing that can be relocated (e.g. harbours need to be close to the sea anyway)
Adaptation of coastal protection strategies and schemes to minimise climate change impacts (vulnerability to extreme weather events, in terms of extreme wave heights, storms and storm surges)	• Local coastal protection measures	• Estimated value of threatened infrastructures and housing	• Map of coastal protection measures by nature

Key issues	Baseline	Scenarios	Levers
	• Municipalities under high risk of coastal erosion	• Potential abandonment of settlement areas • Threatened areas in X years: Predicted areas under the sea level, areas under high risk of coastal erosion in X years...	

Annex 2: Climate change parameters and data

Sea basin parameters and data

Parameters	Existing map	Data	Availability of data	Gaps in data	Feasibility in project
General					
Synthetic map of intensity of meteo-marine evolution	e.g. Map of seawater temperature change between 1950 and 2000	Main physical and chemical data: Temperature (sea/air), salinity, acidification, precipitations, sea level. (30 years ago, and current)			Feasible
Where will CC have the most impact? Synthetic map of predicted changes to meteo-marine state in 50 years	Maybe in IPCC's reports?	Current state (seawater and air temperature, salinity, pH, precipitations, sea level) and predicted evolution			Not feasible if a map doesn't exist yet
Sensitivity to maritime spatial plans zoning (MSP areas based on EMODNet model i.e. Allowed, Restricted, Potential etc…) to climate change		Sensitivity to climate change is defined by 2 issues: - sensitivity of planned activities to CC - plans with the flexibility to allow for relocation of activities if necessary before the next MSP cycle Data needed: - MSP output data (maritime spatial plans) categorized by type			Feasible but might be time-consuming (depending on countries)
Where is climate change causing risks at the moment? Map of current safety risks (sea ice, high traffic, frequent storms)	Maybe in IPCC's reports?				Not feasible in detail if a map doesn't exist yet
Map of predicted safety risks (increased storminess, increased drifting sea ice due to fragmented coastal ice, new Arctic routes with high traffic...)	Maybe in IPCC's reports?				Not feasible if a map doesn't exist
Potential geological carbon storage areas and depleted deposits available		List of depleted deposits List of carbon storage areas			Feasible
Nature					
MPAs: level of impact by climate change already observed		List of MPAs Map of climate change effects (see Synthetic map of intensity of meteo-marine evolution)			Feasible if data/maps available

MPAs under threat: how predicted changes in habitat and species distribution affect their objectives		List of MPAs categorized by regulations (flexible or not) Climate change hotspots and refugia			Feasible if data/maps available
Predicted CC cold and hotspots and refugia	Study from project MSPACE	- Datasets of predicted CC cold spots, hotspots and refugia			Definitely not feasible if the maps from MSPACE are not sufficient
Observed changes in habitats and species distribution		- Habitat maps from 30 years ago and current - Species distribution maps from 30 years ago and current - Dead zones and total loss of biodiversity	Probably not available		Probably feasible if all data is available
Predicted changes in habitat and species distribution					
Threats on ecosystem services		Spatial distribution of ecosystem services, if possible represented by their cost "Map of predicted CC cold- and hotspots and refugia"			Probably feasible if all data is available
Locations with high carbon capture rates					
Blue Carbon storage capacity		Spatial distribution of kelp forests, and other Blue Carbon ecosystems			Feasible?
Socio-economic					
Are there already (small-scale) changes in fish distributions observed?		Fish species spatial distribution 30 years ago and current			Feasible
How will fish distribution change due to CC?	Map of predicted fish distribution	Fish species spatial distribution current and predicted (species of $ interest)			Feasible if the data exists Might be estimated based on seawater temperature otherwise???
Synthetic map of predicted changes to meteo-marine state in 50 years (for safety of navigation and fishing activity)					
Future situation of current MRE farms (threatened by storms, loss of wind power...)		Wind predicted in x years due to CC vs. Current maps of wind potential Current and planned OWFs Maps of storminess?			Feasible if the data exists
Evolution of potential for MRE development (comparing models to current situation)	Models of wind vs. CC	Wind predicted in x years due to CC vs. Current maps of wind potential			Feasible if the data exists
Opportunities and threats for maritime routes		- Maritime traffic and routes (incl. TSS?) - ???			
Predicted changes in routes (e.g. Northern Sea Routes; map)		Predicted changes in routes	Not sure		

Coastal parameters and data

Parameters	Existing map	Data	Availability of data	Gaps in data	Feasibility
General					

Which areas and infra-structures are currently affected or threatened by physical landscape evolutions and risks such as coastal erosion and evolution or floods?	Maps of coastal erosion risk Maps of risks	Infrastructures, incl. houses and cities Coastal erosion risks Risks of flooding, sea-level rise, etc.	Probably available at national level?		Feasible
Frequency and intensity of extreme weather events		Predicted storminess?			Depends on data availability and res-olution
What are the impacts of more regular extreme weather events and shift in average meteo-marine conditions on in-frastructures?		Infrastructures, incl. houses and cities Predicted storminess?			Feasible?
Threatened areas in X years: Predicted areas under the sea level, ar-eas under high risk of coastal erosion in X years	Maps of Predicted ar-eas under the sea level Maps of coastal erosion risk	Estimated sea level rise Coastal Topography			Feasible
Estimated value of threatened infrastruc-tures and housing		Map of threatened in-frastructures Mean value of infra-structure? (e.g. from of-ficial statistics?)	Mean value proba-bly not easily found		Difficult
Can strategic relocation be implemented? Infra-structures and housing that can be relocated (e.g. harbors need to be close to the sea any-way)		All coastal Infrastruc-tures, incl. houses and cities (examining case by case?)			Very difficult
Predicted areas more favorable to toxic blooms					
Nature					
MPAs: level of impact by climate change al-ready observed		List of MPAs Map of climate change effects (see Synthetic map of intensity of me-teo-marine evolution)			Feasible if data/maps availa-ble
MPAs under threat: how predicted changes in habitat and species distribution affect their objectives		List of MPAs catego-rized by regulations (flexible or not) Climate change hotspots and refugia			Feasible if data/maps availa-ble
Predicted CC cold and hotspots and refugia	Study from project MSPACE	- Datasets of predicted CC cold spots, hotspots and refugia			Definitely not feasi-ble if the maps from MSPACE are not sufficient
Observed changes in habitats and species dis-tribution		- Habitat maps from 30 years ago and current - Species distribution maps from 30 years ago and current - Dead zones and total loss of biodiversity	Probably not availa-ble		
Predicted changes in habitat and species dis-tribution					

Threats on ecosystem services		Spatial distribution of ecosystem services, if possible represented by their cost "Map of predicted CC cold- and hotspots and refugia"			Probably feasible if all data is available
Blue Carbon storage capacity		Spatial distribution of kelp forests, and other Blue Carbon ecosystems			Feasible?
Socio-economic					
Current threats to tourism: Frequency of extreme weather events, municipalities under high risk of coastal erosion...		Revenue from tourism by municipality Predicted storminess Risk of erosion Risk of flooding Cost of e.g. replenishing beaches, maintenance of infrastructure			Feasible
Threatened areas in X years: Predicted areas under the sea level, areas under high risk of coastal erosion in X years... and related value of tourism activity (gross added value, number of visits, number of hotel bookings…)		Map of "Threatened areas in X years: Predicted areas under the sea level, areas under high risk of coastal erosion in X years" (see above) Tourism revenue per municipality			Feasible
Estimated value of threatened tourism infrastructures and housing		Map of threatened infrastructures and housing (see above) List of touristic infrastructures Mean value of infrastructure? (e.g. from official statistics?)			Difficult and/or time consuming
Can strategic relocation be implemented? Potential for Tourism infrastructures and housing relocation (e.g. harbors need to be close to the sea anyway)		Professional coastal Infrastructures, incl. houses and cities (examining case by case?)			Very difficult
Municipalities under high risk of coastal erosion and submersion	Map of areas under high risk of coastal erosion	Municipalities Areas under high risk of erosion			Feasible
Threatened areas in X years: Predicted areas under the sea level, areas under high risk of coastal erosion in X years... and associated value of threatened infrastructures and housing		Map of "Threatened areas…" (see above) Infrastructures and housing Mean value of infrastructure			Feasible but time-consuming
Relocation potential		Infrastructures and housing in threatened areas			Difficult
Coastal protection and their cost today		Areas with coastal protection measures Mean cost of coastal protection types			Feasible but time-consuming

Annex 3: information coming from main references

Selection made: green for issues, blue for parameters

The selection of issues is made according to what is related to spatialized information related to climate change.

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3.1 MSP-GREEN project

The MSP-GREEN project runs from 2022 to 2024 and contributes to align maritime spatial plans to the ambition of the European Green Deal (EGD) by creating a framework for plans as enablers of the marine components of the EGD. The framework will provide a cross-cutting approach to the EGD key topics relevant for the marine environment and sustainable transition of the blue economy: climate change, circular blue economy, marine biodiversity, marine renewable energies, and sustainable food provision.

Recommendations on how to strengthen the EGD ambition of EU MSP plans will be prepared. The sea basins' dimension will be promoted by considering environmental, socio-economic, and cultural specificities also, via dedicated Ocean Literacy driven communication.

The project considers five sea basins: the Mediterranean Sea, the Black Sea, the Atlantic Ocean, the North Sea and the Baltic Sea. Full Partners are CORILA (project coordinator), CEREMA, UBO, IEO(CSIC), MoEPRD, FI RCSW, CCMS. Affiliated Entities are IUAV, CNR-ISMAR, IFREMER. Associated Partners are: VASAB, BSH.

In the framework of MSP-GREEN Work Package 2, partners assessed whether and how their national MSP plans have considered the EGD objectives and identified which are the major gaps, the challenges encountered, and the trade-offs accepted in mainstreaming EGD into MSP.

Summary of issues concerning climate change:

Climate change mitigation

- All assessed plans include elements on climate change mitigation mainly approached from the perspective of the energy transition at sea
- Approaches to offshore renewables development vary between plans (spatial provisions/energy production targets/other)
- Focus mainly on offshore wind energy.
- Other renewable sources of energy (wave, solar, current, tide) are poorly considered and mainly from a research and innovation perspective
- Governance: offshore energy production is often outside of the regulatory scope of MSP
- "New" space users: lack of available space, confrontation with "traditional" sea users
- New fuels/energy transition in the maritime sectors and ports
- Blue carbon and the role of ecosystems in climate change mitigation generally not addressed

Climate change adaptation

- Included in all analysed plans but often indirectly (e.g. MPAs indirectly help with CC adaptation)
- When directly tackled, mostly addressing physical landscape evolutions and risks such as coastal erosion and evolution or floods
- Some plans refer to NBS and marine green infrastructures (SP, FR, IT)
- Other CCA elements are *ad hoc* and very specific

  - Adaptation of the fisheries sector

  - Development of toxic micro-algae, bacteria, and viruses

  - Unplanned areas with no strategic objectives identified, leaving flexibility for future changes in activities (FI)

List of parameters identified in existing plans

Climate change mitigation

- Link with energy policy: anticipation of how much space will be needed to reach future targets? At sea, but also in coastal areas (e.g. ORE landing areas), ports …
- … and impact of future CCM measures on other sectors: e.g. fisheries, but also shipping
- Multi-use real options (beyond silver bullet narratives)
- Impact of biophysical changes on CCM sectors: for ORE, new wind regime and impact on areas wind potential, impacts of more regular extreme weather events on CCM infrastructures (e.g. floating…) …
- Fuel transition in shipping, e.g. wind: New routes? New infrastructures in ports? Back to a need for oceanographic data (wind, currents…)
- Energy transition at large: more short sea shipping/cabotage, new routes to plan?
- "Blue carbon": knowledge gaps + socio-economic data (employment, market value…)
- In one plan (IT), CCS, geological perspective, need for detailed identification of exhausted hydrocarbon deposits which can potentially be used for this scope

Climate change adaptation

- NBS: identification, spatialisation, analysis of vulnerability and stressors (including anthropogenic)
- Effects of biophysical changes on sectors

- E.g. fisheries: anticipation in shifts in fish geographic distribution: adapt targeted species and fishing techniques, longer routes? + socio-economic: , employment, professional retraining, vulnerability/dependence of a given territory including the whole transformation chain (see future FI FS T3.2)

- E.g. shipping: new routes due to physical changes ?

- E.g. coastal and maritime tourism: relocation in new areas?

- Conservation: MPAs connectiveness, location, species to be protected …
- Anticipating coastal erosion and risks, work with new sectors such as insurances?

- Land sea interaction, e.g. shifts in delta rivers?
- Relevant circular eco measures, e.g. increase in sediment transport patterns and beach nourishment (coastal erosion)
- Safety at sea related issues?
- Not all will be affected/capable of adapting equally: relevance of socio-economic data, incl. spatial one, in coastal areas at risk

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3.2 e-MSPNBSR

The aim of the eMSP NBSR project (2021-2024) is to enable Maritime Spatial Planners of managing authorities and policymakers from the North and Baltic Sea Regions to reflect on current MSP practices, to learn effectively from each other, and to collectively identify problems and solutions. This will provide new knowledge and information to national governments and the European Commission on implementation, development and research actions, and managerial approaches that can or should be taken to deal with future challenges and opportunities afforded by the sea in a coherent way and with involvement of industry, academia and non-governmental organisations.

Partners: Netherlands Enterprise Agency (RVO), Ministry of Agriculture, Nature and Food Quality of the Netherlands (MINLNV), Ministry of Infrastructure and Water Management of the Netherlands (MIN IenW), Federal Maritime and Hydrographic Agency of Germany (BSH), Gdynia Maritime University, Poland (GMU), Danish Maritime Authority (DMA), Regional Council of Southwest Finland (FI RCSW), Government of Àland (FI GA), Swedish Agency for Marine and Water Management (SwAM), French Naval Hydrographic and Oceanographic Service (SHOM), De Blauwe Cluster, Belgium (BC), The Baltic Marine Environment Protection Commission (HELCOM), VASAB Secretariat, Nordregio, Finnish Environment Institute (SYKE).

It summarised recommendations for climate smart MSP in a policy brief delivered in early 2024.

Message to policy makers: political support for climate-smart and resilient MSP

- Set targets and tasks for all sectors of administration (“climatesmart ocean governance”).
- Establish national and sea basin level fora for maritime sectors, scientists, and MSP and maritime management authorities for understanding climate change impacts and actions.
- Make the necessary legal or policy decisions to steer MSP systems towards climate resilience.
- Provide clear policy targets for offshore renewable energy and emission reduction.
- Strengthen cross-border and sea basin collaboration in planning to enhance climate mitigation and adaptation efforts. Coordinate actions across borders, including the land-sea divide.
- Increase and target financing for multidisciplinary, climate-related marine research.

Messages for planners: MSP system to support resilience

- Enhance climate resilience in MSP
  - Take a holistic approach that combines mitigation and adaptation efforts to enhance resilience.
  - Be aware of both climate-risks and broader system resilience.
- Strengthen the ecosystem approach, because it is the cornerstone for climate-smart MSP!
  - Enhance mutual learning of different aspects of climate change and resilience, aim for a climate-smart narrative.

- Strengthen anticipatory and adaptive capacity
  - Develop adaptiveness of planning in terms of planning evidence as well as in terms of planning solutions.
  - Strengthen MSP systems' capacity to anticipate and adapt to future changes, not only to minimise the damages.
  - Strengthen practices and inclusiveness of stakeholder engagement also from climate change perspectives (Climate and Blue Justice).
- Minimise impacts on marine ecosystems
  - Include climate refugia for the fauna and flora into plans.
  - Support nature conservation through planning, because enhanced ecosystem services support adaptation and resilience.
- Minimise impacts on human sectors and settlements
  - Enhance coastal protection in planning solutions (nature-based and artificial solutions to prevent erosion and to protect coastal settlements). (P)
  - Minimise CC impacts to sectors in planning solutions (e.g. shipping safety and dock height vis-à-vis storms).
  - Include climate change into MSP scenarios: impacts, threats and new economic potential.
- Increase production of offshore renewable energy
  - Plan go-to areas, but avoid valuable habitats and MPAs as well as adverse effects on other users of the sea.
  - Reserve areas for researching and piloting different types of offshore renewable energy solutions.
- Reduce carbon footprint of maritime sectors
  - Assess climate impacts of the planning designations.
  - Include carbon footprint as an element in Strategic Environmental Assessment (SEA).
  - Enhance multi-use of sea areas, including the carbon footprint as a design criteria.
  - Favour low carbon or carbon neutral activities in MSP.
- Increase carbon capture and storage at sea
  - Plan areas for technical carbon capture solutions. (P)
  - Safeguard and enhance nature-based carbon capture through planning solutions (Blue Carbon) (P)

Messages for the knowledge providers: knowledge needs and data practices

- Ecosystem-based studies to balance climate mitigation actions with marine ecosystems and social justice (system resilience).
- Assess climate impacts cumulatively in relation to other human pressures, e.g. eutrophication and fishing.
- Include climate consideration into Monitoring & Evaluation.
- Research on social-ecological marine systems in the changing climate.
- Enhance data sharing processes nationally and internationally: format, storage, display, diffusion, standardization and harmonization
- Invest in cross-border and sea basin communication and collaboration in analysis and data practices
- Improve spatial presentation and visualization of CC impacts.
- Increase knowledge on physical-chemical changes at sea: warming, acidification, sea level, sediment drift, salinity.
- Increase knowledge on vulnerabilities of habitats and species.

- Model geographical changes in species distributions, identify corridors important for ecological connectivity.
- Study (spatially) climate change hot spots, bright spots and nature refuge areas, including social and economic perspectives.
- Study how climate risks affect sectors and different groups of people (climate risk = hazards + exposure + vulnerability).
- Down-scale global climate models to planning area level.
- Present climate change scenarios and pathways in short/mid-term (decadal scale) vs. long-term ("end of century" scenarios).
- Assess and inventory renewable energy resources and energy potential (wind, wave, currents).
- Quantify greenhouse gas emissions of sea activities and of alternative planning decisions, also at the sea basin level.
- Compare carbon footprint of sea-based activities to their landbased counterparts.
- Research conditions for and potential of multi-use also from climate mitigation perspective.
- Research the potential of natural carbon capture (seaweed, etc.), including the climate mitigation potential of protection and restoration of habitats.

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3.3 Quante & Colijn, North Sea Region Climate Change Assessment. 2016 (book).

… For moderate climate change, anthropogenic drivers such as changes in land use, agricultural practice, river flow management or pollutant emissions are often more important for impacts on ecosystems than climate change….

Recent climate change:

Atmosphere:

Temperature has increased everywhere in the North Sea region, especially in spring and in the north. Due to the lower heat capacity of land, land temperatures rise much faster than sea temperatures. The imbalance between the two is now nearly half a degree. Linear trends in the annual mean land temperature anomalies are about 0.17 °C per decade (for the period 1950– 2010) and about 0.39 °C per decade (for the period 1980–2010). Generally, more warm and fewer cold extremes are observed. There are indications that the persistence (duration) of circulation types has increased, with the consequence that 'atmospheric blocking' has become more frequent, thus contributing to the observation that extremes have become 'more extreme'. It is unclear how this is related to the decline in Arctic sea ice. An observed north-eastward shift in storm tracks agrees with projections from climate models forced by increased greenhouse gas concentrations. This is a new phenomenon that has not been observed before. While the number of deep cyclones (but not the number of all cyclones) has increased, whether storminess as a whole has increased cannot be determined: although reanalyses show an increase in storminess over time, observations do not. Variability from decade to decade is large, and clear trends cannot be identified. Furthermore, reanalyses can suffer from homogeneity issues and observations from errors made during digitization, emphasising the need for a manual quality check for the latter. Overall, precipitation has increased in the northern North Sea region and decreased in the south, summers have become warmer and drier and winters have become wetter. Heavy precipitation events have become more extreme.

North Sea:

There is strong evidence of surface warming in the North Sea especially since the 1980s. Warming is greatest in the south-east exceeding 1 °C since the end of the 19th century. Absolute mean sea level in the North Sea rose by about 1.6 mm/year over the past 100–120 years, comparable with the global rise. Extreme levels rose primarily because of this rise in mean sea level. The North Sea is a sink for atmospheric carbon dioxide (CO_2); uptake declined over the last decade owing to lower pH and higher temperatures. Short-term variations in all variables (including sea-surface temperature and sea level) exceed climate-related changes over the past two centuries. This is especially true for salinity, currents (varying with tides, winds, and seasonal density), waves, storm surges and suspended particulate matter (varying with currents, river inputs and seasonal stratification). Coastal erosion is extensive but irregular and some coastlines are accreting. Evidence for a link to climate change has not yet been established.

River flows:

Rivers draining into the North Sea show considerable interannual and decadal variability in annual discharge. In northern areas this is closely associated with variation in the North Atlantic Oscillation, particularly in winter. Discharge to the North Sea in winter appears to be increasing, but there is little evidence of a widespread trend in summer inflow. Higher winter temperatures appear to have led to higher winter flows, as winter precipitation increasingly falls as rain rather than snow. To date, no significant trends in response to climate change are apparent for most of the individual rivers discharging into the North Sea.

Future climate change

Atmosphere:

A marked mean warming of 1.7–3.2 °C is projected for the end of the 21st century (2071– 2100, with respect to 1971–2000) for different scenarios (RCP4.5 and RCP8.5, respectively), with stronger warming in winter than in summer and relatively strong warming over southern Norway. The overall warming is accompanied by intensified extremes related to daily maximum temperature and reduced extremes related to daily minimum temperature, both in terms of strength and frequency. Simulations project marked future changes in some aspects of the large-scale circulation over the Atlantic-European region, of which the North Sea region is part. Changes in the storm track with increased cyclone density over western Europe in winter and reduced cyclone density on the southern flank of the storm track over western Europe in summer are projected to occur towards the end of the 21st century. A general tendency for more frequent strong westerly winds and for less frequent easterly winds in the central North Sea as well as in the German Bight in the course of the 21st century was projected using SRES A1B and SRES B1 scenarios. Projections suggest an increase in mean precipitation during the cold season and a reduction during the warm season for the period 2071–2100 relative to 1971–2000, as well as a pronounced increase in the intensity of heavy daily precipitation events, particularly in winter and a considerable increase in the intensity of extreme hourly precipitation in summer.

North Sea:

Consistent results are found for projections regarding a warming of the surface water to the end of the century (about 1–3 °C; A1B scenario). Exact numbers are not given due to differences in spatial averaging and reference periods from published studies. Coherent findings from published climate change impact studies include an overall rise in sea level, an increase in ocean acidification and a decrease in primary production. Larger uncertainties exist for projected changes in salinity, mostly a freshening was reported, but contrasting signals were also projected. Uncertainties for projected changes in extreme sea level and waves are large. Model studies reveal large uncertainties in future changes in net primary production with decreases ranging from 1 to 36 % (and not statistically significant across all parts of the North Sea region). Substantial natural variability in the North Sea region from annual to multi-decadal time scales is a particular challenge for isolating and projecting regional climate change impacts. Separating natural variations and regional climate change impacts is a remaining task for the North Sea.

River flows and urban drainage:

Increased hydrological risks due to more intense hydrological extremes in the North Sea region such as flooding along rivers, droughts and water scarcity, are projected by climate models and are of socio-economic importance for the region. Risk is particularly enhanced in winter due to increases in the volume and intensity of precipitation. Models project that peak flow in many rivers may be up to 30 % higher by 2100, and in some rivers even higher. The impacts projected lead both to opportunities and challenges in water management, agricultural practices, biodiversity and aquatic ecosystems. The exposure and vulnerability of cities in the North Sea region to changes in extreme hydrometeorological and hydrological conditions are expected to increase due to greater urban land take, rising urban population growth, a concentration of population in cities and an aging population. Business-as-usual approaches are no longer feasible for these cities.

Impacts of Recent and Future Climate Change on Ecosystems

Marine ecosystems:

The marine ecosystem of the North Sea is highly productive, intensively exploited and well-studied. The changing North Sea environment is affecting biological processes and organisation at all scales, including the physiology, reproduction, growth, survival, behaviour and transport of individuals. The distribution, dynamics and evolution of populations and trophic structure are also affected. Long-term knowledge and exploitation of the North Sea indicates that climate affects marine biota in complex ways. Climate change influences the distribution of all taxa, but other factors (fishing, biological interactions) are also important. The distribution and abundance of many species have changed. Warmer water species have become more abundant and species richness (biodiversity) has increased. This will have consequences for sustainable levels of harvesting and other ecosystem services in the future.

Coastal ecosystems:

Accelerated sea-level rise, changes in the wave climate and storms may result in a narrowing of dunes and salt marshes where they cannot spread inland, particularly in the case of a narrow and steep foreshore. The relative importance of accelerated sea-level rise, changes in the wave climate, storms, and local sediment availability and their interactions are poorly understood. Human impacts on geomorphology and sediment transport interact with the potential impacts of climate change. Estuaries and most mainland marshes will survive sea-level rise. Back-barrier salt marshes with lower suspended sediment concentrations and tidal ranges may be more vulnerable. Depressions away from salt-marsh edges and creeks on back-barrier marshes may be at particular risk. Plant and animal communities can suffer habitat loss in dunes and salt marshes through high wave energy. Natural succession, and management practices such as grazing and mowing have a strong impact. Minor storm floodings in spring negatively affect breeding birds. Invasive species may change competitive interactions. Plant and animal communities are affected by changes in temperature and precipitation and by atmospheric deposition of nitrogen. Their interactions result in faster growth of competitive species. Increased plant production may cause losses of slow-growing and low-statured plant species.

Climate Change Impacts on Socio-economic Sectors

Fisheries:

North Sea fisheries may be impacted by climate change in various ways. Consequences of rapid temperature rise are already being felt in terms of shifts in species distribution and variability in stock recruitment. Although an expanding body of research exists on this topic, there are still many knowledge gaps, especially with regard to understanding how fishing fleets themselves might be impacted by underlying biological changes and what this might mean for regional economies. It is clear that fish communities and the fisheries that target them will almost certainly be very different in 50 or 100 years from now and that management and governance will need to adapt accordingly.

Offshore activities/energy:

There is no doubt that energy systems and offshore activities in the North Sea region will be impacted by climate change. While most studies suggest an increase in hydropower potential, climate projections are highly uncertain regarding how much the future potential of other renewable energy sources such as wind, solar, terrestrial biomass, or emerging technologies like wave, tidal or marine biomass could be affected, positively or negatively. Both offshore and onshore activities in the North Sea region (of which offshore wind, oil and gas dominate) are highly vulnerable to extreme weather events, in terms of extreme wave heights, storms and storm surges.

Recreation:

Sea-level rise, coastal erosion and storms can destroy coastal infrastructure and alter coastal landscapes. Rebuild costs and a decline in tourism revenue can have significant economic impacts. Nevertheless, tourism in the North Sea area is expected to profit from rising temperatures, lower summer precipitation and a longer season. Destination attractiveness is largely determined by thermal environmental assets. However, landscape changes, natural and man-made, such as reduced beach width and higher sea walls, may decrease destination appeal. Tourists are unlikely to change travel behaviour. Coping with climate change and its effects will require changes in government policy and innovative approaches from tourism suppliers. Investment cycles should be made on a long-term basis.

Coastal protection:

All countries around the North Sea with coastal areas vulnerable to flooding due to storm surges are ready to take up the challenges expected to occur as a consequence of climate change. Scenarios of accelerating sea-level rise leading to sea levels by 2100 of up to 1 m or more above present day, in some countries accompanied by increased storm surge set-up and wave energy, have been used as a basis for evaluation and planning of the adaptation of coastal protection strategies and schemes. Coastal protection strategies differ widely from country to country, not only in terms of distinct geographical boundary conditions but also in terms of the length of planning periods, the amount of regulations and budgeting. All countries, except Denmark and the UK, which allow coastal retreat at some stretches of their coasts, aim at keeping the current protection line in place to protect the hinterland. Combatting coastal erosion by nourishments is currently the most effective solution used for sandy coastlines and will continue to be a major tool for balancing climate change impacts in these environments.

Coastal management and governance:

Broadly shared assessments of the urgency of adaptation are hampered by the difficulty of identifying the climate-driven component of observed change in the coastal zone. Due to uncertainty about the extent and timing of climate-driven impacts, current adaptation plans focus on no-regret measures. The most considered no-regret measures in the North Sea countries are spatial planning in the coastal zone (set-back lines), coastal nourishment, reinforcement of existing protection structures and wetland restoration including managed realignment schemes. In Germany, the Netherlands and Belgium coastal adaptation is steered by national and regional programmes and plans. The UK and the Scandinavian countries pursue active public involvement by transferring adaptation responsibilities to private stakeholders and partnerships.

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3.4 NORSAIC Webinar on Climate change parameters

From challenges to data, final board

Land-sea interactions	Conditions	Waves and surges (high frequency sea elevation variations)			
		Coastal line (past, present, forecast)			
		Erosion rate			
		River discharge (run-off and loads	Nutrients discharge (from agriculture, wastewater treatment plants, industry and so on)		
		Land use infrastructure for energy grids etc.			
	Resources	Coastal structures	Build	Value of threatened infrastructures and housing	
			Natural	Ecosystem structure, ecosystem-engineer species	MSFD descriptors assessment
	Local knowledge				
International cooperation to reach a common goal	How much marine limits are sensitive to climate change?				
	Assess cumulative impact of human activities and relate to goals				
	Climate change scenarios				

	Common goals (balance goals nature-nergy-food?)				
Anticipate shifts in maritime activities location/spatial distribution	Common goals (balance goals nature-nergy-food?)				
	Index of vulnerability to climate change				
	Temperature changes have to be monitored since they impact fish and aquaculture	Shift on species distribution			
	List of possible adaptations for each activity				
	Climate change scenarios				
	Productivity (food provision)				
	Socio-economic drivers of activities	Social behaviour of stakeholders			
Ensure maritime activities will not create excessive cumulative pressures on marine ecosystems weakened by climate change	Monitoring datasets	MSFD descriptors assessments			
	Biodiversity				
	Assess cumulative impact of human activities and relate to goals				
	carrying capacity				
	Data and info on possible deadzones				
	Data on the threshold of pressures and ecosystems				
	Common goals (balance goals nature-nergy-food?)				
	Migration dead ends	Shift on species distribution			

	for negative cumulative impacts, suitable tools and methods exist today to visualise and evaluate environmental impacts. for the evaluation and budgeting of possible positive impacts, the tools available are little known or unknown				
Identify variables of interest, trends and projections. Necessity of a tool to test scenarios like digital twin of the Ocean	Physcal ecosystems	Physics (bathymetry, water temperature), Chemistry (salinity, O2, carbon, nitrate), Oceanography (currents, wave highs)			
	Biological Ecosystems (=species and habitats)	Protected Species (mammals, turtles, birds) Fishing Resources Habitats Less considered (not less Important) compartments : phytoplancton, zooplancton			
	Ecosytem services				
	Human ecosystems (= activities)	Social perception of climate change			
		Activities pressures	Global human settlement (JRC). Coastal cities exposure, cost of damages		

	Rainsing awareness information				
	Interaction between each specify variables :Ecological niches (physics on biology), Impacts (humans on Biology), Activities niches (biological on humans), and on themselves (ex : trophic network in biological ecosystems, interactions between activities)				

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3.5 Baltic Sea Climate Change Fact Sheet (eMSP-NBSR project)

78 authors, no maps except map about Climate future of the Baltic Sea giving for each of 6 bioregional zones a synthesis of expected changes for the most relevant parameters.

The following items document each parameter: description, what is already happening, what can be expected, knowledge gaps, policy relevance. Plus mention of the linked parameters and main policies.

Direct parameters

Air temperature

Water temperature

Large scale atmospheric circulation

Sea ice

Solar radiation

Salinity and saltwater inflows

Stratification

Precipitation

River run-off

Carbonate chemistry

Riverine nutrient loads and atmospheric deposition

Sea level

Wind

Waves

Sediment transportation

Indirect parameters: Ecosystem

Oxygen

Microbial community and processes

Benthic habitats

Coastal and migratory fish

Pelagic and demersal fish

Waterbirds

Marine mammals

Non-indigenous species

Marine protected areas

Nutrient concentrations and eutrophication

Ecosystem function

Indirect parameters: Human use

Offshore wind farms

Coastal protection

Shipping

Tourism

Fisheries

Aquaculture

Blue Carbon storage capacity

Marine and coastal ecosystem services

Annex 4: webinar agenda and participants

Interreg North Sea

Co-funded by the European Union

Norsaic

Date: 25.01.24
Time: 13.00-15.30 CET

Online-Link:

Click here to join the meeting

AGENDA

	Climate change parameters in MSP
1.	Welcome and Introduction
2.	Climate change in MSP: what is at stake?
a.	Brief input from MSP GREEN (10 min)
b.	Brief input from eMSP (10 min)
c.	Discussion about challenges from the perspective of MSP (30 min) (https://app.klaxoon.com/participate/board/MDRCTHW)
	Coffee break (10 min)
3.	Climate change in MSP: data and information needed
a.	Brief input from Mercator Ocean (10 min)
b.	Discussion about data needed for MSP (30 min) (https://app.klaxoon.com/participate/board/MDRCTHW)
4.	Existing projects and references (10 min)
5.	Conclusion and next steps (10 min)

25 participants, coming from nearly all North Sea countries:

Country	**Organisation**
Belgium	Provincie West-Vlaanderen; Flanders research institute for agriculture, fisheries and food
Denmark	Aalborg University Copenhagen
Finland	SYKE
France	Cerema; Shom; Mercator Océan
Germany	BSH ; University of Oldenburg
Sweden	Swedish Agency for Marine and Water Management
The Netherlands	Ministry of Infrastructure and Water Management; BUAS; DELTARES

Annex 5: Description of methods used

Annex 5.1 Fish distribution shift

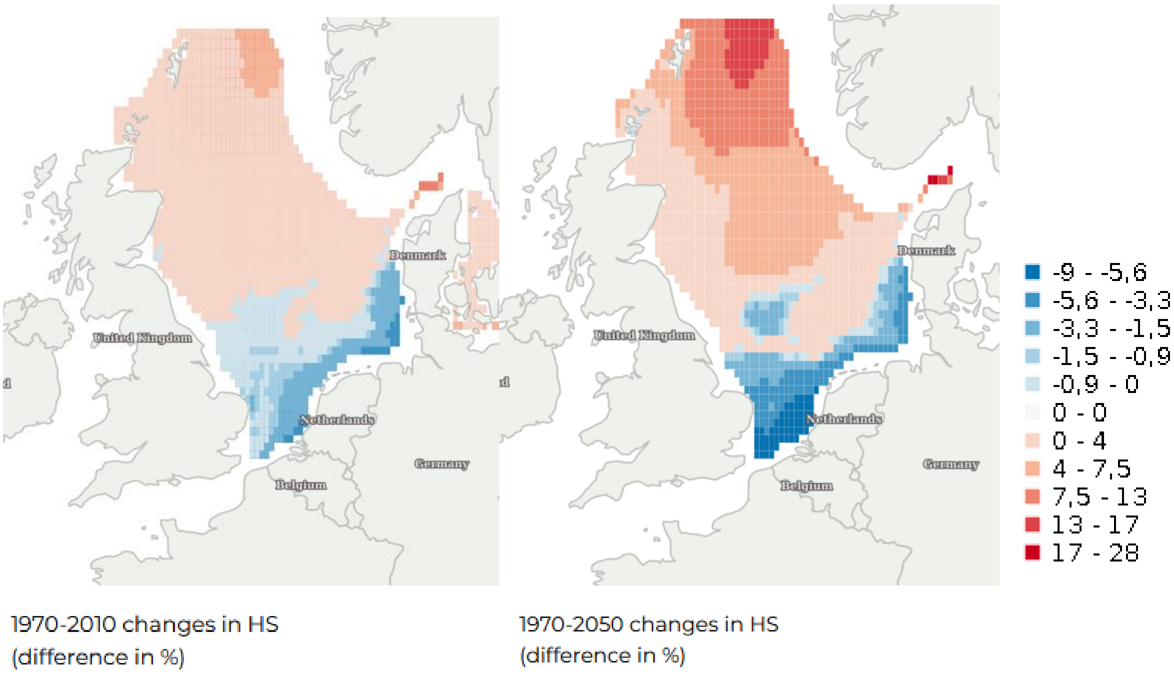


Figure 3b: The map shows changes in habitat suitability (given in %) for Cod from 1970 to 2050 (observed / estimated using a species distribution model (TIMoFiD) within the scope of the project CoastalFutures) [15]

The map shows habitat suitability (given in %) and biomass (given in tons) of commercial fish species in the North Sea and Baltic Sea. For the North Sea, habitat suitability is shown for the 1970s and as a change in response to climate change across decades from 1970 to 2050. For the Baltic Sea, habitat suitability is shown for the 1990s and as a change in response to climate change across decades from 1990 to 2050. Habitat suitability was estimated using a species distribution model (TIMoFiD) within the scope of the project CoastalFutures, founded by German Ministry of Education and Research (grant No: 03F0911F). The model used fish abundance and environmental data collected during the ICES-coordinated International Bottom Trawl Survey over 51 years. Temperature data used for model fitting were retrieved from AHOI, whereas those used for projections were retrieved from HANSOM, for the North Sea, and MOM, for the Baltic Sea (both under the climate scenario RCP8.5). Biomass was mapped according to habitat suitability as redistribution of three scenarios of total biomass. Those scenarios were retrieved from ICES Stock Assessment Database.

[15] https://atlas.thuenen.de/catalogue/#/map/286

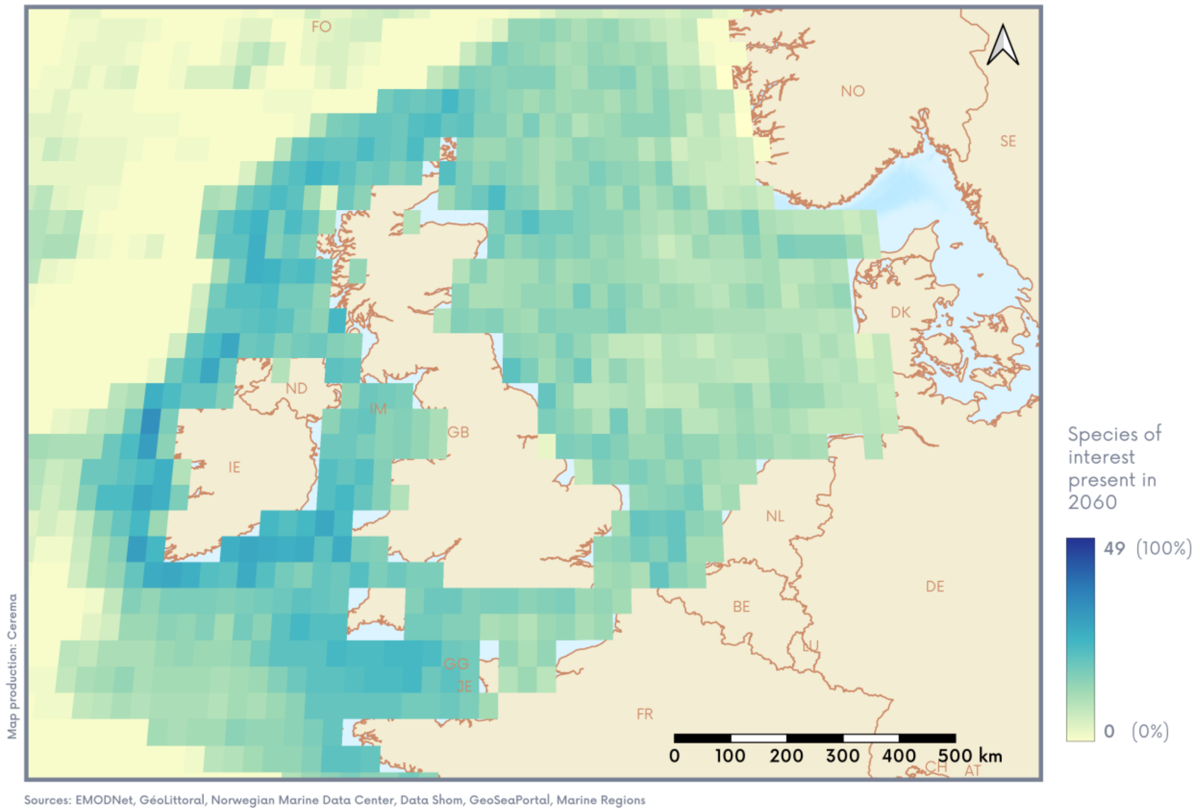


Figure 5: Modelled presence of commercial fish species in 2060.

Source: EMODnet.

In Figure 5, the probability of presence of 49 commercial fish species in 2060 is displayed.

The data is derived from the works of Townhill, Couce et al., 2023. In the 2023 study, the outputs of 5 different Environmental Niche Models were computed for 49 fish species of commercial interest, projecting the environmental conditions in 2060 based on three different climate change scenarios (i.e. carbon emission scenarios). For each species, a suitability value between 0 and 1 was produced combining the 5 outputs:

- Closer to 1 meant that more models agree that the area will be suitable for the studied species
- Closer to 0 meant that more models agree that the area will not be suitable for the studied species.

In this map, the data was combined to show how many different species are likely to be found in each cell in 2060:

- The AB1 scenario was kept (it showed the mildest effects)
- Each species with a suitability over 0,8 was considered likely to be found in the area. Conversely, each species with a suitability below 0,8 was considered unlikely to be found in the area.

- In each cell, the number of species likely to be found was counted.

Annex 5.2 Blue Carbon Storage Capacity

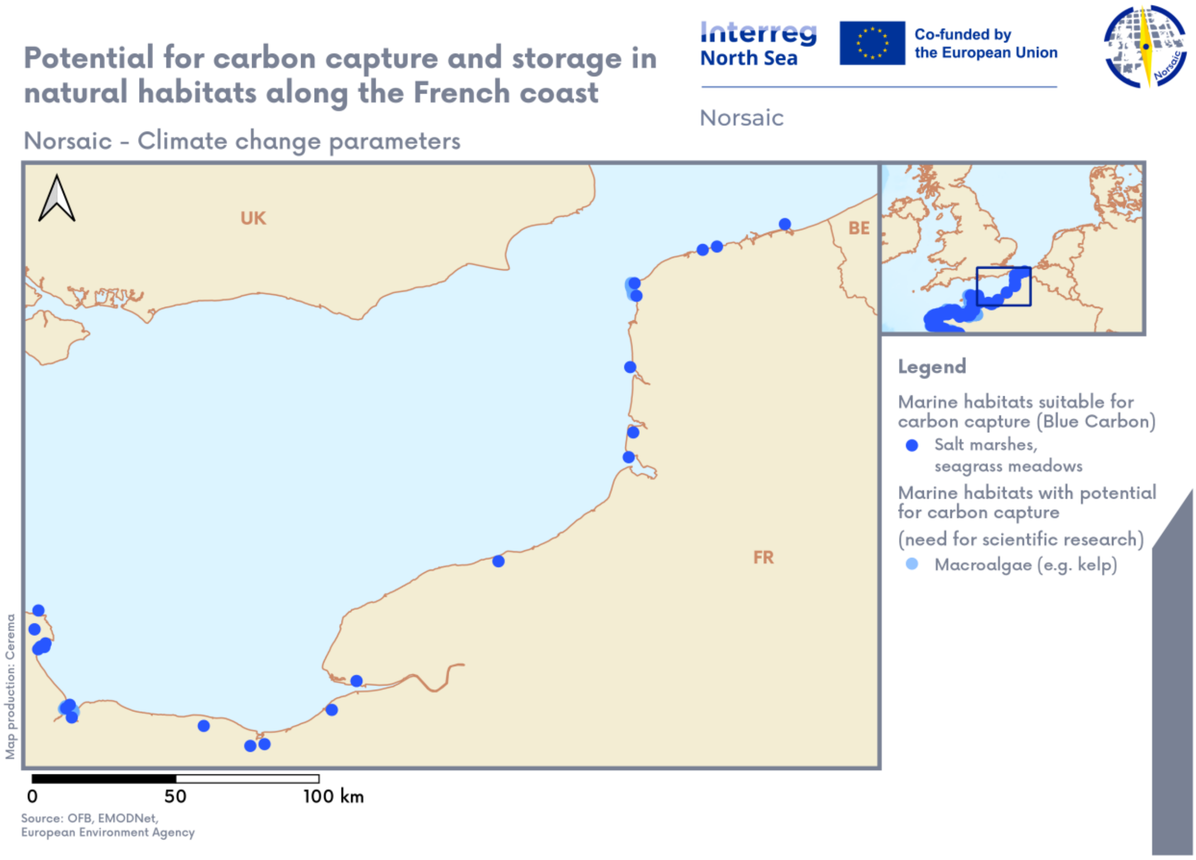


Figure 10: Ecosystems and potential ecosystems along the French coast and in the French North Sea and Channel suitable for carbon storage and natural carbon absorption (Blue Carbon)

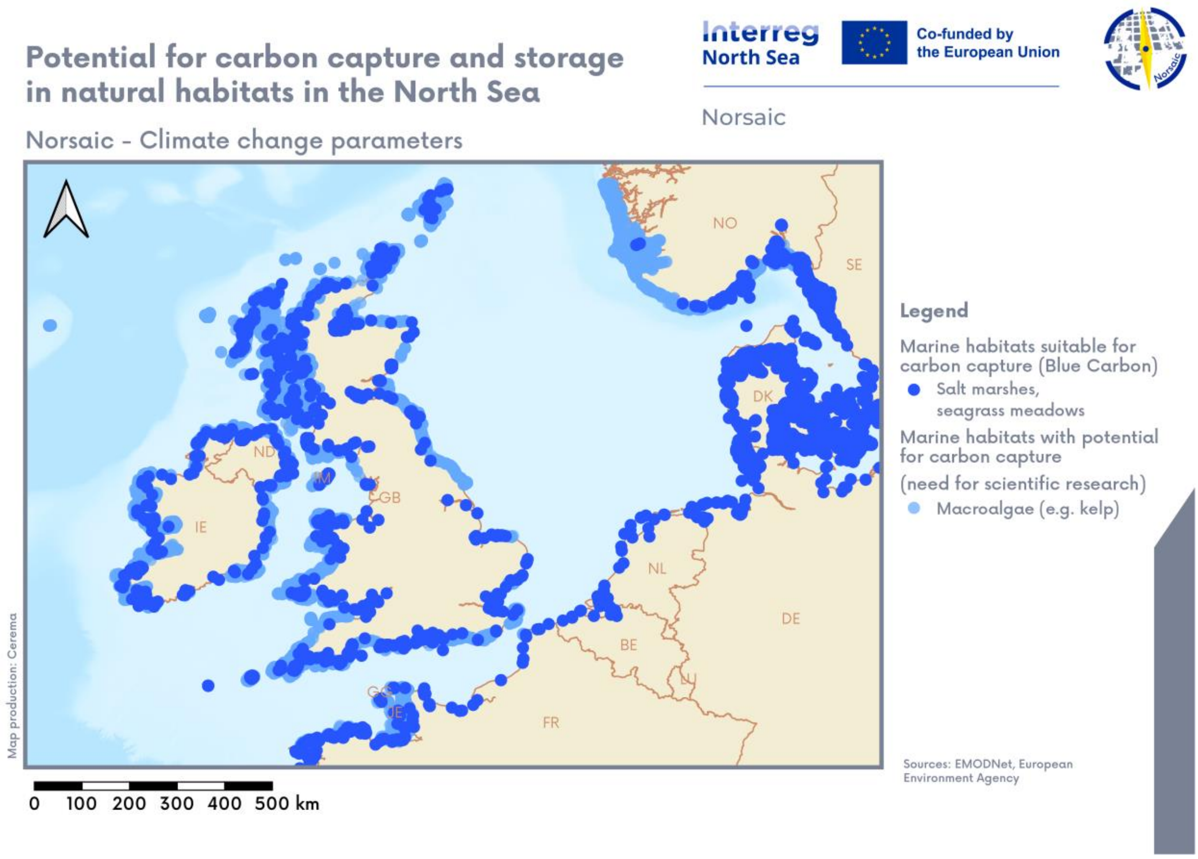


Figure 11: Identified coastal and marine ecosystems in the North Sea, the Channel, the Celtic Seas and the Danish Straits suitable for, or with potential for, carbon storage and natural carbon absorption (Blue Carbon).

The figures above represent maps of ecosystems with confirmed or suspected potential for carbon capture, along the French coasts and in the Greater North Sea basin. As appears on the maps, there is a great number of sites suitable for carbon storage. Initiatives exist at several scales to restore or protect carbon-storing habitats in order to enhance their potential, such as the Blue Carbon Initiative, co-organized by the Intergovernmental Oceanographic Commission (IOC, a branch of Unesco), Conservation International (CI) and the International Union for Conservation of Nature (IUCN). In the North Sea, the Netherlands have initiated a tentative assessment of Blue Carbon-related projects in 2015, but no projects fully related to enhancement of Blue Carbon were found. However, the assessment found several environmental projects regarding restoration of confirmed or suspected Blue Carbon habitats.

More recently, Germany funded the CARBOSTORE research program (https://www.carbostore.de/index.php.en) on this topic. This research project concluded that while estuaries are a source of greenhouse gases, coastal ecosystems like seagrass and saltmarshes more than compensated for these emissions, and absorbed large quantities of CO_2 (Rosentreter et al., 2023). Scientific studies on the topic, particularly in the United Kingdom, agree on an estimated absorption of a few hundred tons of CO_2 equivalent per square kilometer per year for both seagrass meadows and saltmarshes, with saltmarshes being slightly more efficient. Estimated values across the considered studies range from 42 to 370 tCO_2e/km^2/year for seagrass, and from 235 to 804 tCO_2e/km^2/year for saltmarshes (Norris et al., 2021, Burrows et al., 2024).Variations exist between estimates, in particular with regard to seagrass meadows. This can be explained by the different species of seagrass (*Posidonia oceanica, Zostera noltii, Zostera marina*) and their different rates of CO_2 capture and storage.

In the last 10 years, the United Kingdom conducted a full assessment of Blue Carbon potential within its EEZ. British waters contain vast areas of BC habitats, with estimates ranging between 440 and 470 km^2 of saltmarshes, and 70 to 90 km^2 of seagrass meadows, distributed between the North Sea, Celtic Sea, Irish Sea and UK's overseas territories (Norris et al., 2021, Burrows et al., 2024). These estimates must be taken with caution: while it is easy to identify saltmarshes (they are accessible, well-documented and are easily identified through remote sensing), seagrass meadows (and potential other Blue Carbon habitats like kelp beds) are more difficult to map. For example, the extent of seagrass meadows and kelp beds is well known in certain high-priority areas of the United Kingdom, but most of the EEZ can only be mapped through the use of suitability models (Burrows et al., 2024). In total, it is estimated that these saltmarshes and seagrass beds store 271,000 tC/yr (Burrows et al., 2024).

From these studies, it appears Blue Carbon offers important opportunities to compensate global carbon emissions and achieve net-zero emissions though its rapid carbon capture rates (yearly capture rates per hectare by Blue Carbon habitats are higher than terrestrial forests), and the long-term carbon storage it ensures (millenia, compared to centuries for terrestrial forests). Furthermore, beyond their participation to carbon capture and storage, Blue Carbon habitats tend to have various other benefits for human societies such as coastal protection or biodiversity increase (Norris et al., 2021).

The recommendations issued after these studies in the UK include funding of further research on the potential for coastal and marine habitats to absorb and store carbon, increasing the protection of BC habitats, and a better inclusion of the effects of Blue Carbon habitats on carbon capture and storage into national greenhouse gas management plans.

Indeed, Blue Carbon habitats need to be protected. Recognized Blue Carbon habitats (saltmarshes, mangroves and seagrass meadows) are coastal and therefore submitted to high amounts of human-induced pressures, since coastal waters concentrate a lot of human activities. Furthermore, while thriving Blue Carbon habitats capture and store large amounts of CO_2, the destruction of these Blue Carbon habitats could cause the massive release of all the previously stored CO_2. For instance, the Norris report mentions an estimated 1-2% loss of tidal marshes worldwide every year, causing the emission of 0.02 to 0,24 billion tonnes of previously stored CO_2 per year (Norris et al., 2021). Threats to Blue Carbon habitats include climate change and associated impacts, fishing. Potential threats also include aggregate extraction, offshore renewable energy installations and anchoring and mooring (Burrows et al., 2024).

The UK assessment also shows that there is potential in the UK EEZ for restoring damaged or degraded Blue Carbon habitats in order to improve carbon capture and storage: discrepancies have been observed between the predicted extent of seagrass (and kelp, a potential Blue Carbon habitat) in areas where data is available, and the quite smaller observed extent in such areas. This discrepancy would be indicative of an extensive loss of Blue Carbon habitats. Using these suitability models, it is estimated that 200 km^2 to 820 km^2 of seagrass meadows could be restored in the British waters. (Burrows et al., 2024)

Annex 5.3: Sensitivity of maritime spatial plans to climate change

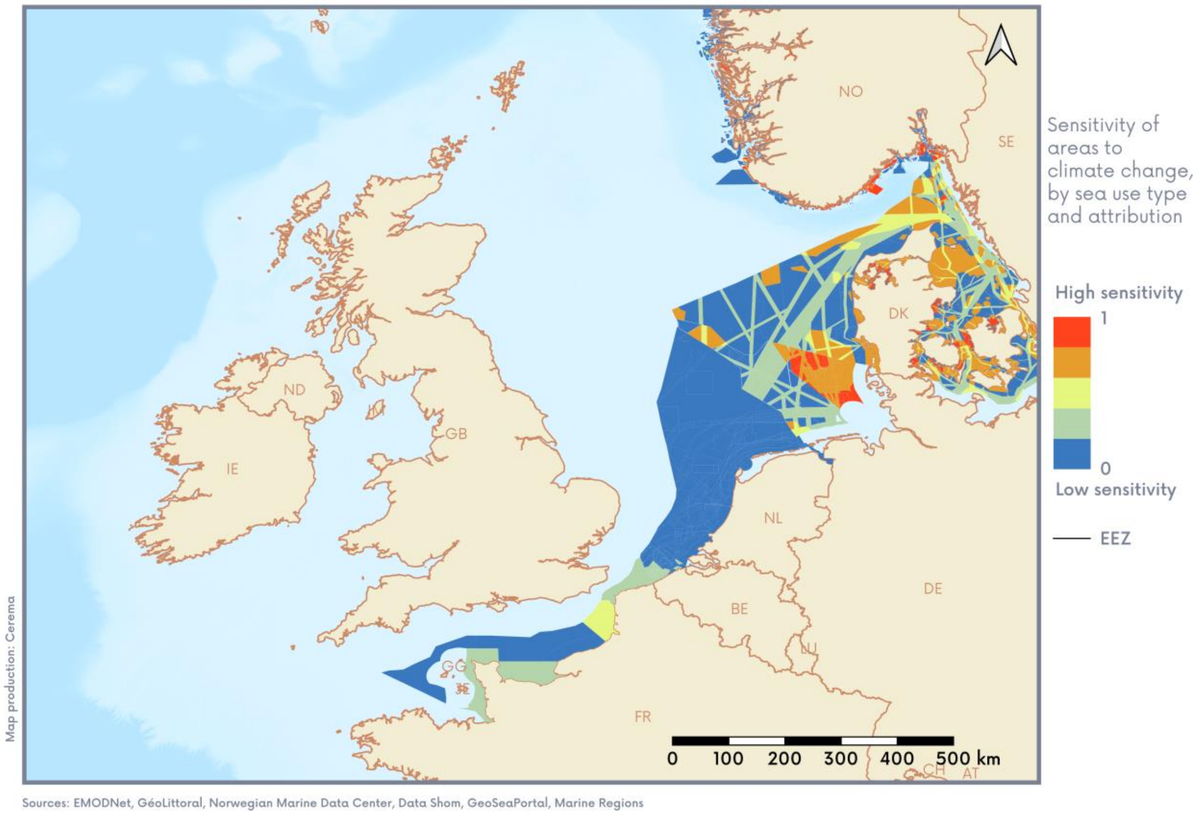


Figure 11: sensitivity of the maritime spatial plans to climate change.

Rule (based on EMODnet model):

A sea use: **A**

Sensitivity of a sea use: $\boldsymbol{\sigma_A}$ on a range of 0 to 1

The sensitivity **s(U,A)** of sea use functions **U** for a sea use **A** will follow a pattern specific to **A** (see table below). It is also on a range of 0 to 1

We evaluate the sensitivity **S(M)** of the zoning to climate change in a particular place **M** as the weighted (by the sensitivity of sea uses) average of sensitivity of sea use functions given to the sea uses.

$$S(M) = (\sum_A s(U_M,A)*\sigma_A)/ \sum_A \sigma_A$$

Sea use function sensitivity

Simplified function giving the sensitivity of a sea use function for a sea use, considering only if the sea use is fixed or mobile.

- Fixed:

reserved 1

priority 0,7

potential 0,3

allowed 0

restricted 0

forbidden 0

“Reserved” and “priority” are the most important options, so they are the most sensitive. Nevertheless “priority” means it is not the only option of the plan, so the risk is less important.

“Potential” is a decision even weaker and more adaptable, nevertheless we can consider it is not neutral as a sea use designated “potential” could constrain decisions about other uses.

“Allowed” is neutral. As sea use function it remains open, so it is adaptable.

“Restricted” and “forbidden”

<u>- Mobile:</u>

reserved 1

priority 0,3

potential 0

allowed 0

restricted 0

forbidden 0

Globally the sensitivity to climate change of a Sea Use Function given to mobile activities could be considered as null for itself but will constrain other activities, limiting their possibilities to adapt spatially if it is reserved or priority. We keep 1 for “reserved” and lower at 0,3 for “priority”.

A **Sea use**	σ_A	**s(U,A)** **Reserved**	**s(U,A)** **Priority**	**s(U,A)** **Potential**	**s(U,A)** **Allowed**	**s(U,A)** **Restricted**	**s(U,A)** **Forbidden**
Aquaculture	1	1	0,7	0,3	0	0	0
Fisheries	1	1	0,3	0	0	0	0
Ports	0,5	1	0,7	0,3	0	0	0
Energy	0	1	0,7	0,3	0	0	0
Windfarms	0	1	0,7	0,3	0	0	0
Maritime traffic	0,5	1	0,3	0	0	0	0

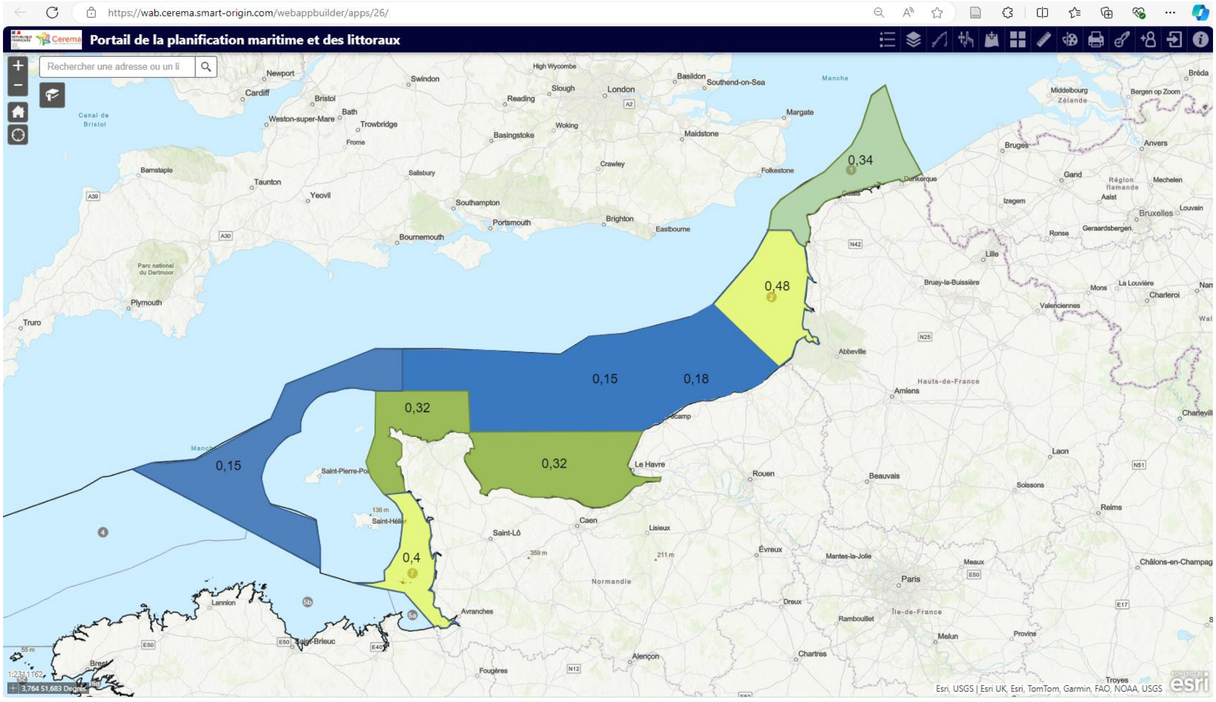
Military	0	1	0,7	0,3	0	0	0
Nature protection	1	1	0,7	0,3	0	0	0
Raw material extraction	0	1	0,7	0,3	0	0	0
Oil and gas	0	1	0,7	0,3	0	0	0
Scientific research	0	1	0,3	0	0	0	0
Cables	0	1	0,7	0,3	0	0	0
Pipelines	0	1	0,7	0,3	0	0	0
Tourism and recreation	1	1	0,7	0,3	0	0	0
Cultural heritage	0	1	0,7	0,3	0	0	0
Disposal areas	0	1	0,7	0,3	0	0	0
Others	0						

(in this table we simplified by considering that sea uses are sensible or not to climate change -except ports and transport rated 0,5- and by giving two patterns of sensitivity of sea use function depending on the character mobile or fixed of the sea use: explanations about the two patterns are given in annex below)

Example:

French East Channel and North Sea strategy 2019:

Colors: blue (0-0,20), green (0,20-0,40), yellow (0,40-0,60), orange (0,60-0,80), red (0,80-1)


https://wab.cerema.smart-origin.com/webappbuilder/apps/26/
Portail de la planification maritime et des littoraux
0,34
0,48
0,15
0,18
0,32
0,32
0,15
0,4