GES4SEAS POLICY BRIEF #2

BRINGING CLIMATE CHANGE INTO THE MARINE STRATEGY FRAMEWORK DIRECTIVE (MSFD) REVISION

How can this Policy Brief support you?

This document is intended for the European Commissions's (EC), Joint Research Centre (JRC), European Environment Agency (EEA), Member States, and Regional Seas Conventions experts and policymakers discussing the revision of the MSFD, and any successive developments in the EU Marine Strategy, to include climate change (CC) into the good environmental status (GES) assessment, based upon the findings of GES4SEAS project and experience.

Key Messages

The EC acknowledges that CC is not explicitly included in the MSFD.

We propose considering a CC index in Descriptor 7 (Alteration of hydrological conditions), to determine the vulnerability of European seas to CC, and include some indicators/criteria in Descriptors 1, 2, 3, 4, 5 and 6, to assess the effects of CC on features (sensu MSFD) and ecosystem components. This follows the 2014 revision of the Environmental Impact Assessment (EIA) directive in which CC was included.

Modelling should be considered in building scenarios for CC and cumulative effects of multiple pressures, which can feed into calculating indicators/criteria for MSFD descriptors and assessment tools, such as that developed in GES4SEAS (e.g., Tikta). To date, CC has been included in the MSFD (Art. 14) as force majeure, i.e. causes of change outside local management. It is recommended that the Programmes of Measures (PoM) to attain GES should tackle the consequences of the suite of pressures included in CC, even if not including tackling its causes.

Narrative of the problem, with GES4SEAS examples

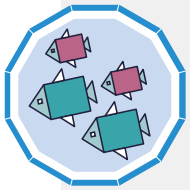
Currently, the MSFD focuses on human activities and pressures, when assessing GES. However, **despite the increasing impact of CC on marine ecosystems, this stressor is not explicitly considered in the monitoring and assessment under the MSFD.** Hence, **in GES4SEAS**, a Horizon Europe project dealing with the cumulative effects of multiple human pressures on marine ecosystem components **we emphasise that CC should be included as an important stressor when assessing GES and designing PoM.**

GES4SEAS has developed models exploring the consequences of CC, the implementation of Marine Protected Areas (MPAs), restoration activities for habitat forming species, together with fisheries management for biodiversity, ecosystem function and service provision, investigating cumulative impacts, such as those from offshore wind farms, fishing or maritime transport, including CC. **The lessons learned from these models, as well as from the research papers published, have been used in the recommendations included in this policy brief, with some examples below.**

As a result of **14 papers published by GES4SEAS, on the effects of CC** on different ecosystem components, we have seen that **marine ecosystems across European seas and beyond are increasingly threatened by CC, invasive species and human activities.**

In the **Atlantic Ocean**, in Portugal, cumulative risk assessments show that **rising sea temperatures, sea-level rise**, and anthropogenic pressures like **fishing** and **tourism** threaten coastal and marine habitats. Management strategies have a greater influence on spatial risk patterns than climate scenarios, emphasizing the **need for ecosystem-based planning.** This affects Descriptors 1, 3, 4, and 6.

In **Atlantic estuarine environments, sea-level rise will migrate seagrass (*Zostera noltii*) habitats landward**, although anthropogenic barriers may limit gains. In this context, systems-informed decision-making and scenario-based planning, as demonstrated in the North Sea, are essential for anticipating trade-offs and guiding **sustainable maritime spatial planning (MSP).** This affects Descriptors 1 and 6.



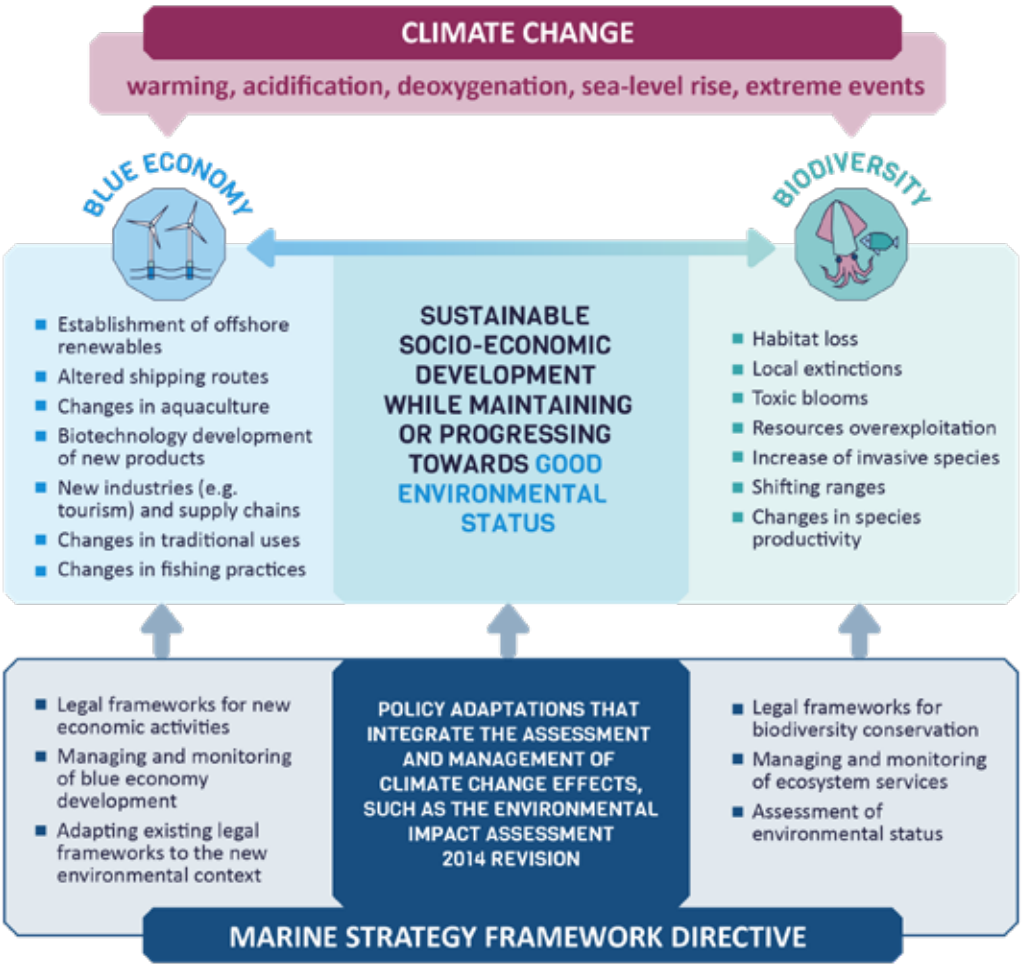
In the **Eastern Mediterranean**, **CC** and **invasive species** are **altering marine ecosystems and reducing fish catches** (although in some cases invasive species of fish and crustaceans are being used as successful fishery resources). Modelling on the continental shelf shows that business-as-usual scenarios lead to declining native species and increasing invasive biomass. However, **establishing marine reserves, improves native biomass and yields spillover benefits for nearby fisheries.** This affects Descriptors 2 and 3.

In the **Northwestern Mediterranean, ocean warming** has altered fisheries catch and revenue composition, with tropicalization and deborealization affecting species and fleets. Juvenile swordfish diets have also shifted toward cephalopods and gelatinous organisms, signalling **ecosystem changes**. Mass mortality events in the Mediterranean have reduced benthic trait diversity, especially among calcifying and slow-growing species, increasing vulnerability to ecological transformation. Marine heatwaves are projected to intensify and penetrate deep into the Mediterranean, affecting MPAs year-round. **Even adaptive baseline thresholds cannot prevent prolonged exposure, threatening biodiversity at all depths.** This affects Descriptors 1, 2, 3, 4, 5, and 6.

In the **Black Sea**, machine learning models show that **temperature** and **salinity** drive **zooplankton dynamics**, while **nutrient levels** influence **phytoplankton blooms**. Future scenarios suggest **intensified eutrophication, with implications for ecosystem health.** This affects Descriptors 5 and 7.

Globally, GES4SEAS has demonstrated that penguin populations face unevenly distributed stressors from CC, fisheries, and land-based human disturbances. Species such as the Humboldt, African, and Chinstrap penguins are under the most pressure. **Local management of anthropogenic stressors may help mitigate cumulative impacts.** This affects Descriptors 1 and 3.

On top of human pressures, all these effects from CC, detected in several ecosystem components, will influence MSFD Descriptors (1, 2, 3, 4, 5 and 6) and can threaten achieving GES. This should be considered in the PoM, including the prevention, conservation, restoration and adaptation actions, as well as in monitoring and assessment.



Socio-ecological, socio-economic and governance context of cumulative pressures and climate change effects management at sea.

Policy implications

European Directives

- Directive 2008/56/EC: contribution to the revision of the MSFD, including changes in some articles.
- Directive 2014/89/EU: contribution to the MSP framework.
- Directive 2014/52/EU: contribution to CC effects assessment before and after PoM.

Other Policy / International Objectives

- It could be of interest for Regional Seas Conventions.
- Of interest within the Biodiversity Strategy Nature Restoration Law, and MSP Directive.
- The integration of CC indicators and criteria in the MSFD would contribute to achieving United Nation Framework Convention on Climate Change objectives in supporting the assessment of CC impacts and identifying prevention and mitigation measures.

Sustainable Development Goals

Key Facts

Descriptor 7 (Alteration of hydrological conditions) can include, as one of the criteria, the European Marine Climate Change Index (EMCCI) created by the EEA that assesses the vulnerability of seas to CC. This should be considered as a multiple stressor to the system.

Descriptors 1, 2, 3, 4, 5, and 6 should include additional indicators/criteria, measuring the effects of CC on different features or ecosystem components (in mammals, fish, benthic fauna, habitats, food webs, etc.). These effects could include shifting distributions, changes in phenology, or newly introduced species due to CC.

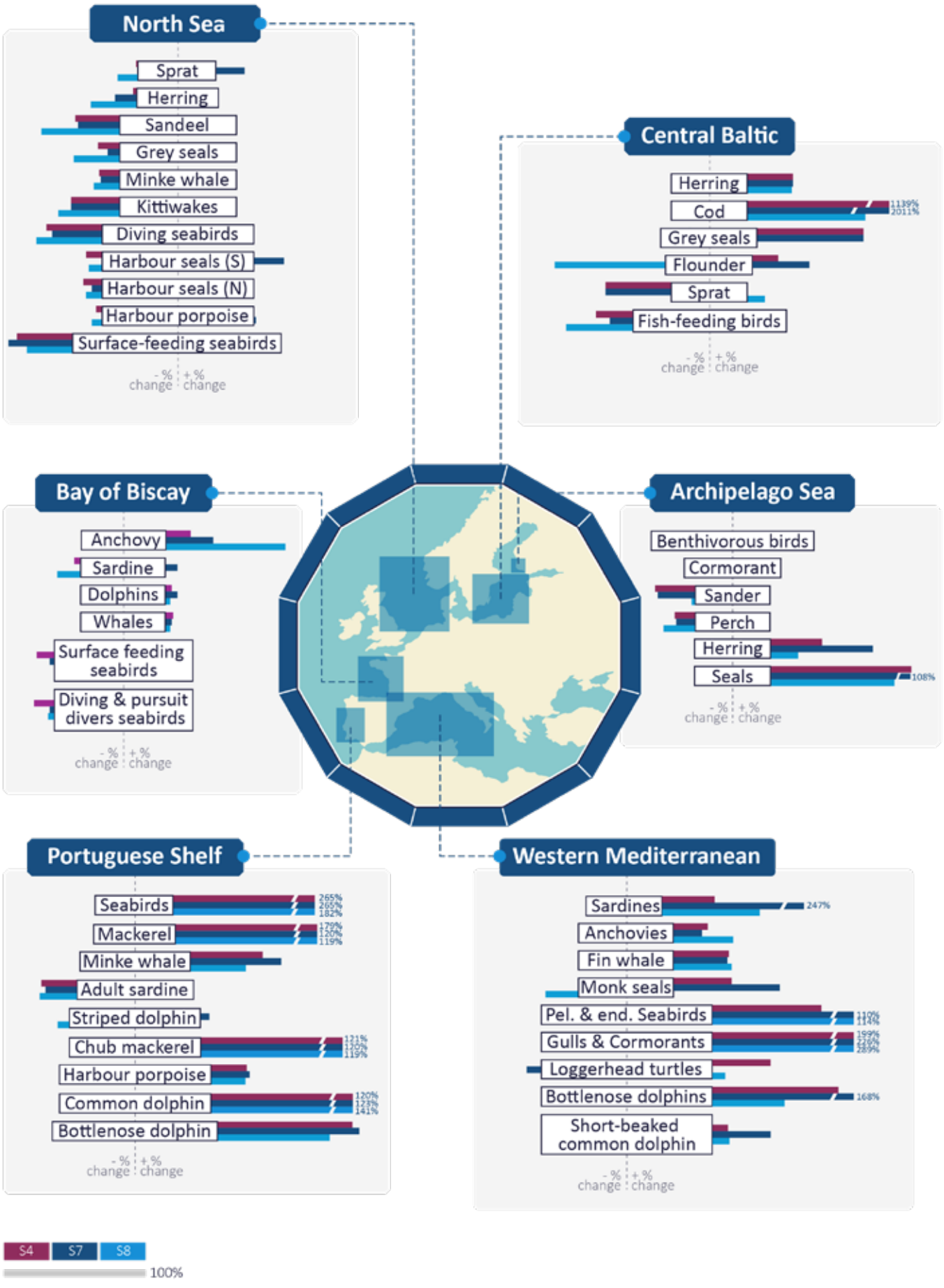
Use available tools (e.g, GES4SEAS developed tools such as Tikta or EasySat Indicators), together with others such as Ecosim with Ecopath (EwE), to analyse scenarios under CC, to assess the effects on current environmental status and future ones, and propose adaptation and mitigation management measures.

Beyond the State of Art

In GES4SEAS we have developed a range of conceptual and mechanistic modelling approaches to study marine ecosystem dynamics, CC and cumulative effects on GES. We applied EwE food-web models, across multiple regional European Seas (North Sea, Baltic Sea, Bay of Biscay, Portuguese Shelf, and the Western Mediterranean Sea), and sub-regions of these areas. We built this on previous developments within EU projects FutureMARES, DEVOTES, CERES, and CLIMFISH.

The models explore the consequences of the cumulative impacts of CC, fisheries, shipping, and wind farms, and the mitigating effects of the implementation of MPAs (as measures to assist on achieving GES), restoration activities for habitat forming species (in line with the European Nature Restoration Regulation), together with fisheries management for biodiversity, ecosystem function and service provision.

We demonstrate how these models can be used to investigate cumulative direct and indirect effects of human activities, by including offshore wind farms (both fixed and floating) into the marine environment alongside changes in maritime transport intensity and test scenarios of potential change due to management measures, under CC. These outcomes can be used in reporting under the MSFD. For doing that, these scenarios have been included in the tool developed by GES4SEAS, to enable comparisons between current and future cumulative impact scenarios.



Example of marine ecosystem modelling projections under cumulative impacts scenarios. Percentage change in biomass of selected groups between 2020s and 2090s for Scenarios 4, 7 and 8 (S4, S7, S8). S4, Status-quo with cumulative effects (RCP4.5); S7, Global Sustainability with cumulative effects (RCP4.5); S8 National Enterprise with cumulative effects (RCP8.5).

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