Interreg NEXT Black Sea Basin

Co-funded by the European Union

MARMAPS

Outputs of the Decision Support Framework for Designating Marine Protected Areas in the Black Sea

Contents

Introduction

Protecting biodiversity is crucial for preserving a healthy planet and ensuring long-term human well-being. It provides stability and resilience to ecosystems in a changing world. Biodiversity also ensures, among others, food security, raw materials, pharmaceutical substances and livelihoods for millions of people.

Although marine ecosystems cover most of the Earth's surface, they are still undervalued and poorly protected. The EU Biodiversity Strategy (2020) recognises this fact with a commitment to protect at least 30% of Europe's seas by 2030, with a minimum of 10% under strict protection in areas of high biodiversity value. Over 190 countries have endorsed the Kunming-Montreal Global Biodiversity Framework, adopted in 2022, which sets out the goal of effectively protecting and managing 30% of the world's terrestrial, inland water, and coastal and marine areas by 2030.

The MARMAPS project promotes the conservation of Black Sea ecosystems and supports regional knowledge of biodiversity conservation planning and implementation. The project aims to have a long-term impact by developing a framework for setting conservation priorities for marine protected areas (MPAs) and fostering a dialogue among stakeholders involved in MPA governance.

The Black Sea ranks third in terms of MPA coverage across EU waters after the Baltic Sea and the Mediterranean Sea. Protected EU waters in the Black Sea currently account for 14% of the total area, with Bulgaria responsible for 8% and Romania for 22% of their respective marine zones. This mainly comprises Natura 2000 sites designated under the EU Habitats and Birds Directives as well as smaller nationally designated protected areas. As of 2022, Ukraine had 9% MPA coverage and Georgia 2%, including part of the Emerald network and nationally designated nature reserves. There are no marine protected areas in the Black Sea zones of Russia and Türkiye. Most MPA coverage in the Black Sea is categorised as either minimally or lightly protected at present.

A key question is how to meet international and EU obligations to protect marine biodiversity and valuable Black Sea ecosystems. This must be balanced against the various uses of maritime space. At the same time, the limited resources available for conservation should be used effectively and efficiently to minimise further losses. The systematic conservation planning approach presented in the methodology section addresses these issues.

The decision support tool produces a set of scenarios based on a wide range of variables for pinpointing optimal locations for designating new MPAs. The tool employs an innovative three-dimensional spatial analysis to identify priority areas across depth zones. This approach enhances the protection of important species and supports the preservation of the ecological processes that are essential for healthy marine ecosystems. It also considers the impact of human presence and activities.

This report presents a full set of 60 spatial prioritisation results for the Black Sea, which are grouped into four base scenarios.

1. Current species distribution scenario: It reflects the distribution of species under the current environmental conditions. This base scenario is implemented both with and without the socioeconomic costs stemming from blue economy activities.
2. Current distribution of species under climate change scenarios: This group of scenarios examines the impact of climate change on the current and near future species distributions in the Black Sea. It takes into account three climate change scenarios, explored by the Intergovernmental Panel on Climate Change (IPCC), and known as Representative Concentration Pathways (RCPs):
    a. RCP2.6: strong mitigation, aiming to keep global warming below 2°C
    b. RCP4.5: moderate stabilization with average temperature between 2°C and 3°C above preindustrial level by the end of the century
    c. RCP8.5: high emissions, high warming
3. Future distribution of species under climate change scenarios: These scenarios explore the future distribution of marine biodiversity in the Black Sea under the climate change conditions described above in category 2.
4. Severe climate change or worst-case scenario: This scenario explores conservation priorities for the Black Sea under a severe climate change future, combining multiple climate change components to identify areas likely to remain valuable for biodiversity even under extreme warming.

Each base scenario includes variants that either do or do not take existing MPAs into account. Another dimension that can be combined with the above is species weights, which reflect conservation priorities in the Black Sea, and ensure that a greater emphasis is placed on the most vulnerable and regionally important species.

Each result is presented on two pages. These include a description of the base scenario and run variant, climate scenario and included data layers, as well as the role of existing MPAs and species weights. The description is accompanied by two maps: the first shows the selection frequency of each planning unit, while the second shows the areas of each country's exclusive economic zone identified as the highest priority for conservation, representing the top 30% and top 10% respectively.

The aim of spatial conservation planning is to explore how spatial priorities might change in the face of different climate scenarios and policy choices, and to provide decision-makers with a tool for making choices about the conservation of Black Sea biodiversity under real-life constraints.

Methodology

The Systematic Conservation Planning (SCP) framework supports systematic and scientifically informed decision-making both in the planning of actions and in the establishment of protected area (PA) networks, aiming to optimize the benefits for biodiversity while minimizing social and economic costs (Margules & Pressey, 2000; Margules & Sarkar, 2007). Moilanen et al. (2009) identify six widely used steps in the workflow:

1) Collection of biodiversity data for the study area (usually important species and habitat types)
2) Identification of conservation objectives for the study area
3) Division of the study area into Planning Units (PUs)
4) Calculating the amount of each biodiversity element found in each PU
5) Calculating the cost value of each PU
6) Using software to identify PUs that promote biodiversity conservation, reduce fragmentation and lower costs

A variety of spatial prioritization tools have been developed with a wide range of applications in ecological matters in terrestrial and aquatic ecosystems (Ribeiro & Atadeu, 2019). Software such as *Marxan, Zonation,* and *prioritizr* use algorithms to optimize the spatial distribution of PAs, taking into account ecological data and socioeconomic considerations, and allow researchers to explore different scenarios, facilitating more informed decisions in order to maximize biodiversity benefits while minimizing negative impacts on local communities and the economy (Ball et al., 2009; Hanson et al., 2025; Moilanen et al., 2009).

The aim of this spatial prioritization analysis is to identify optimal locations for the designation of new marine protected areas (MPAs) in the Black Sea. For this reason, we employed an innovative 3-step spatial analysis, moving beyond traditional 2D methodology with the aim to consider the full depth and complexity of marine ecosystems.

Data

Marine species distribution data were obtained from AquaMaps (Kaschner et al., 2019), which provides standardized range maps based on ecological niche modeling. To capture conservation priorities in the Black Sea, species were weighted according to extinction risk (IUCN categories; IUCN 2025), endemism and policy recognition (Council Directive 92/43/EEC; Important Marine Mammal Areas), ensuring higher emphasis on species of greatest vulnerability and regional importance. Human pressures were represented as cost layers and combined into a cumulative index to reflect the intensity of anthropogenic activities across the basin, based on data collected from various sources (NGA 2019; EMODnet; Global Fishing Watch). To estimate the ecological relevance of these pressures, expert-derived impact scores were analyzed, providing consensus-based weights that capture the synergies between ecosystem sensitivities and human activity.

prior3D

The *prior3D* R package employs advanced algorithms to perform nested prioritization across depth layers, selecting planning units that maximize biodiversity representation within a predefined geographic extent (Doxa et al., 2025). More specifically it begins by solving a 2D optimization problem at the lowest depth layer; the solution at each level informs the upper levels. The analysis then runs iteratively across different protection targets (10%, 20%, 30%, etc.) to generate maps that show how frequently each area is selected for protection. The more frequently a planning unit is selected, the more important it is considered.

priorCON

To enhance ecological connectivity, we employed the *priorCON* R package, which identifies clusters of features exhibiting strong ecological linkages, using graph community detection methods (Adam et al., 2024). For this study we utilized an edge list previously generated from a high-resolution sea current dataset for the Black Sea (Nagkoulis et al., 2025). Connectivity was quantified using the PageRank algorithm originally developed by Google to rank web pages (Brin & Page, 1998), which estimates the relative importance of each planning unit based on the number and quality of connections directed to it. The core assumption is that important nodes accumulate more connections and are connected to other important nodes.

prioritizr

The final prioritization analysis was conducted using the *prioritizr* R package (paired with the algorithmic solver Gurobi; Gurobi Optimization LLC), a systematic conservation planning tool which uses mixed integer linear programming (MILP) techniques to provide a flexible interface for building and solving conservation planning problems (Billionnet, 2013; Rodrigues et al., 2000). In this framework, conservation features consist of the selection frequency map produced by prior3D and the PageRank connectivity map derived from *priorCON*. The final output of the framework consists of a binary solution for each PU (1=Selected, 0=Not selected), for area targets of 10% and 30%, and a map showing the selection frequency of each PU across different targets.

Each step of the framework (*prior3D, priorCON,* and *prioritizr*) was carried out independently within the Exclusive Economic Zone (EEZ) of each Black Sea country. This approach ensured that the algorithm was constrained to allocate an equal proportion of priority areas within every national jurisdiction. By doing so, potential biases that could arise if the analysis were conducted at the basin-wide scale without jurisdictional constraints are avoided, considering the algorithm might otherwise concentrate priority areas disproportionately in certain countries while leaving others underrepresented.

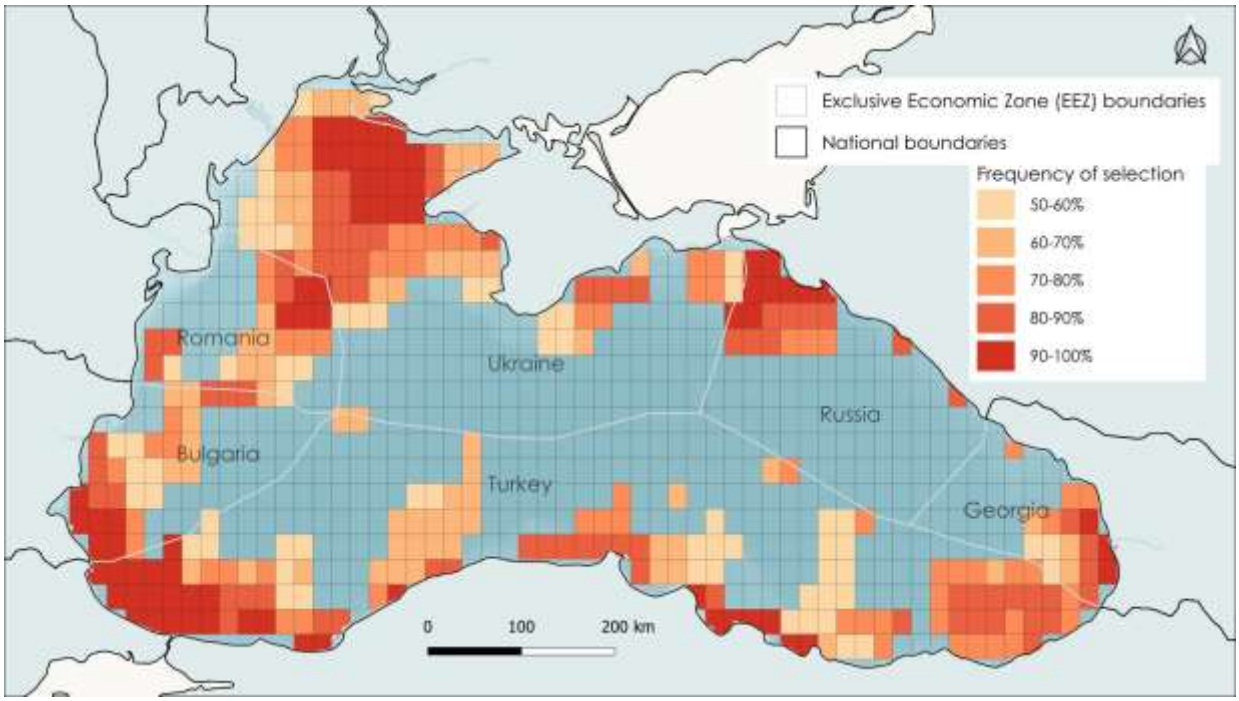
Current species distribution scenario

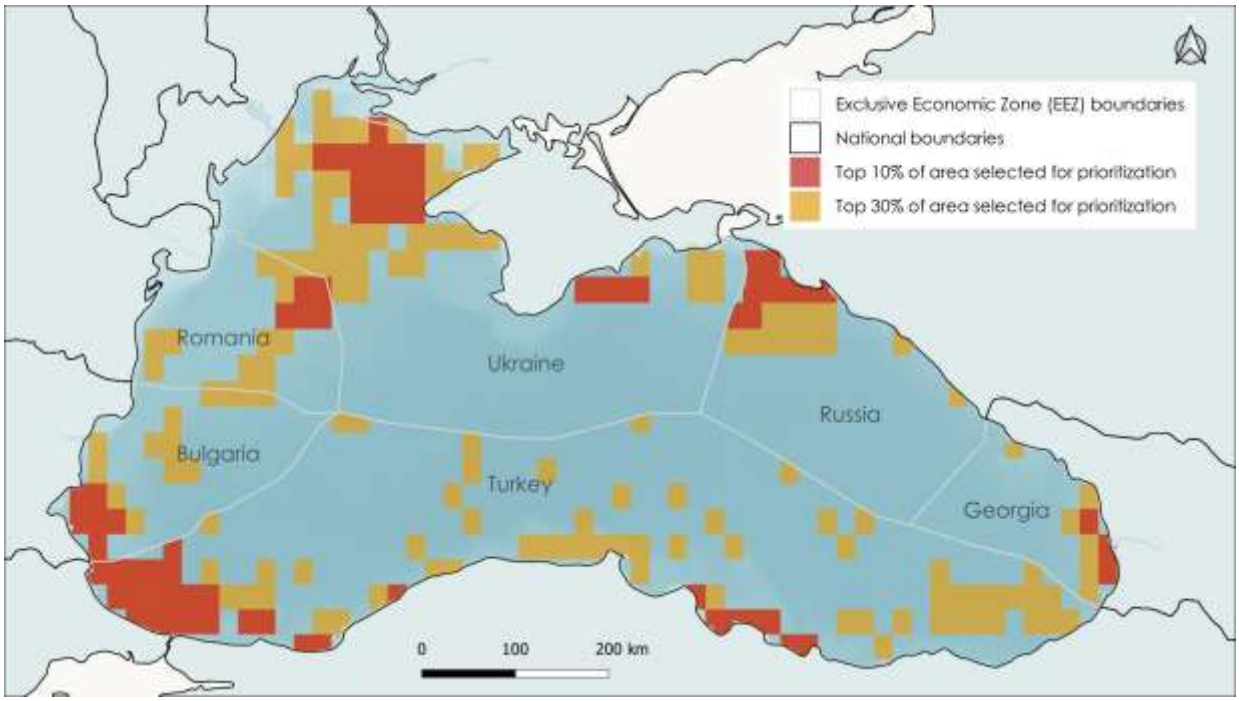
Scenario: Current
Run variant: No MPAs & species weights used

What this scenario represents
This run identifies conservation priority areas based purely on current species distributions in the Black Sea.

Data and inputs used
Current species distributions: Species distributions under current environmental conditions.
Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary
This scenario provides a reference view of current biodiversity priorities.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current*
Run variant: *No MPAs – Species weights used*

What this scenario represents

This run identifies conservation priority areas based purely on current species distributions in the Black Sea, while giving higher priority to species of greater conservation concern.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

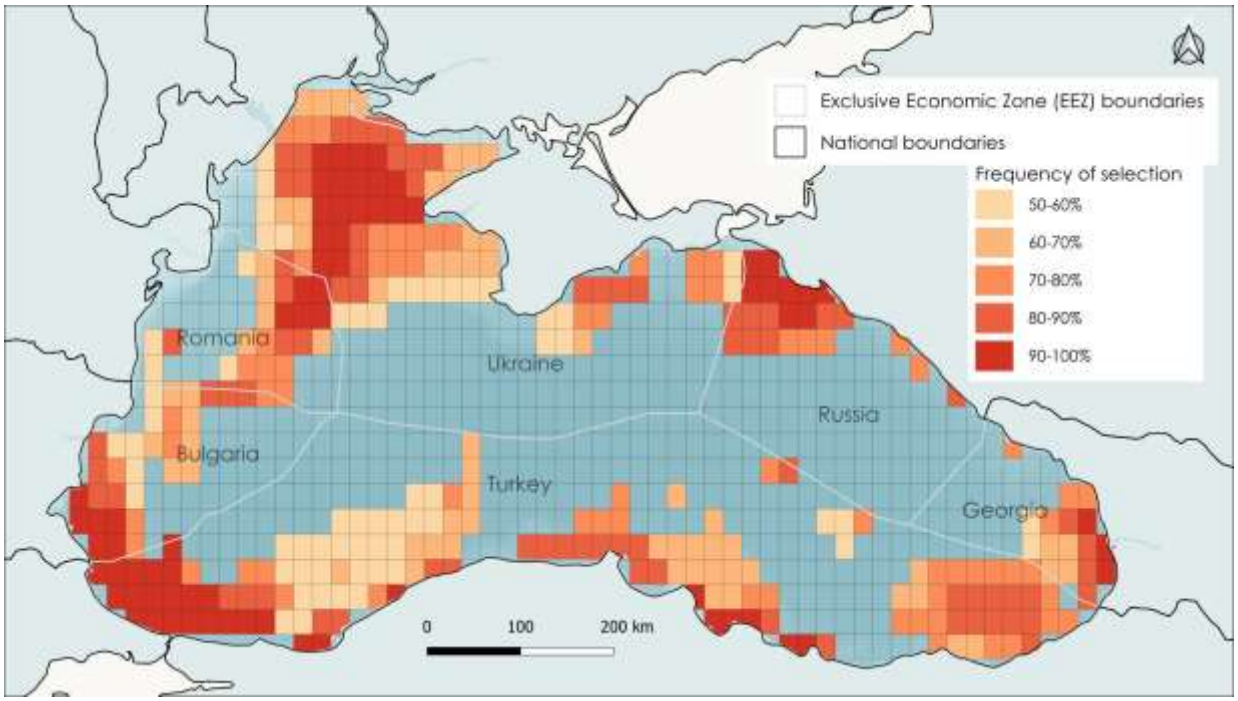
Species weights were applied to give higher conservation priority to areas supporting:

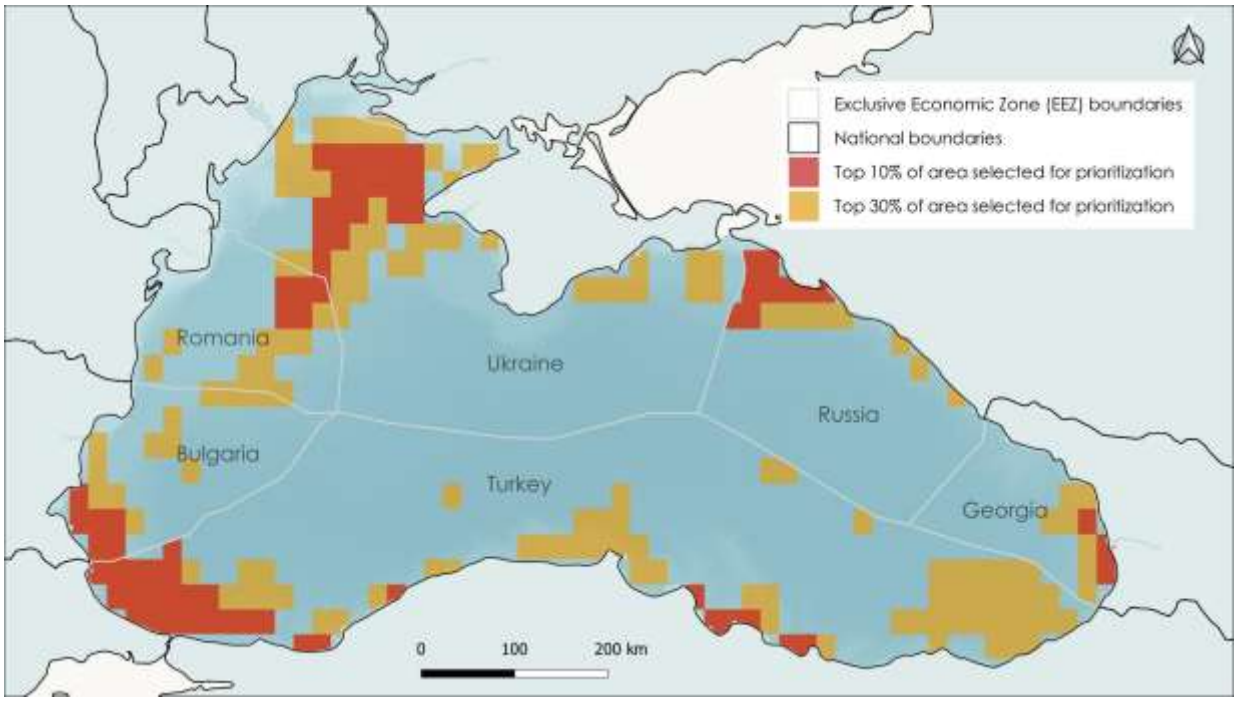
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities, purely data-driven, while emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current*
Run variant: *MPAs locked in – No species weights used*

What this scenario represents

This run identifies conservation priority areas based purely on current species distributions in the Black Sea, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

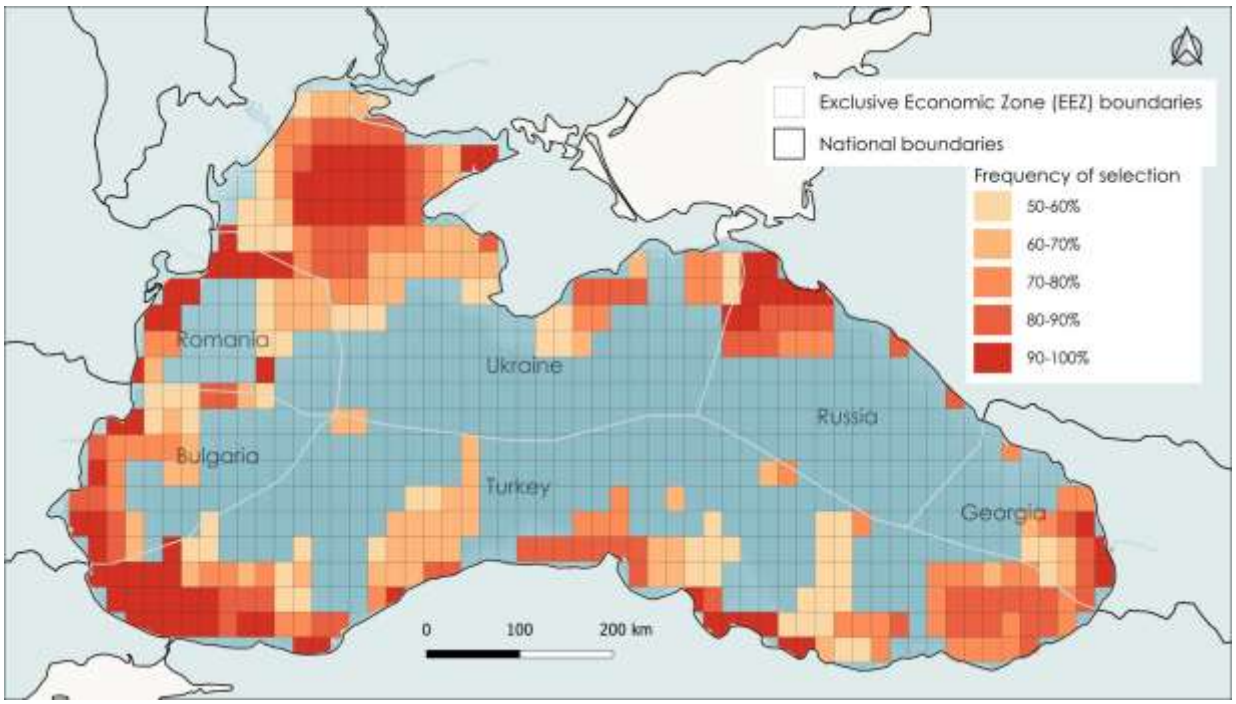
MPAs locked in – what this means & why:

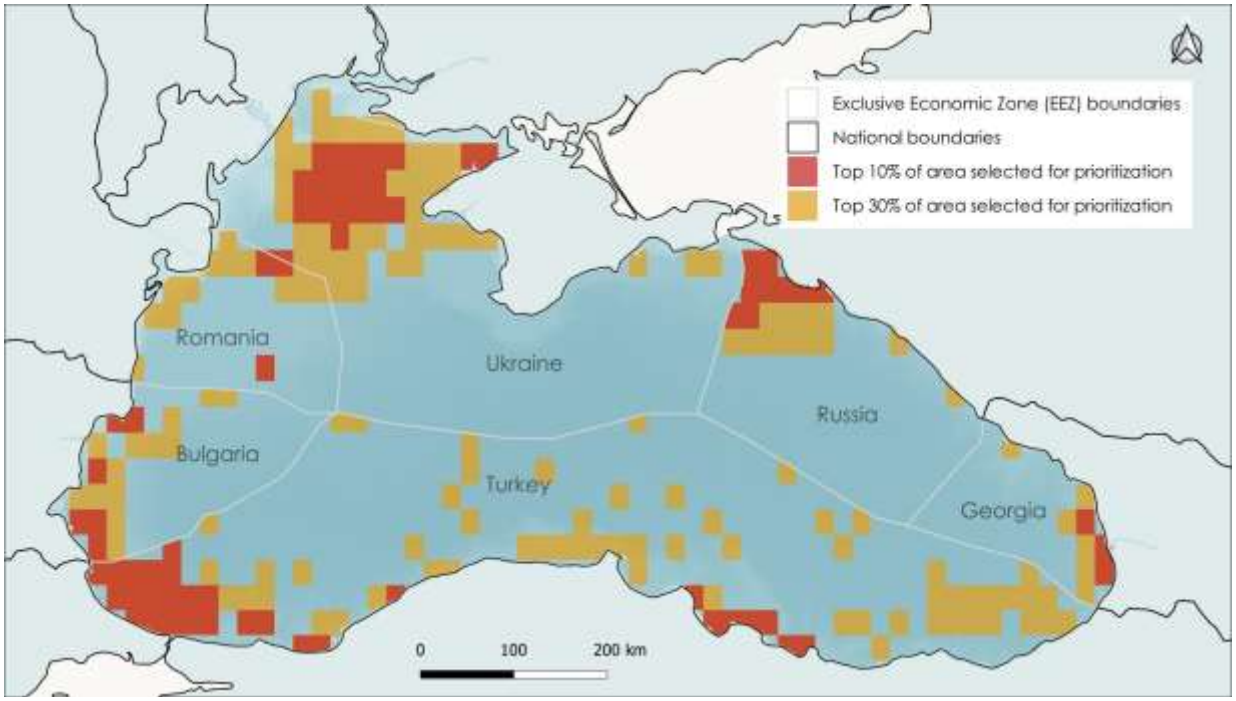
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities, purely data-driven, while ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based purely on current species distributions in the Black Sea, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

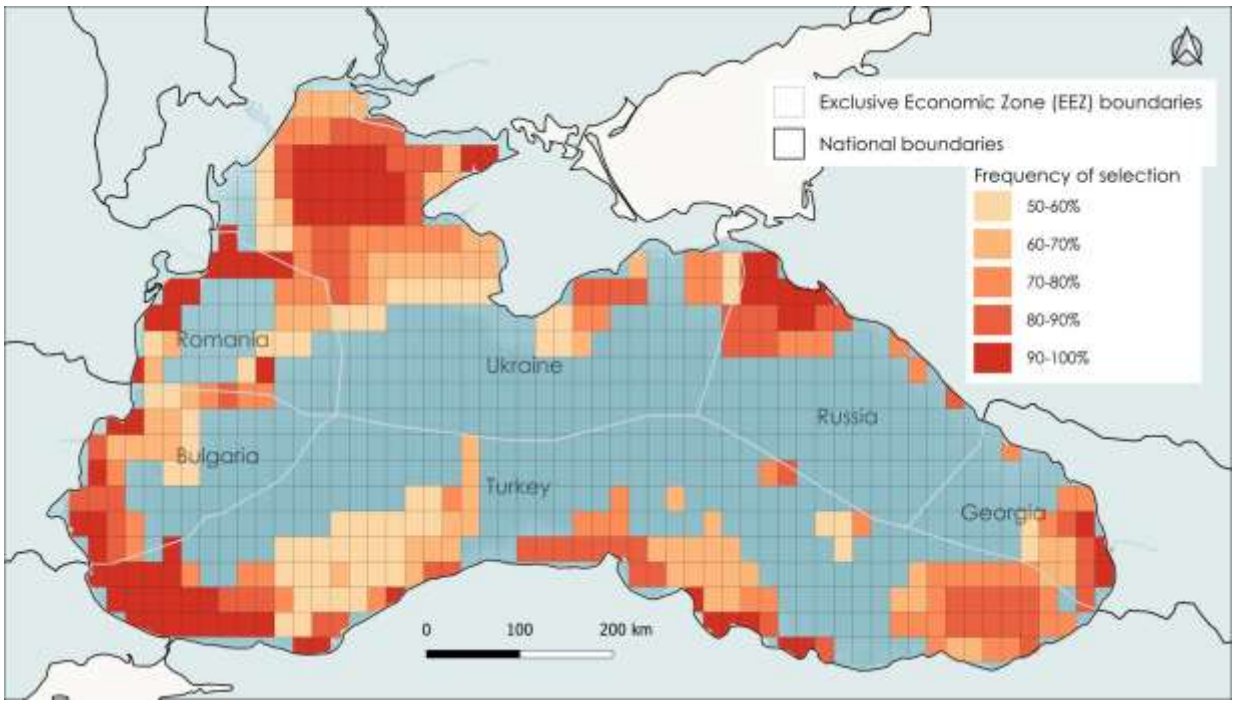
Species weights were applied to give higher conservation priority to areas supporting:

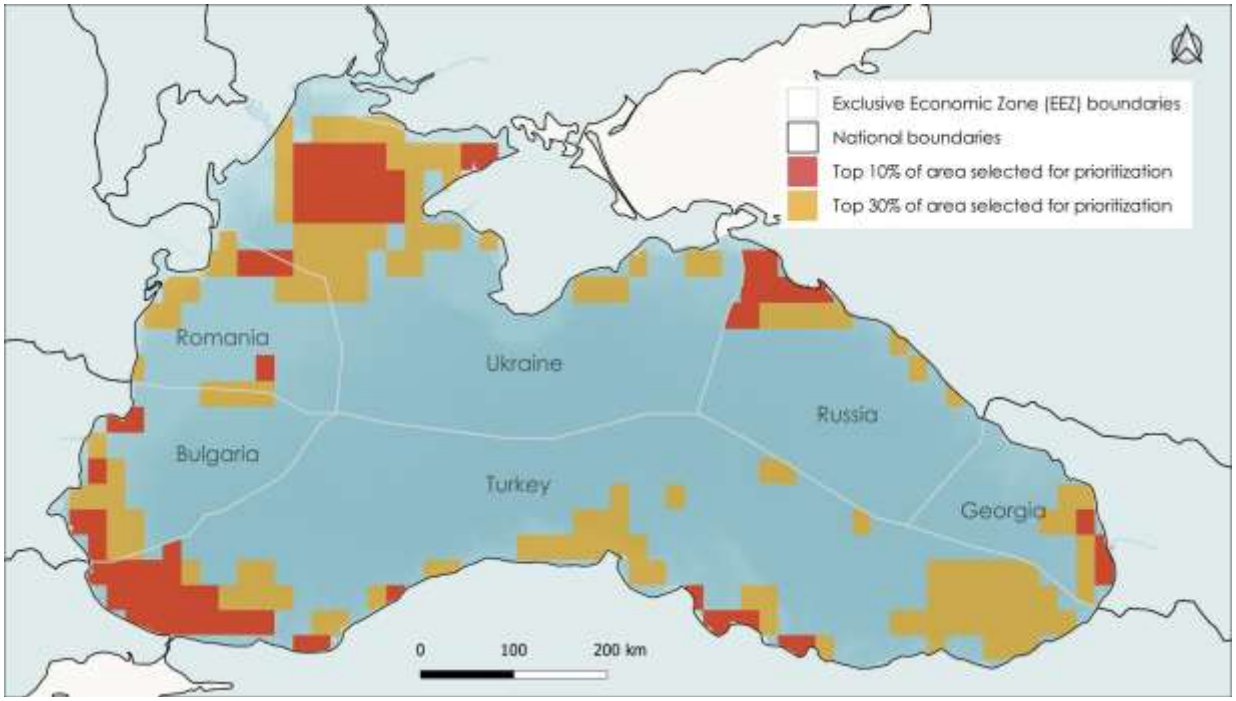
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities, purely data-driven, while ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current*
Run variant: *No MPAs & no species weights*

What this scenario represents

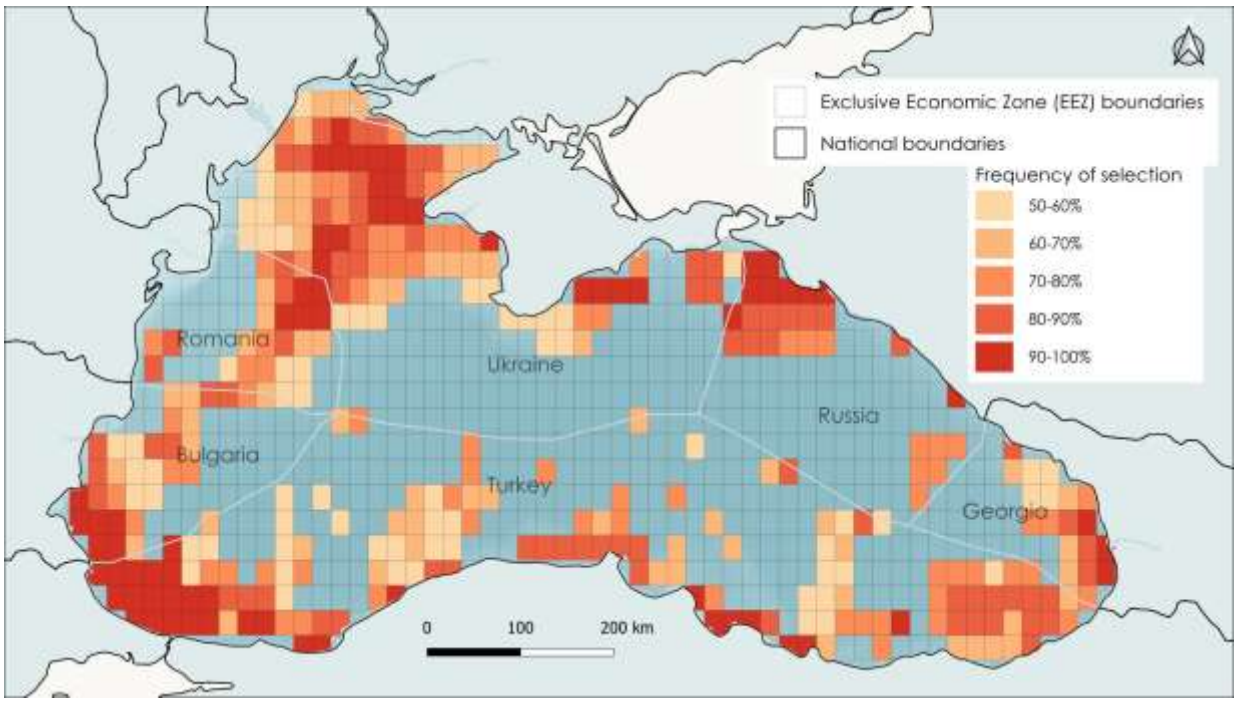
This run identifies conservation priority areas based purely on current species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts.

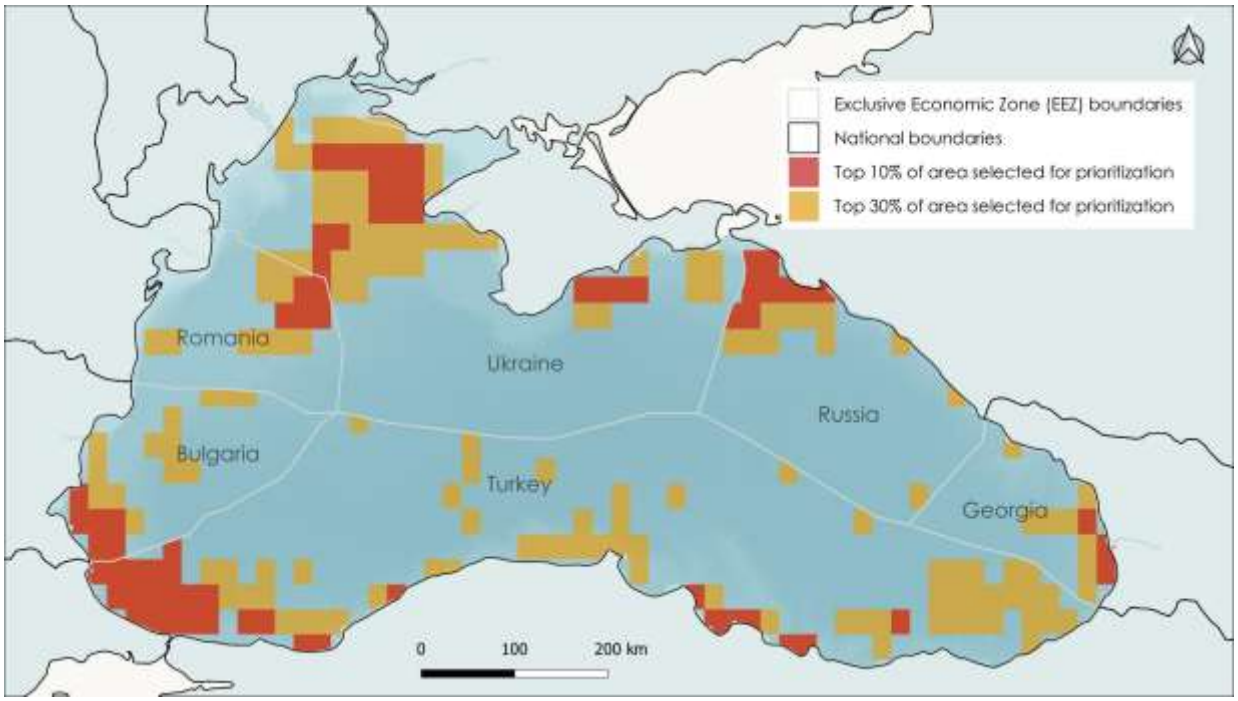
Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary

This scenario provides a reference view of current biodiversity priorities, purely data-driven, balancing biodiversity needs with socio-economic considerations.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current*
Run variant: *No MPAs - Species weights used*

What this scenario represents

This run identifies conservation priority areas based purely on current species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while giving higher priority to species of greater conservation concern.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

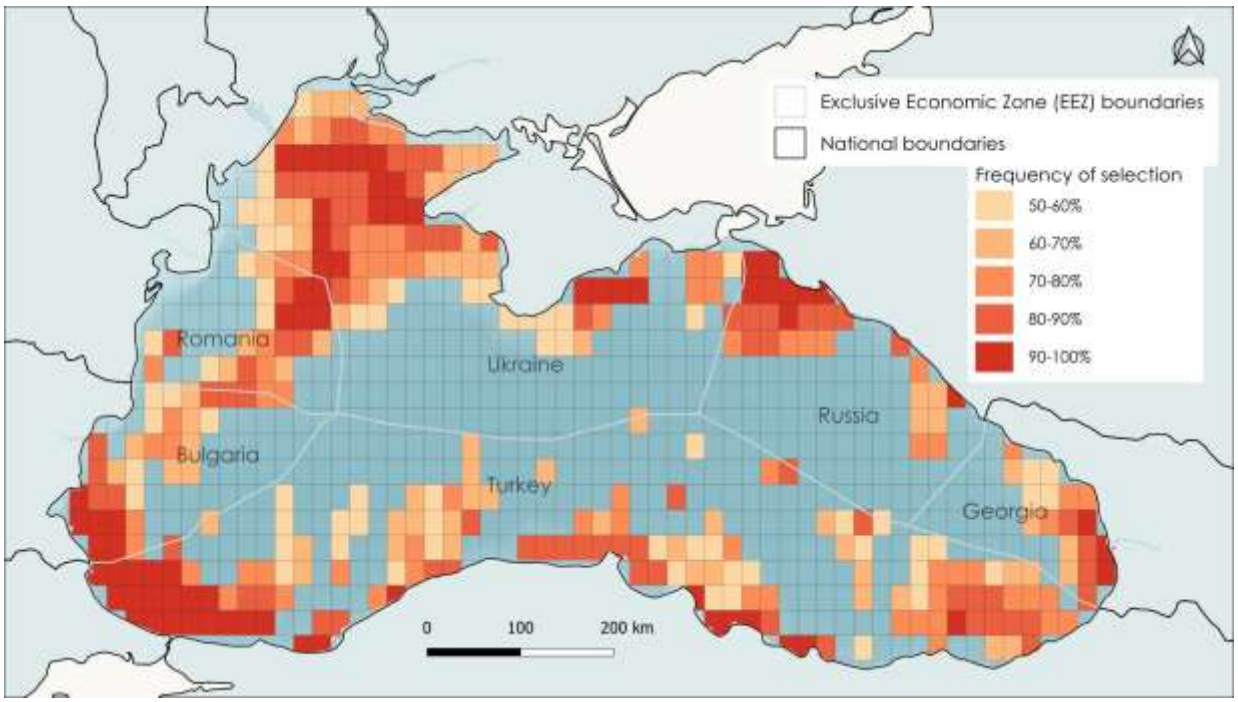
Species weights were applied to give higher conservation priority to areas supporting:

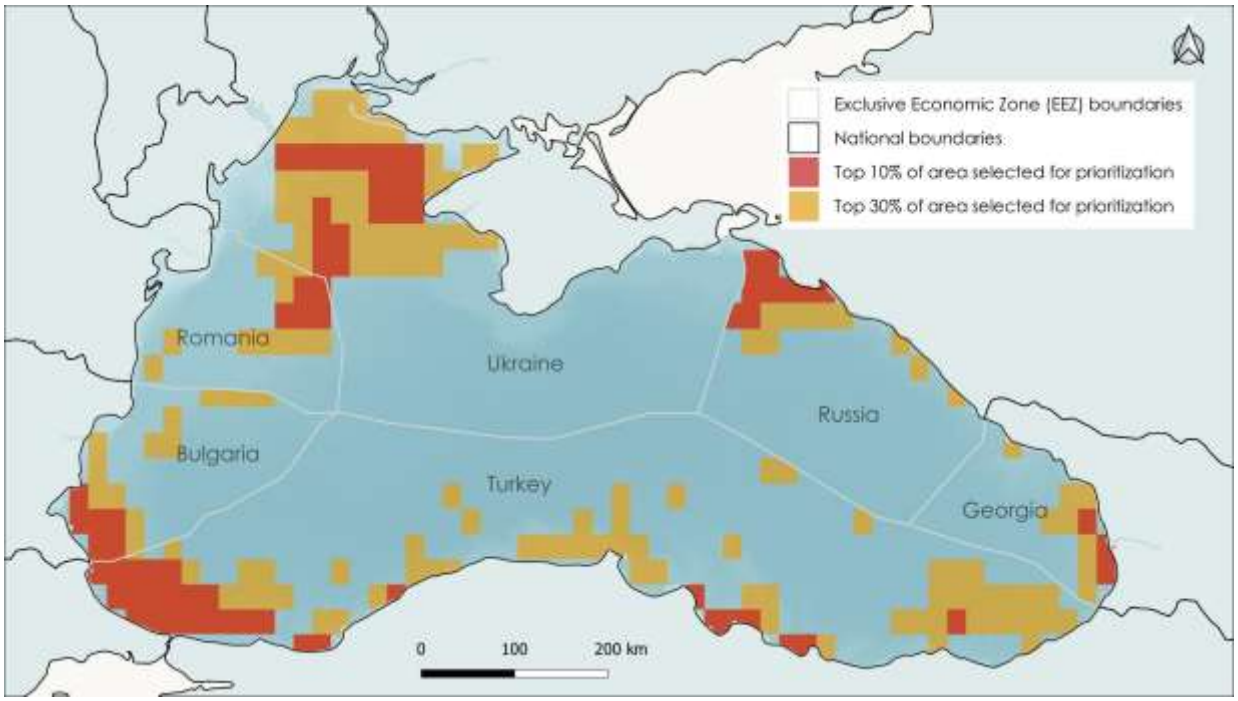
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities, purely data-driven, balancing biodiversity needs with socio-economic considerations and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current*
Run variant: *MPAs locked in - No species weights used*

What this scenario represents

This run identifies conservation priority areas based purely on current species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

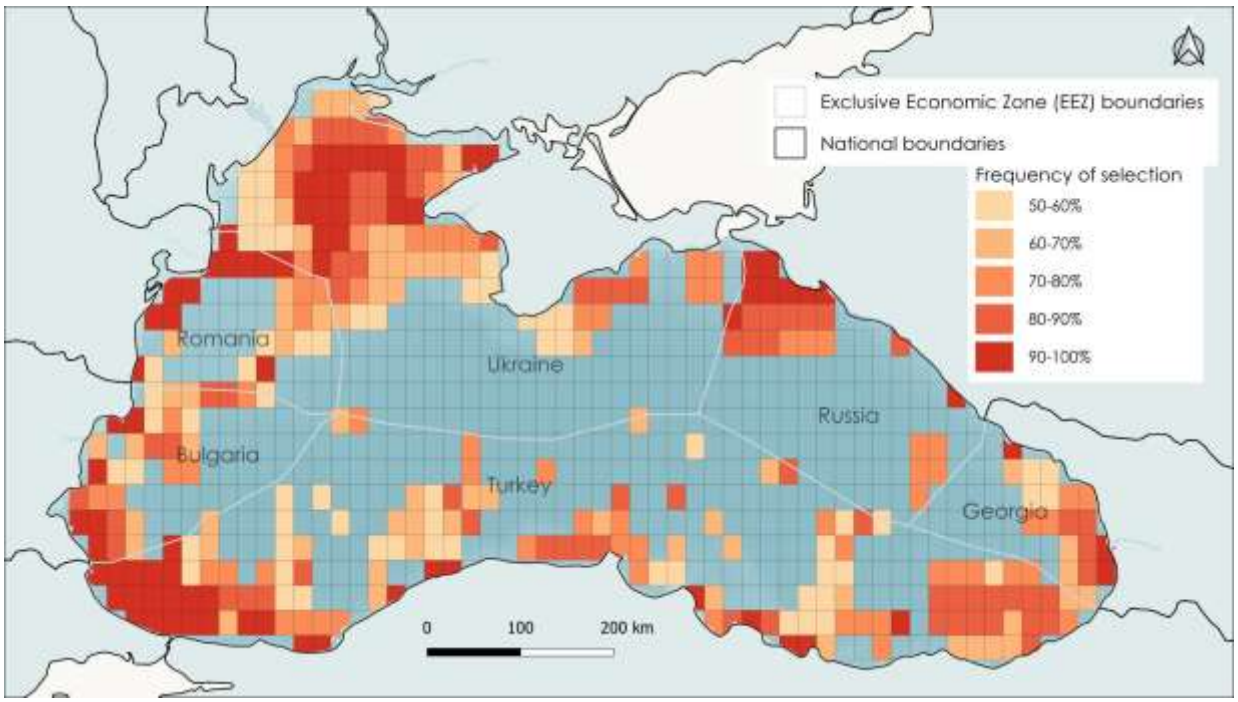
MPAs locked in – what this means & why:

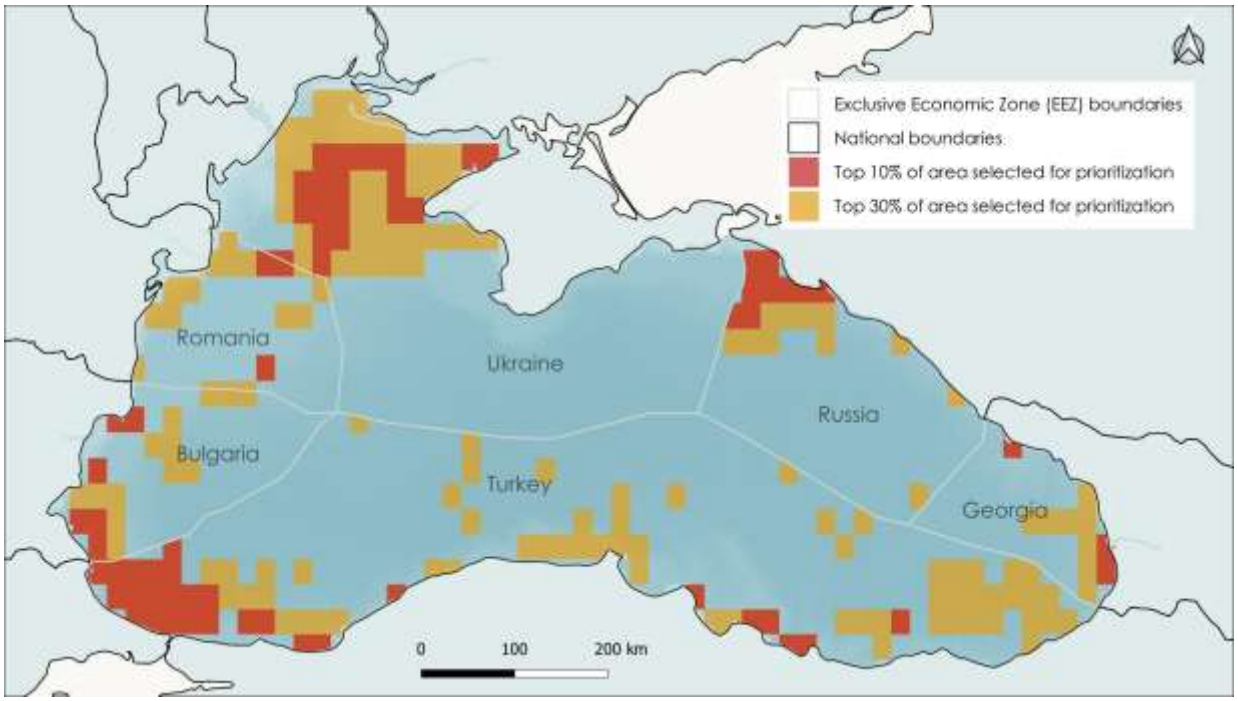
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities, purely data-driven, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based purely on current species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

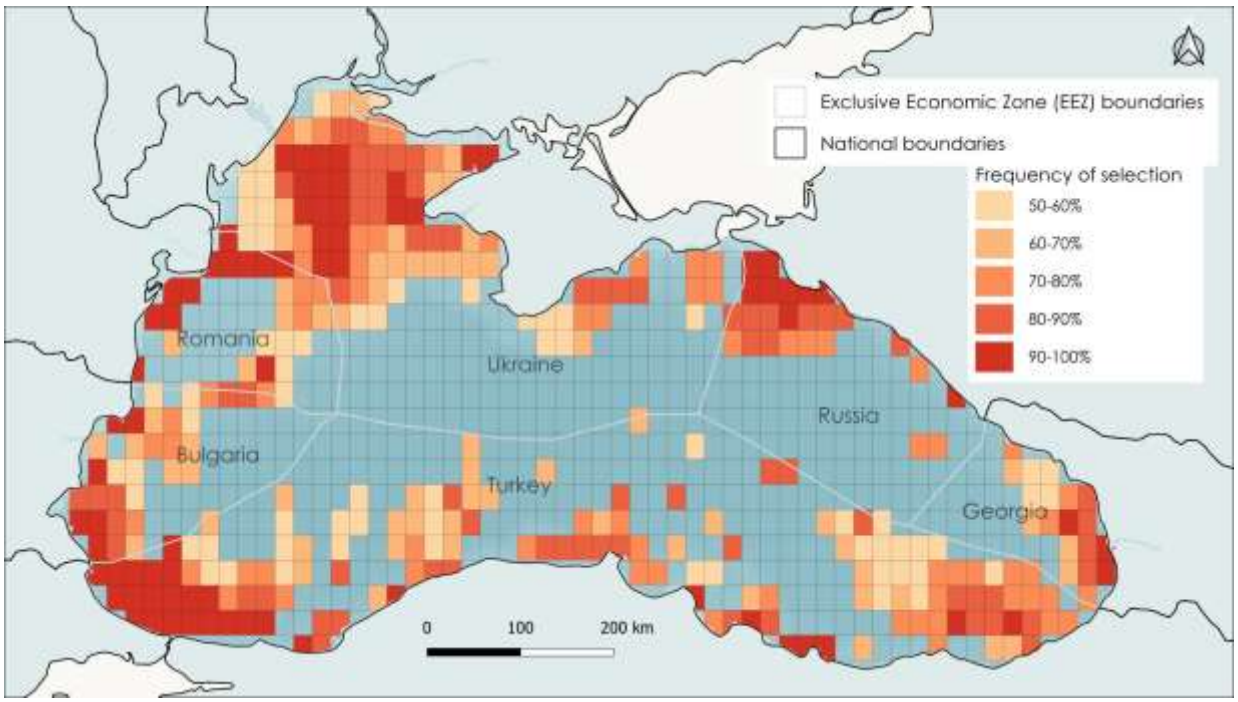
Species weights were applied to give higher conservation priority to areas supporting:

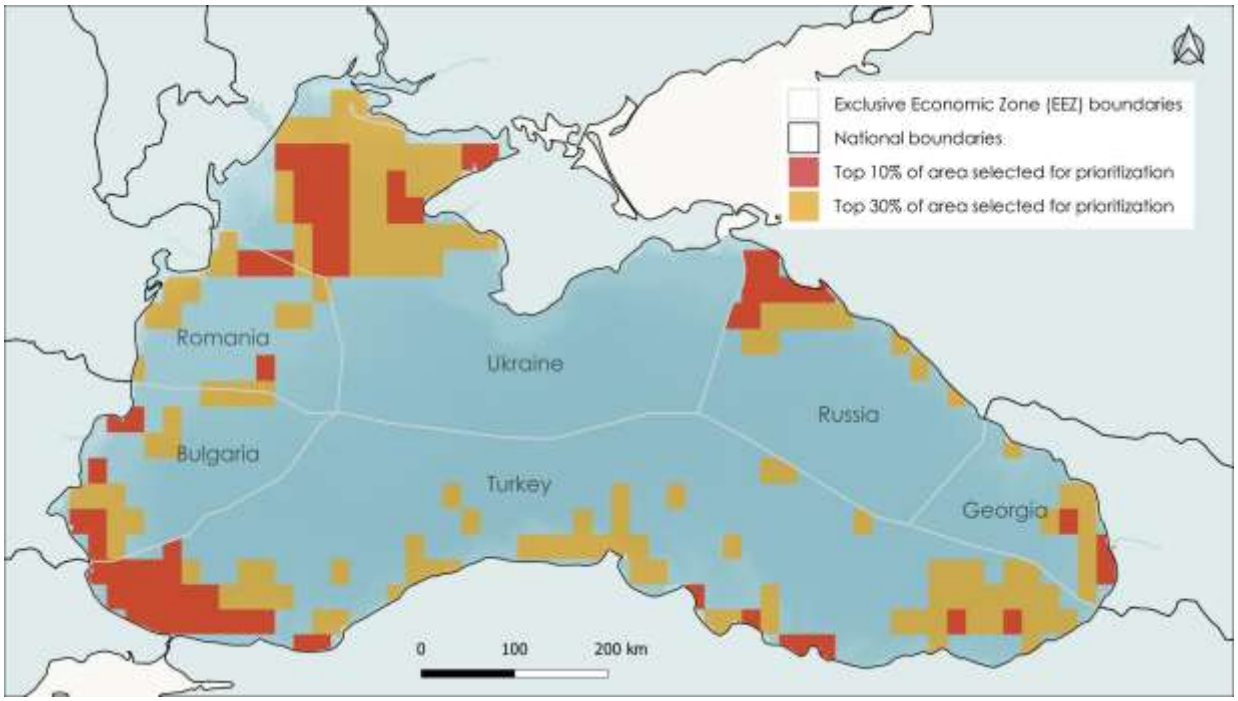
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities, purely data-driven, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Current distribution of species under climate change scenarios

RCP 2.6

Scenario: *Current, accounting for climate change*
Run variant: *No MPAs - no species weights used*

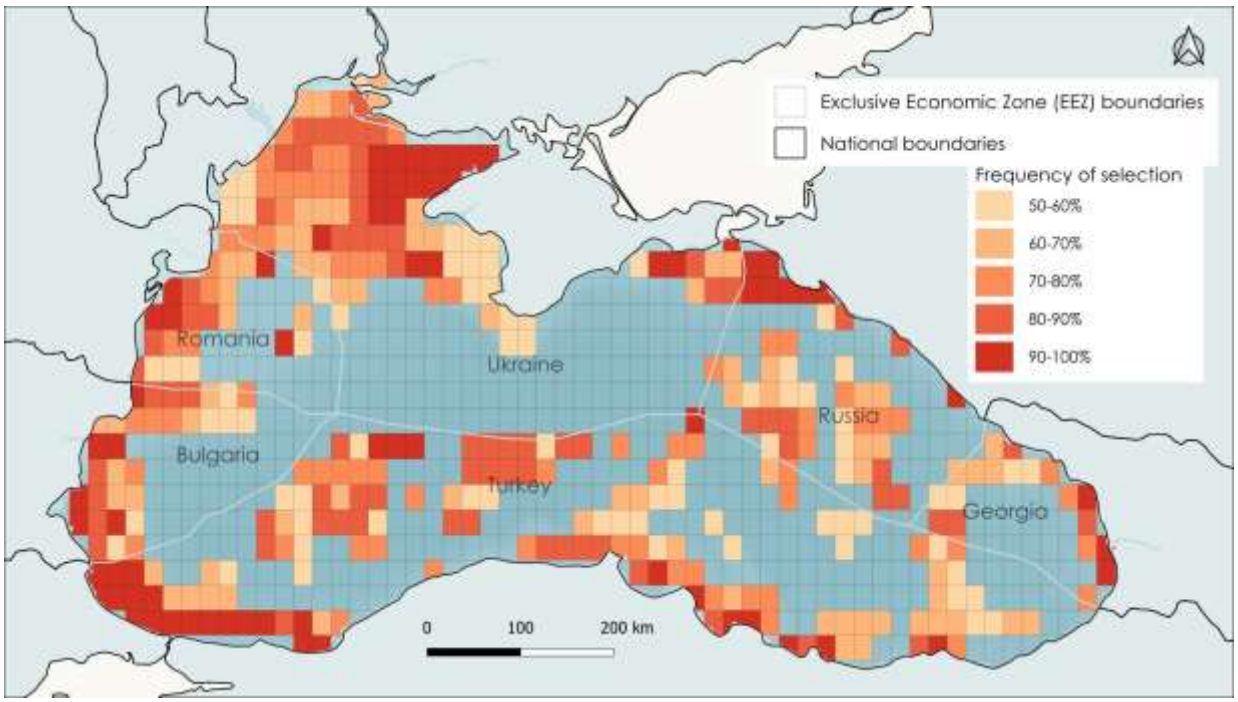
What this scenario represents
This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 2.6 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts.

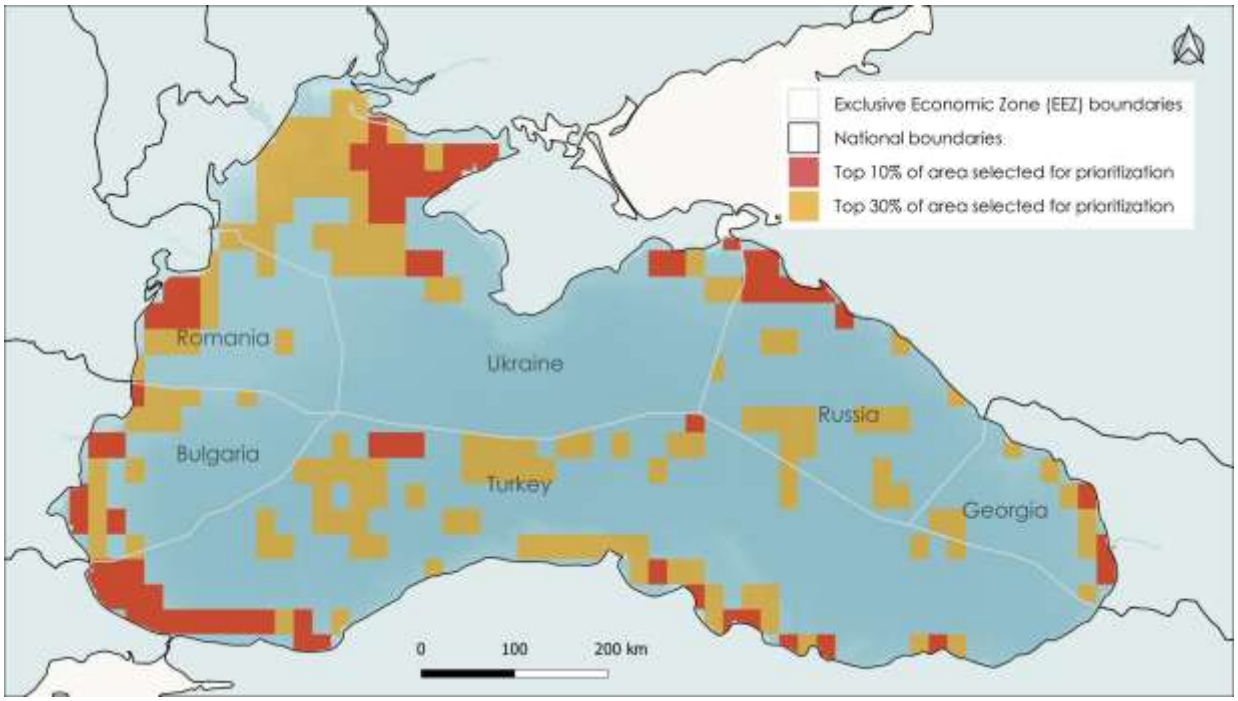
Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary
This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes and balancing biodiversity needs with socio-economic considerations.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: No *MPAs – Species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 2.6 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

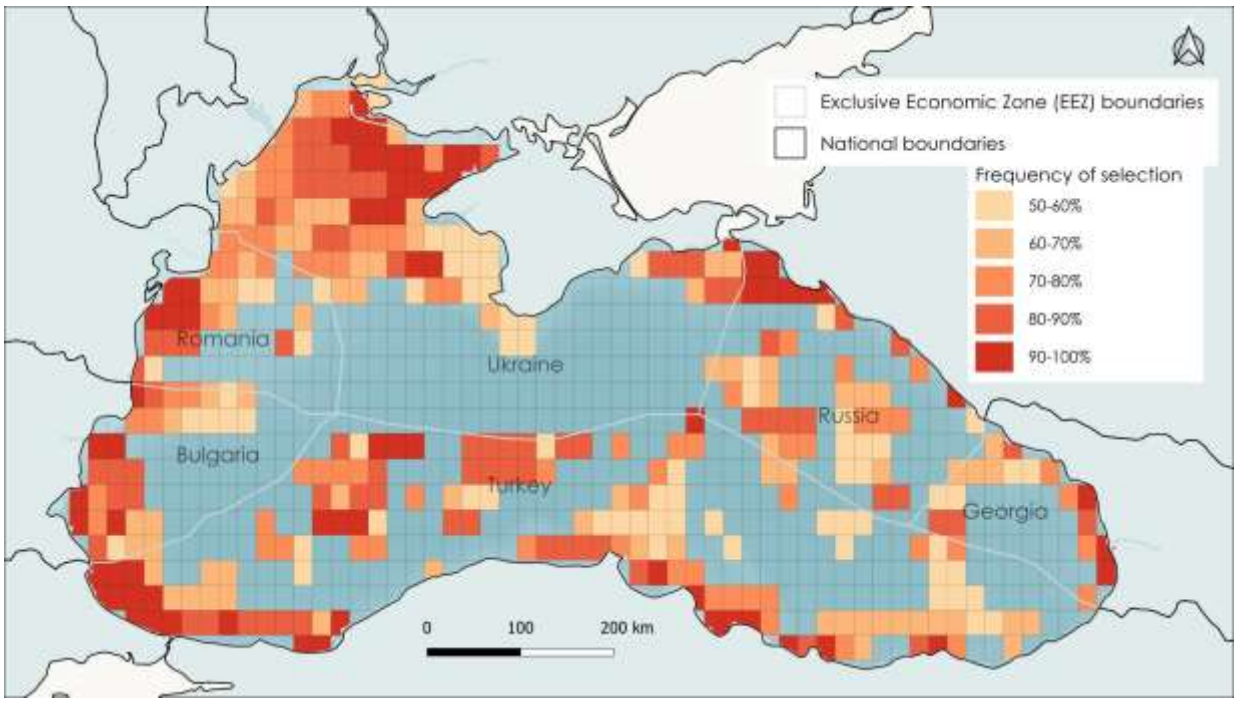
Species weights were applied to give higher conservation priority to areas supporting:

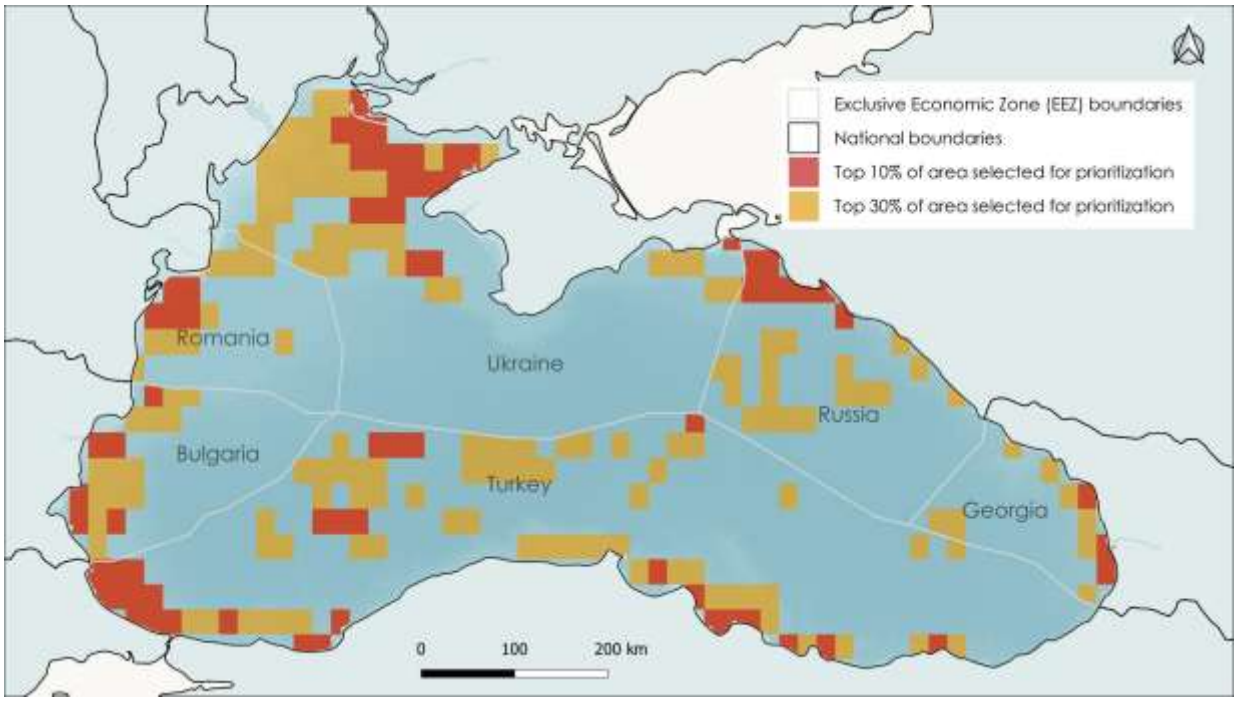
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future ((Representative Concentration Pathway 2.6 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Climate scenario used:

The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

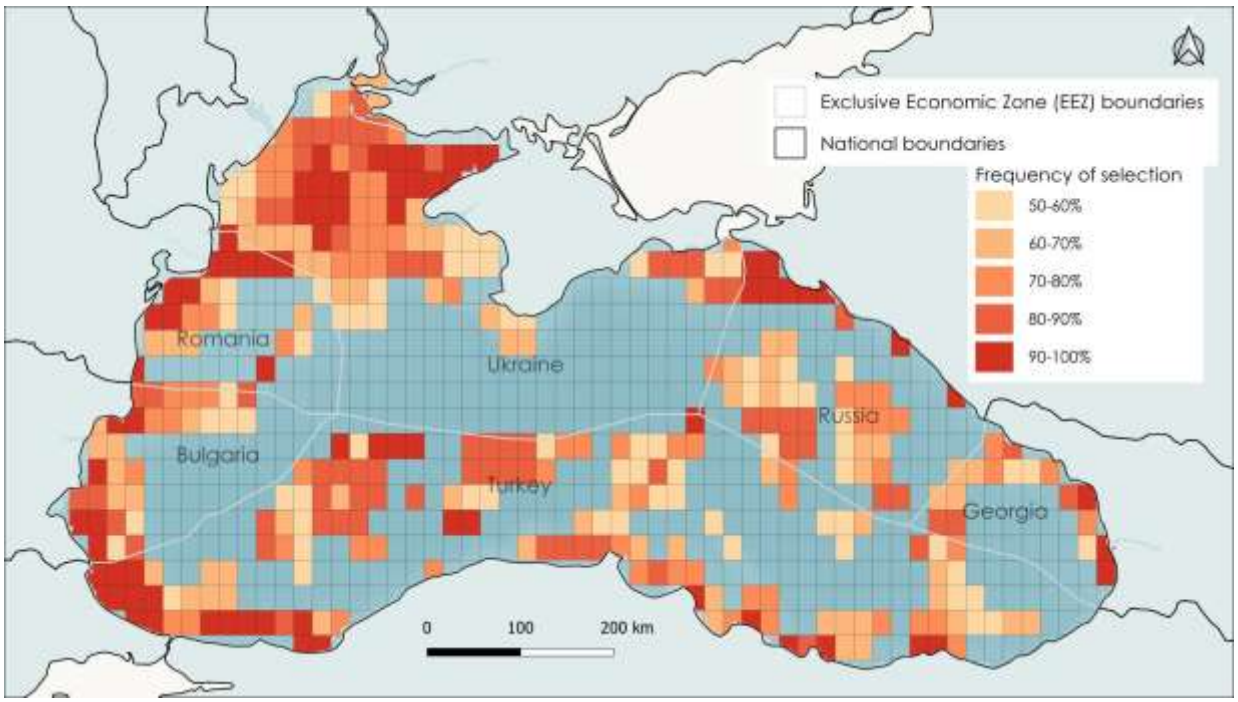
MPAs locked in – what this means & why:

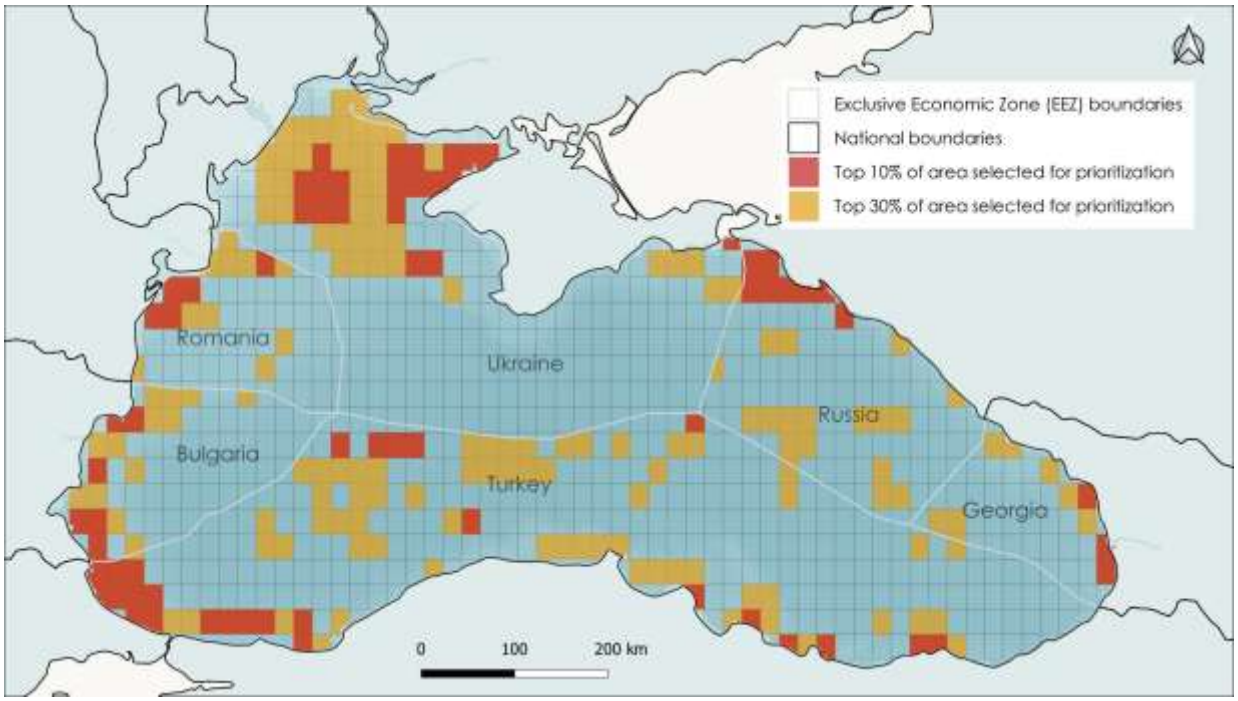
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 2.6 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

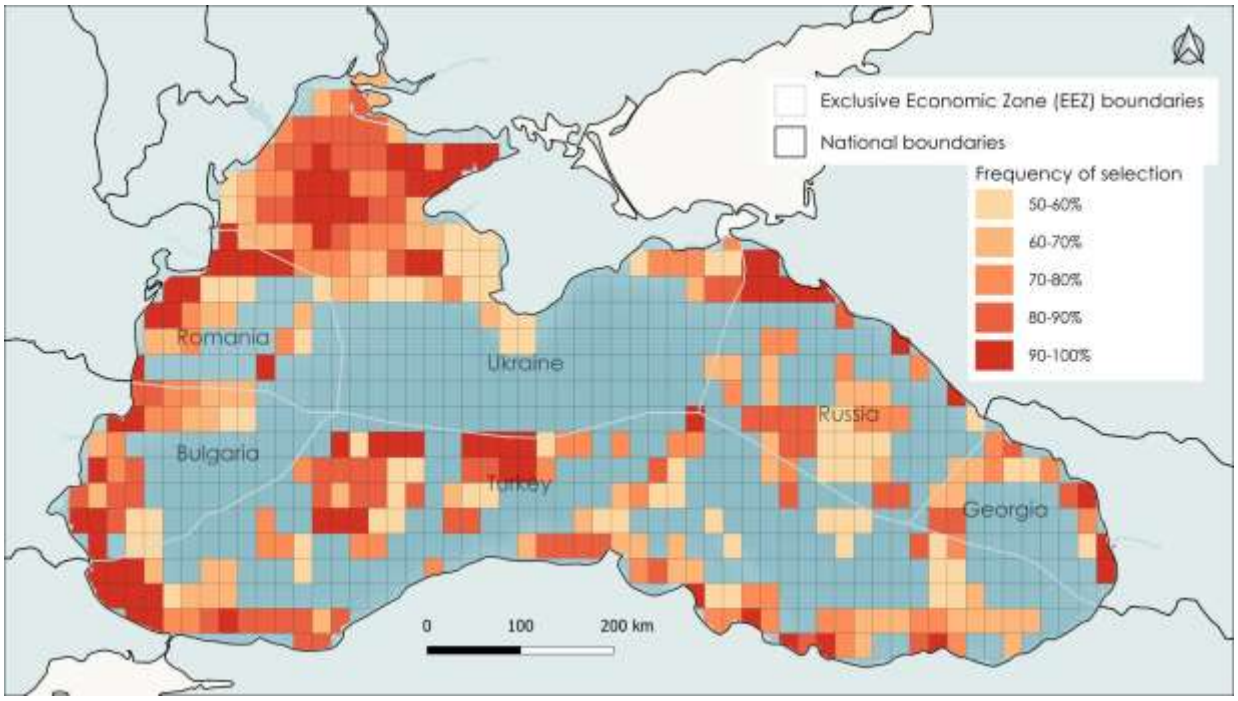
Species weights were applied to give higher conservation priority to areas supporting:

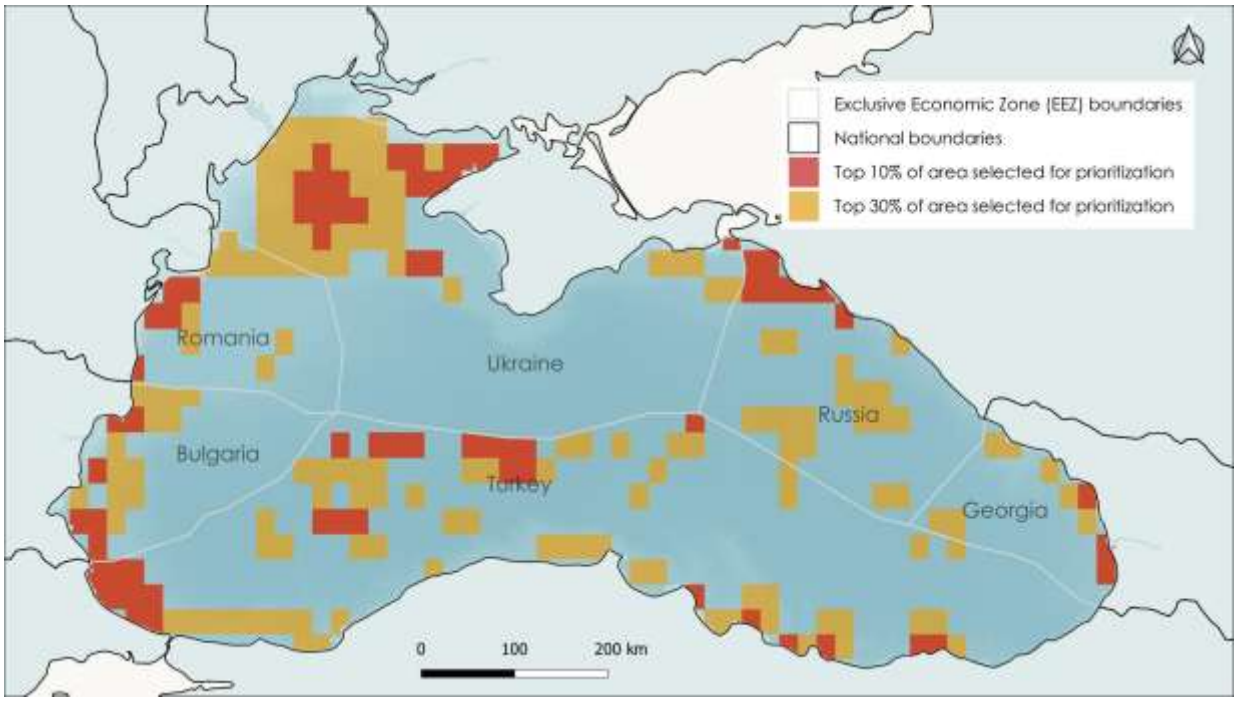
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.





Scenario: *Current, accounting for climate change*
Run variant: *No MPAs - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 2.6 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts.

Climate scenario used:

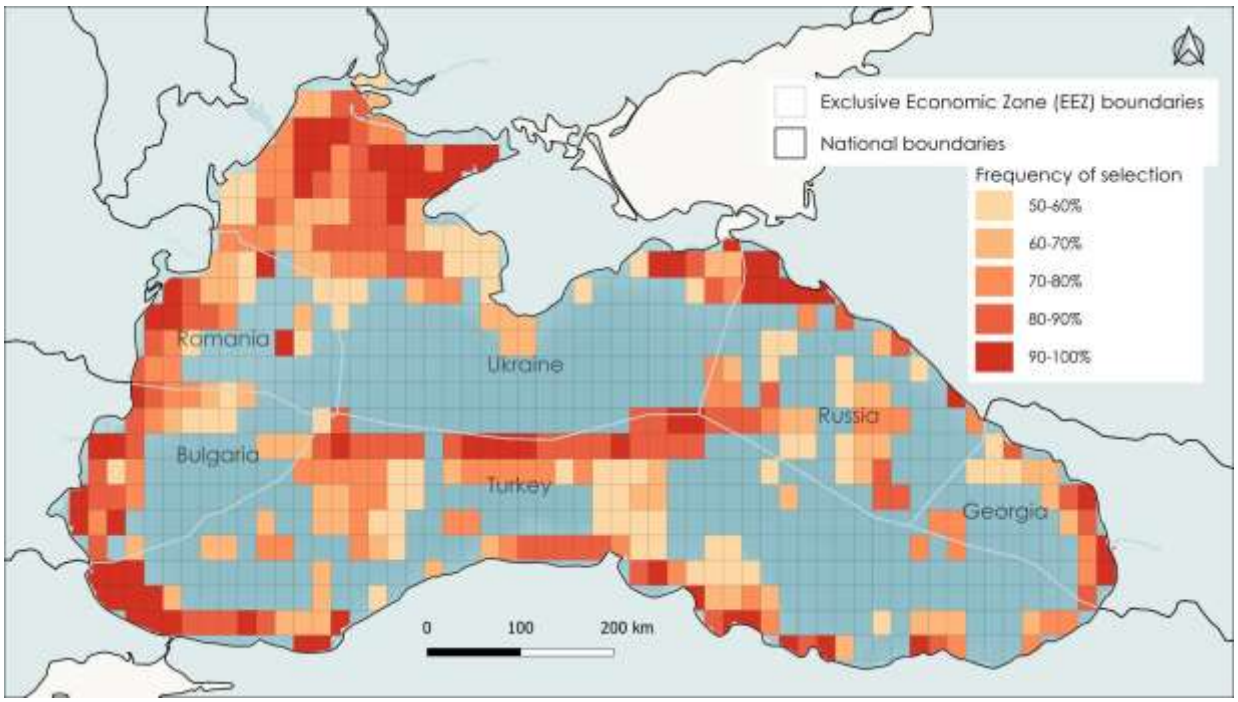
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO2 absorption by trees.

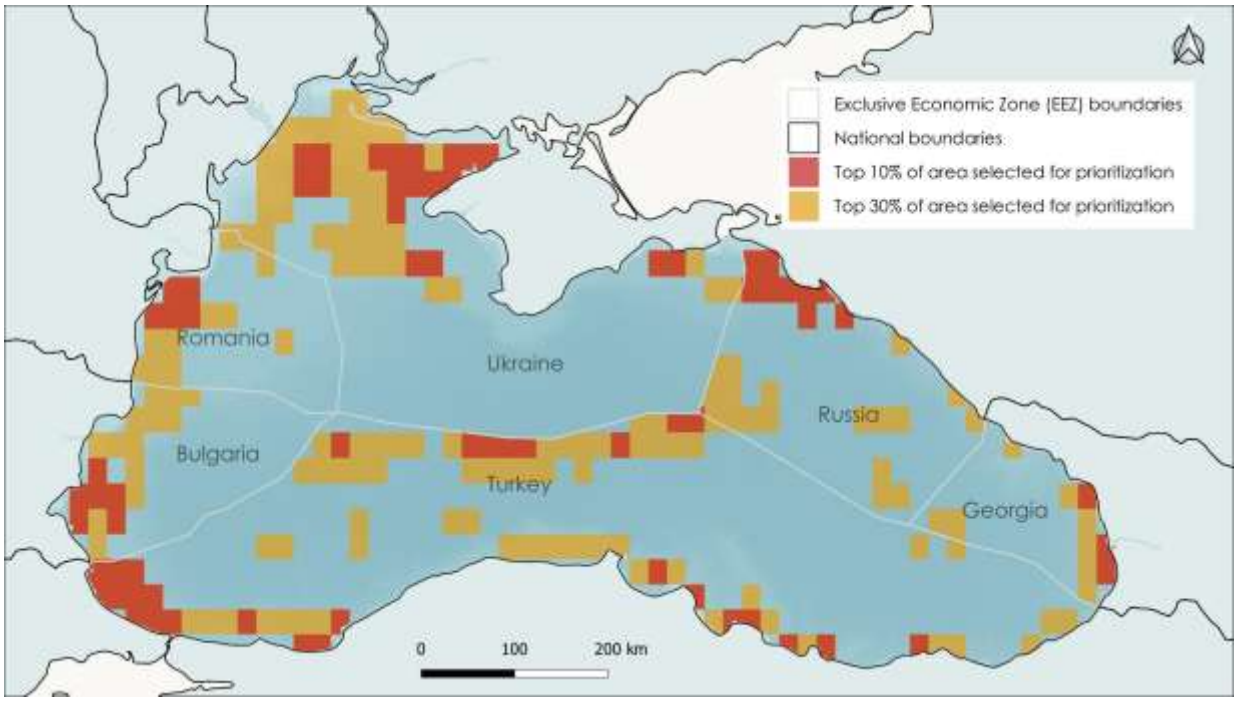
Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes and balancing biodiversity needs with socio-economic considerations.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: No *MPAs & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 2.6 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO2 absorption by trees.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

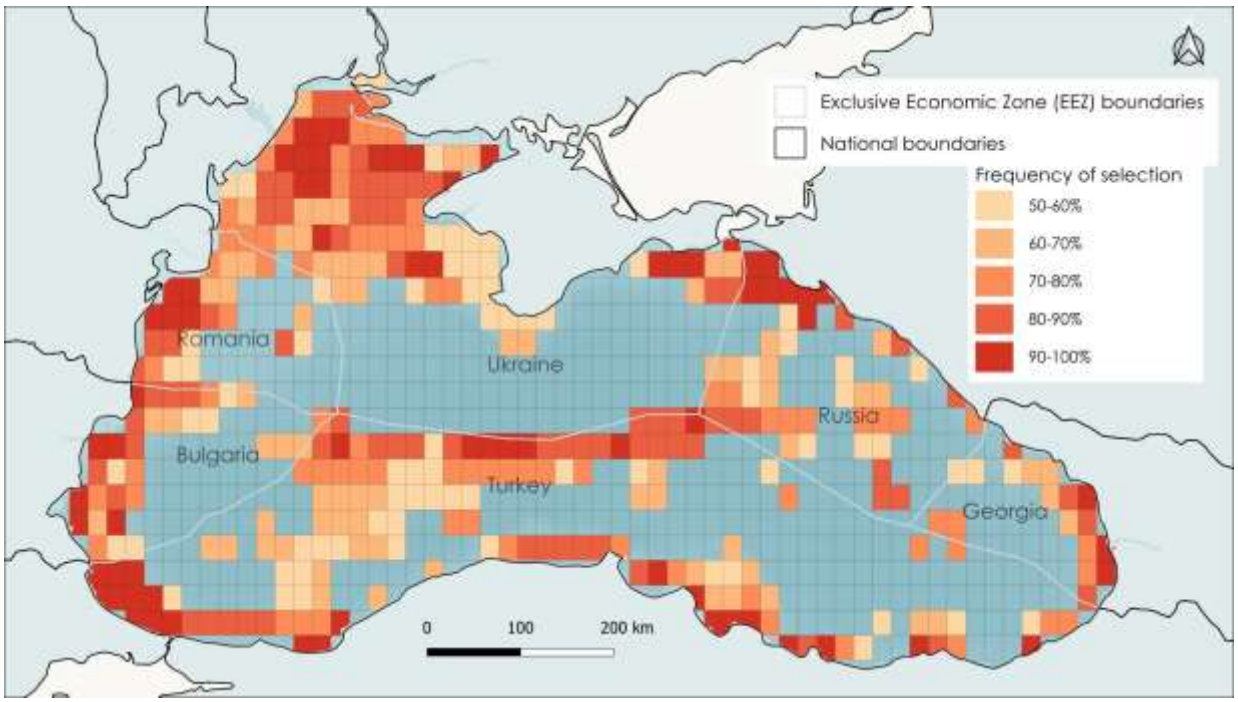
Species weights were applied to give higher conservation priority to areas supporting:

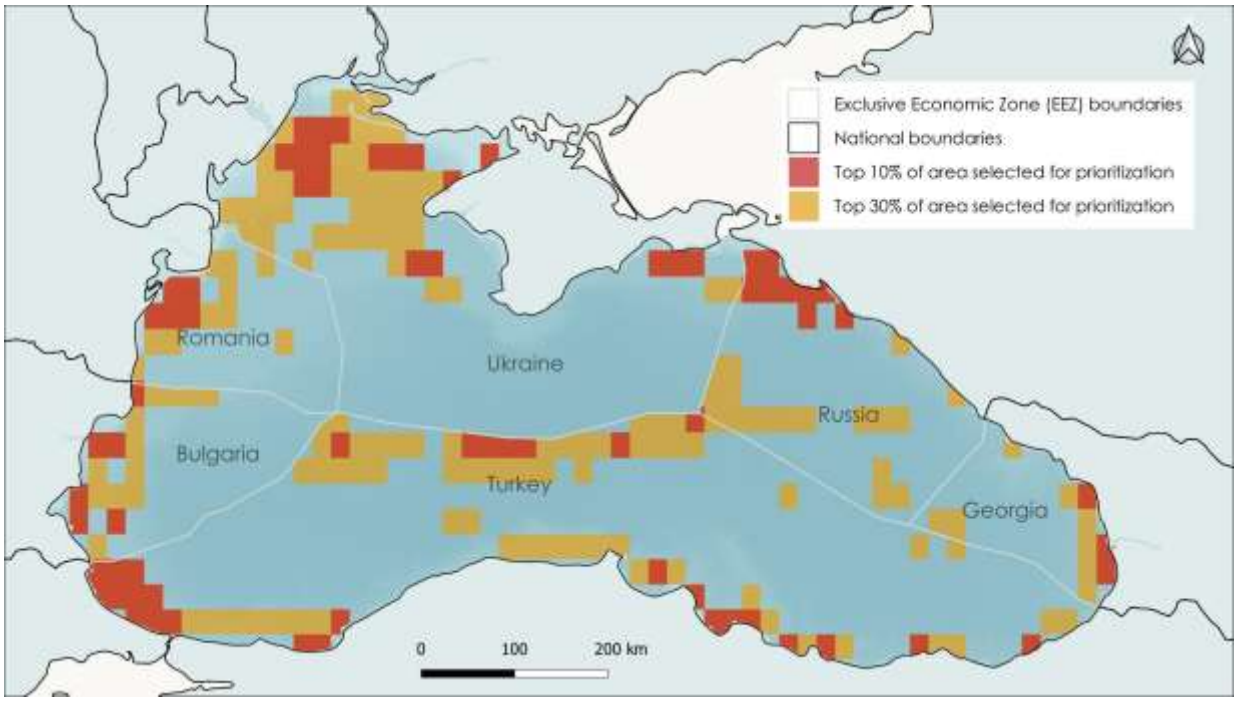
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 2.6 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Climate scenario used:

The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

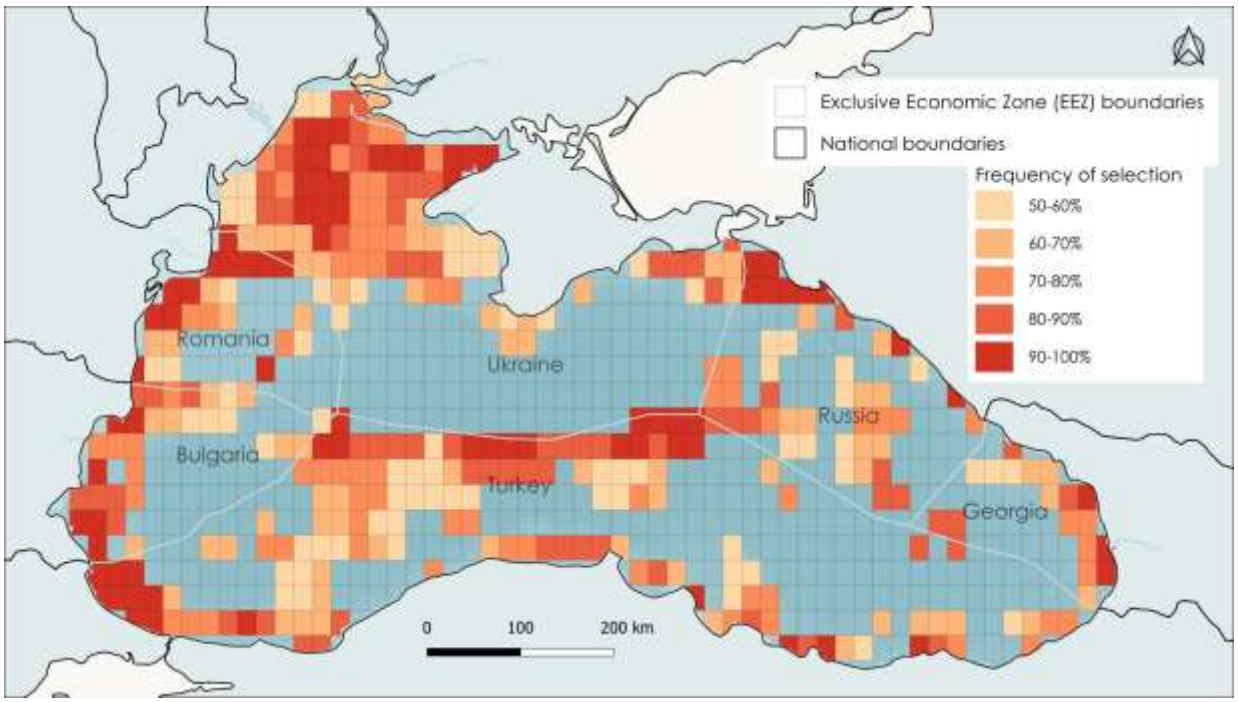
MPAs locked in – what this means & why:

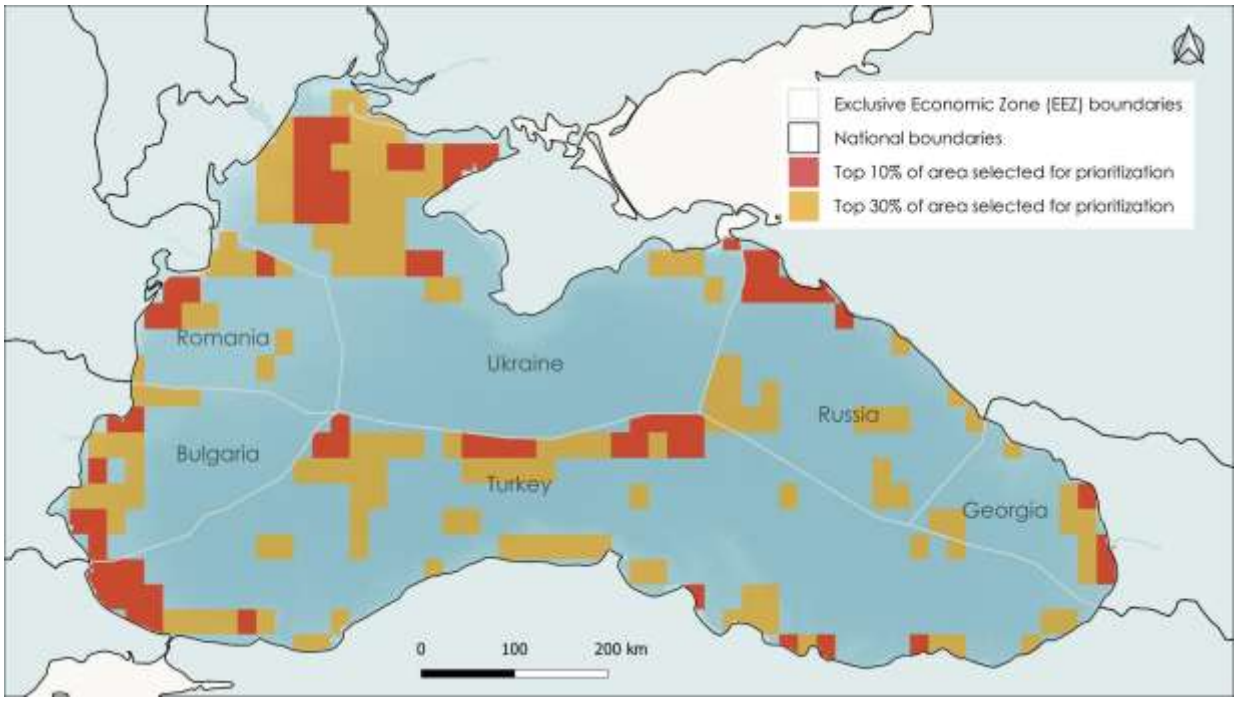
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 2.6 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO2 absorption by trees.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP2.6 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

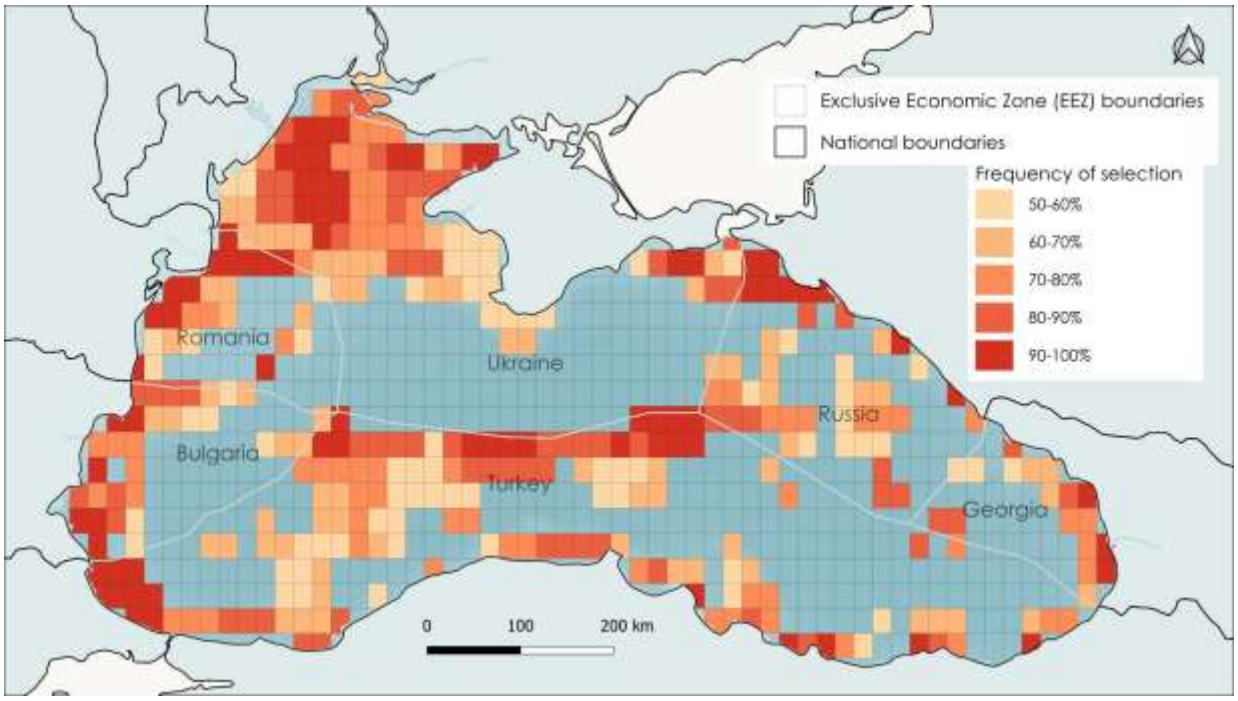
Species weights were applied to give higher conservation priority to areas supporting:

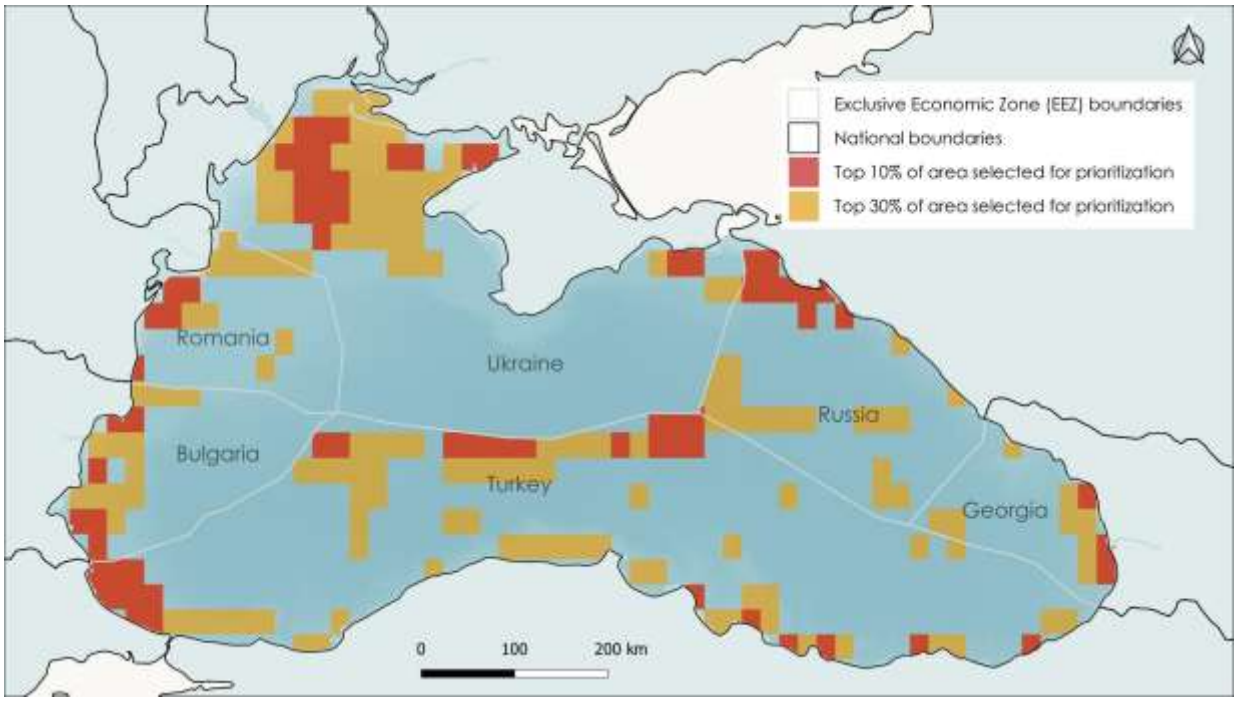
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.





RCP 4.5

Scenario: *Current, accounting for climate change*
Run variant: *No MPAs - no species weights used*

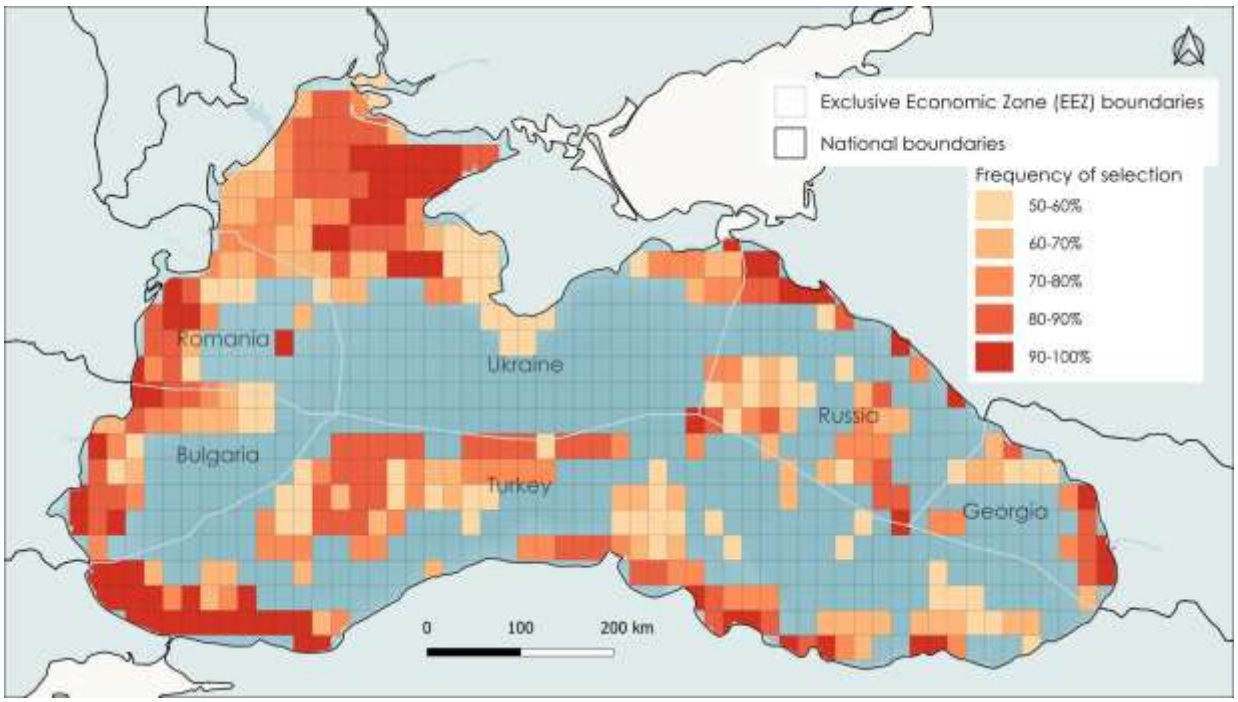
What this scenario represents
This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 4.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts.

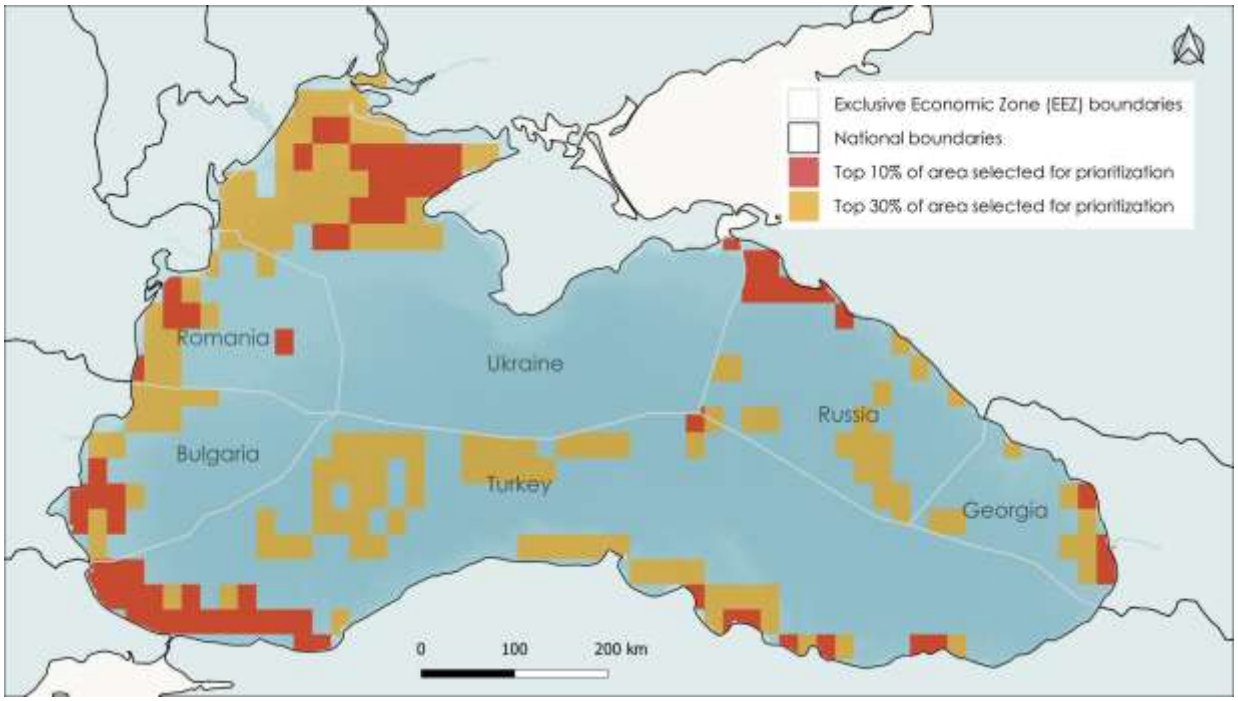
Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP4.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary
This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes and balancing biodiversity needs with socio-economic considerations.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: No *MPAs & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 4.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP4.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

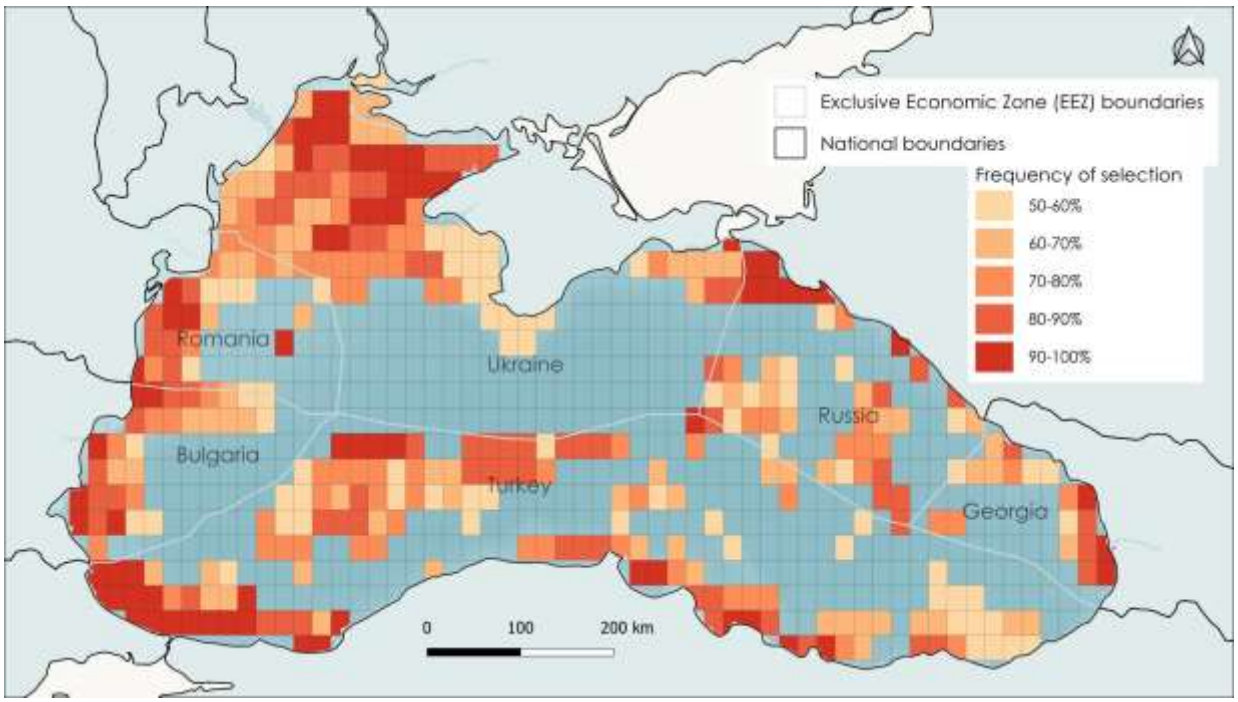
Species weights were applied to give higher conservation priority to areas supporting:

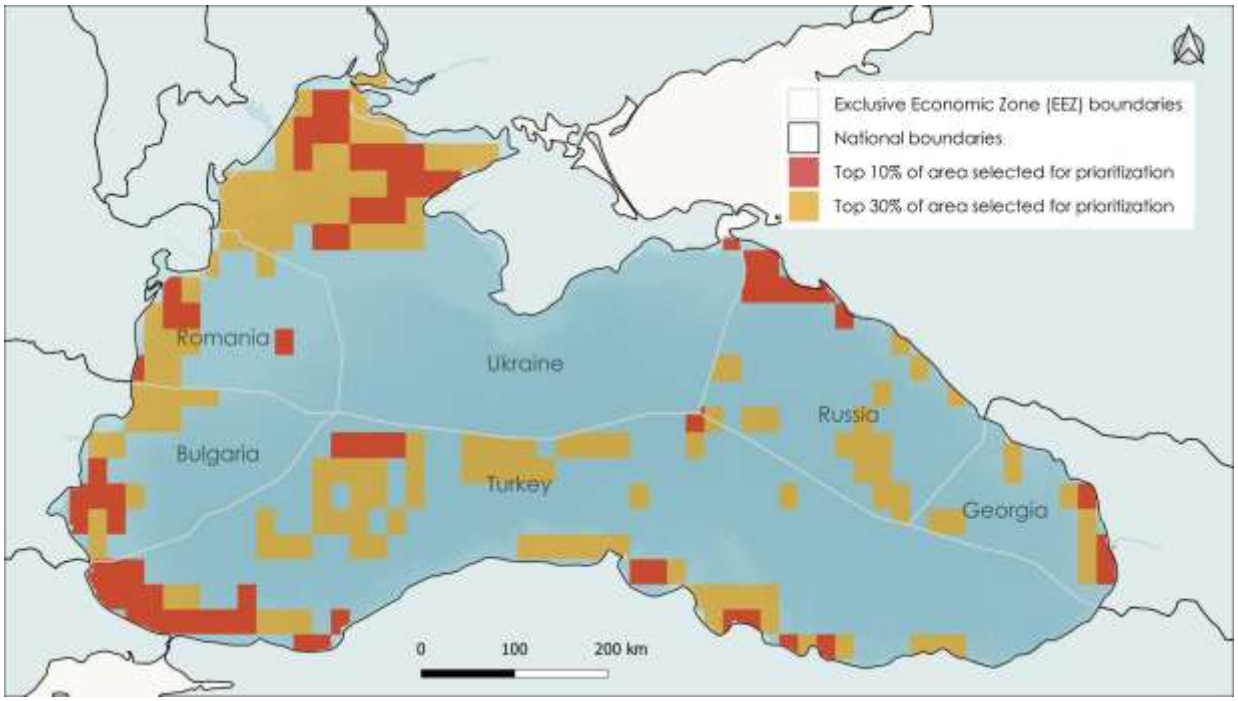
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 4.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP4.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

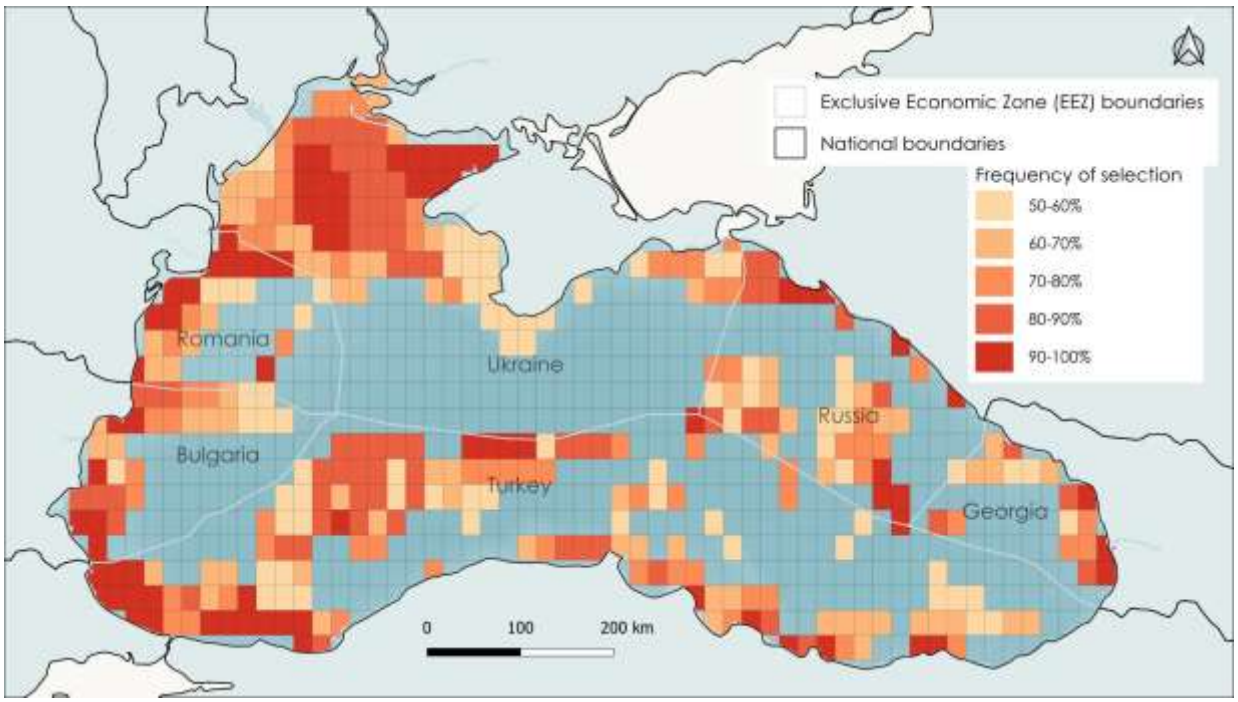
MPAs locked in – what this means & why:

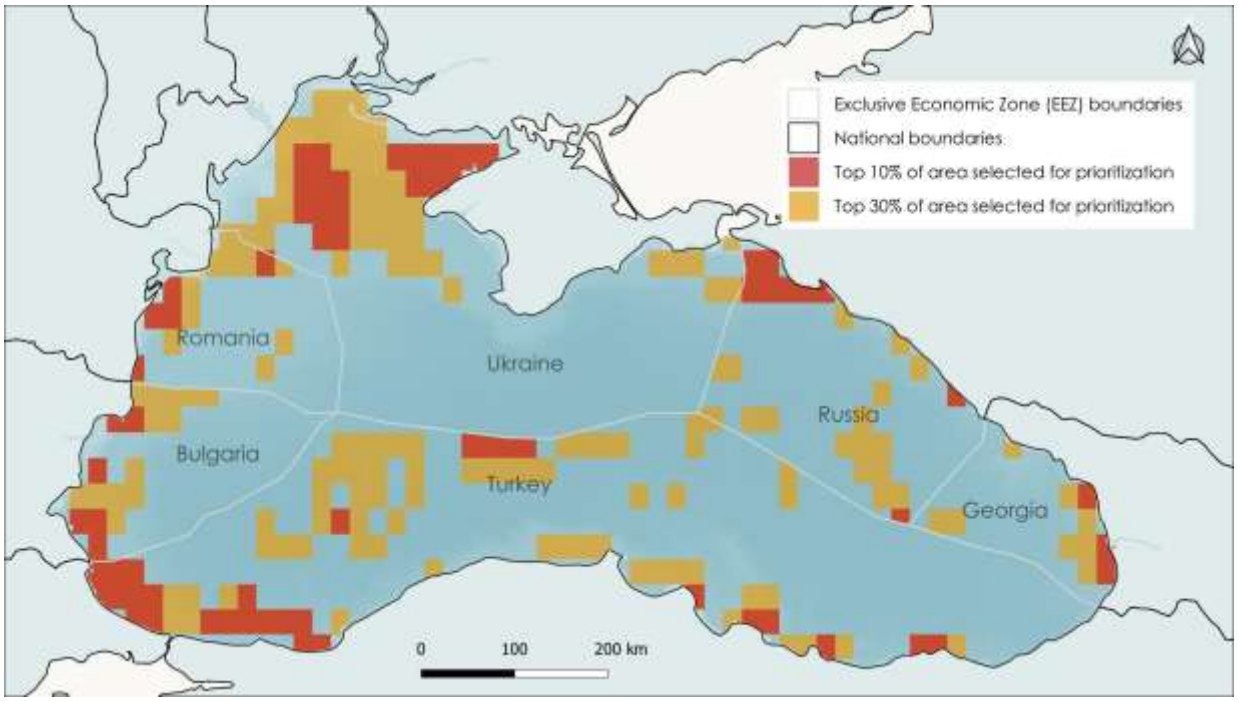
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future ((Representative Concentration Pathway 4.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP24.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

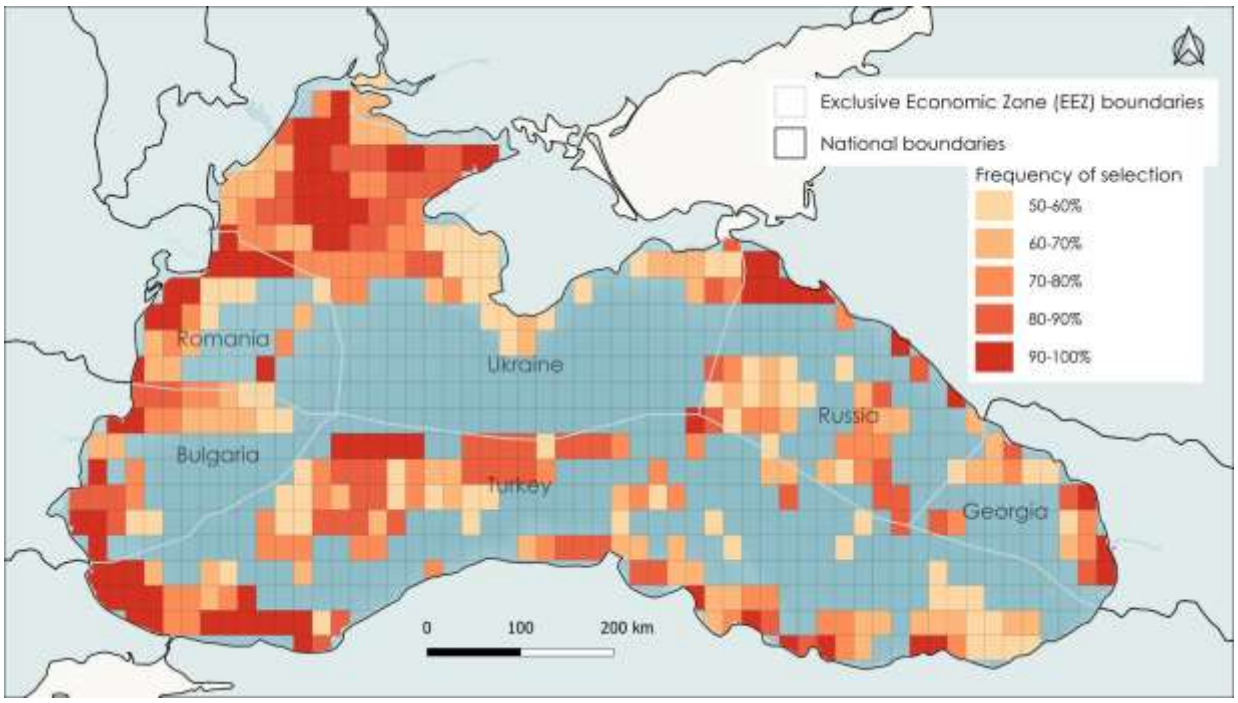
Species weights were applied to give higher conservation priority to areas supporting:

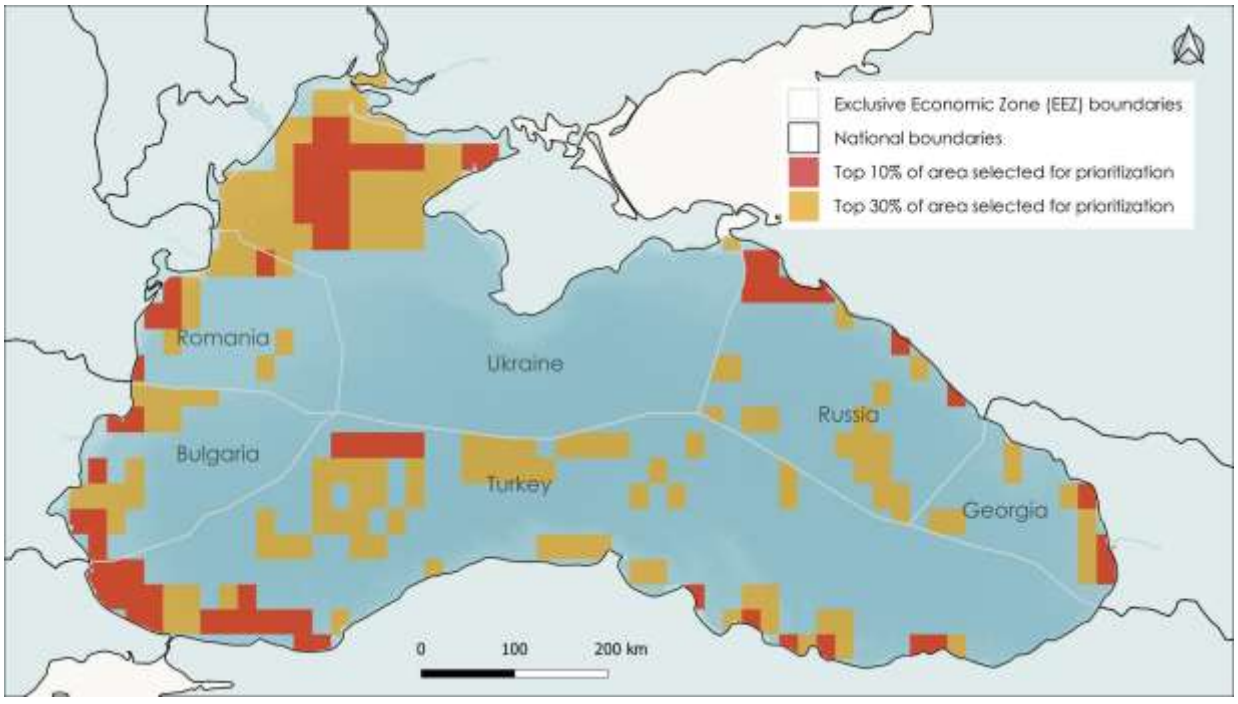
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.





Scenario: *Current, accounting for climate change*
Run variant: *No MPAs - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 4.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts.

Climate scenario used:

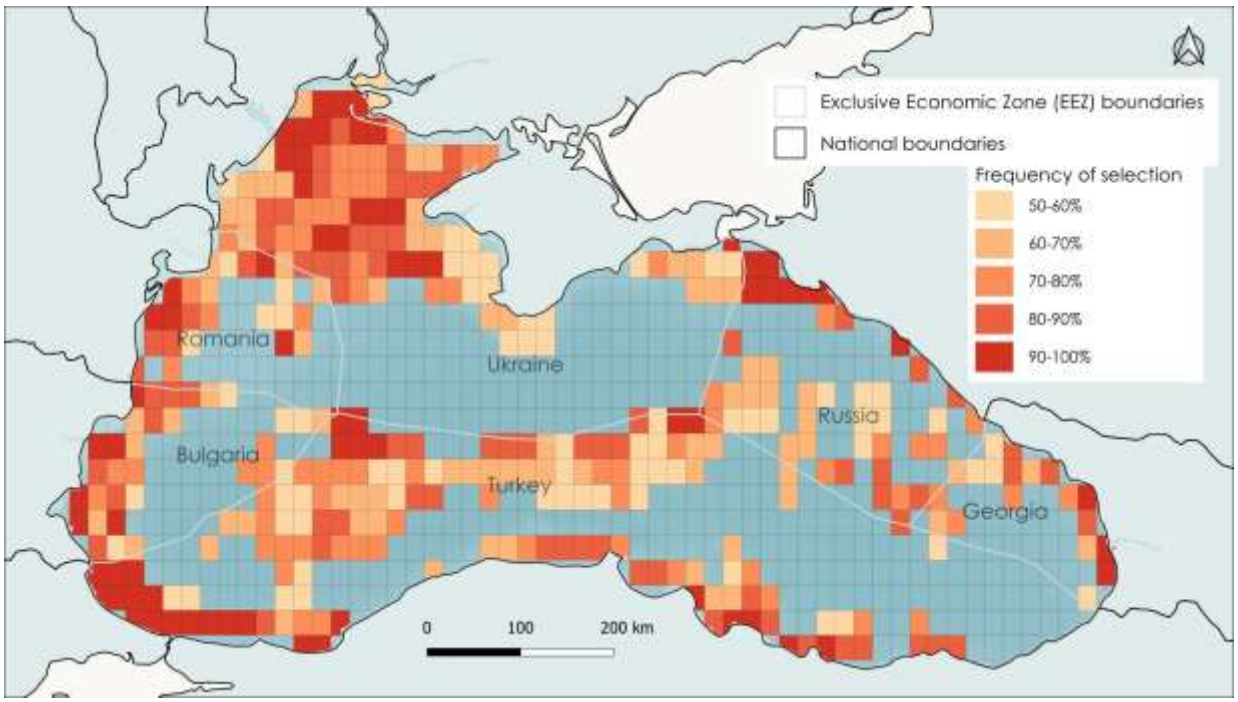
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

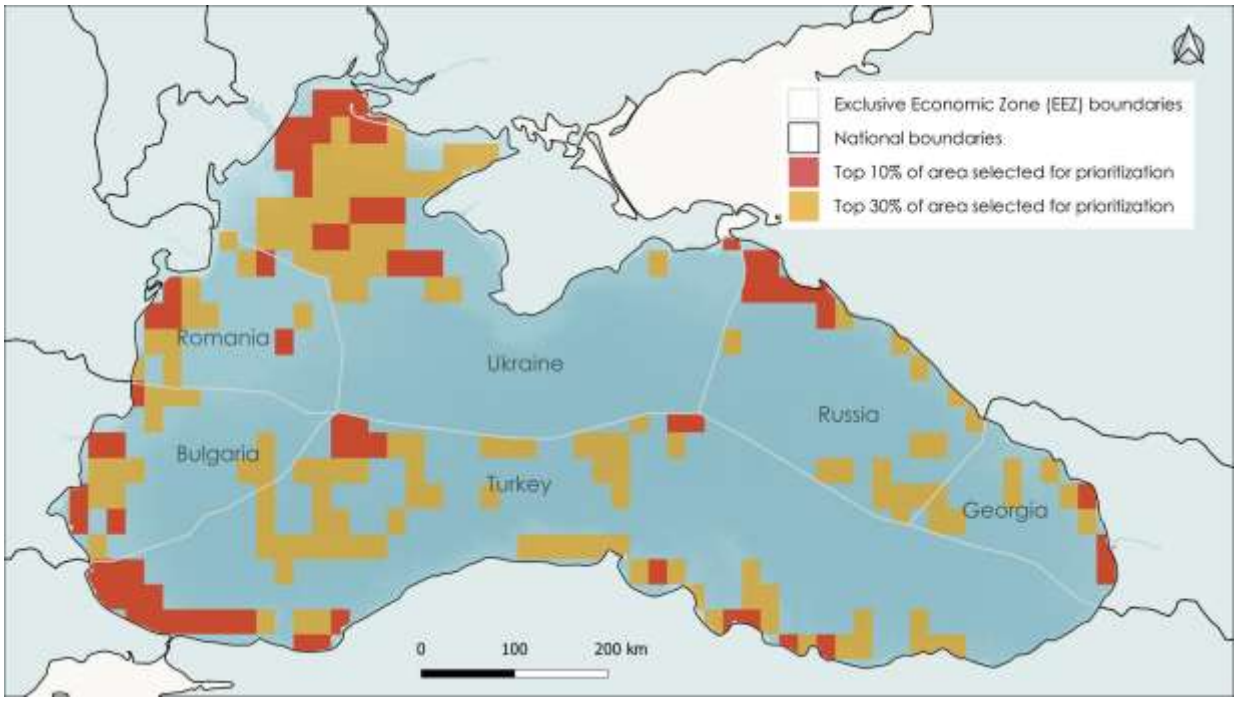
Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP4.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes and balancing biodiversity needs with socio-economic considerations.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: No *MPAs & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 4.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP4.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

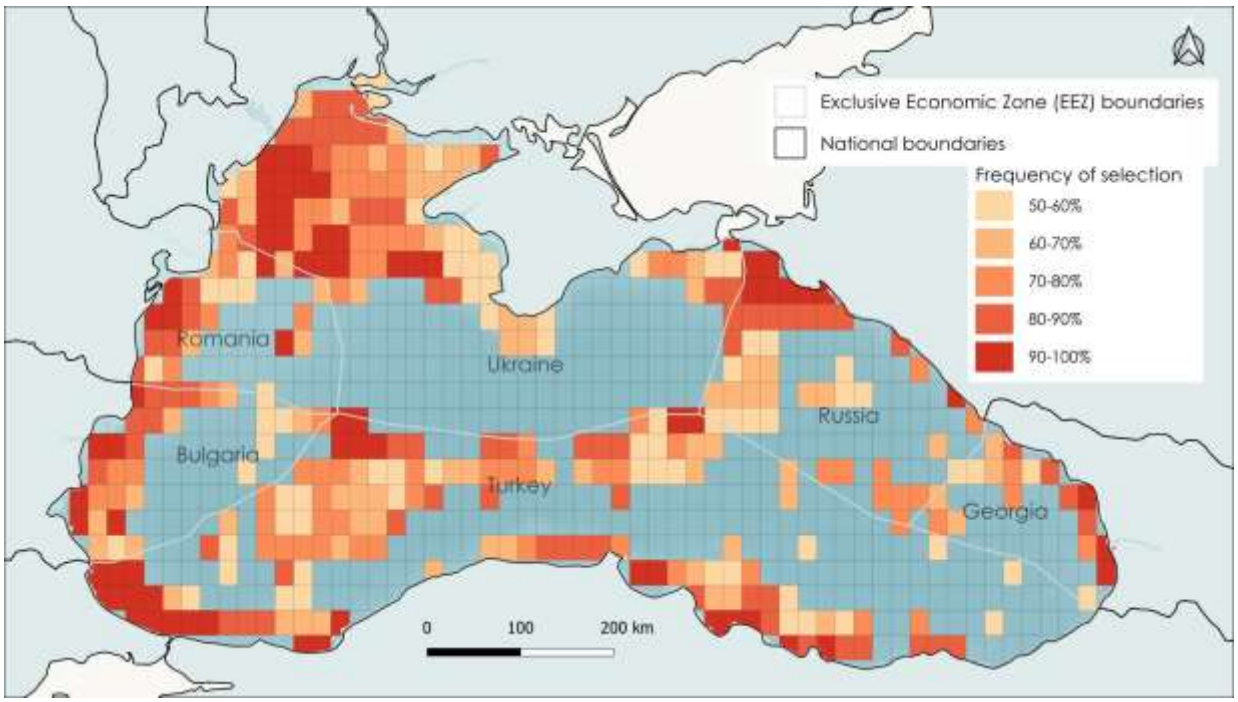
Species weights were applied to give higher conservation priority to areas supporting:

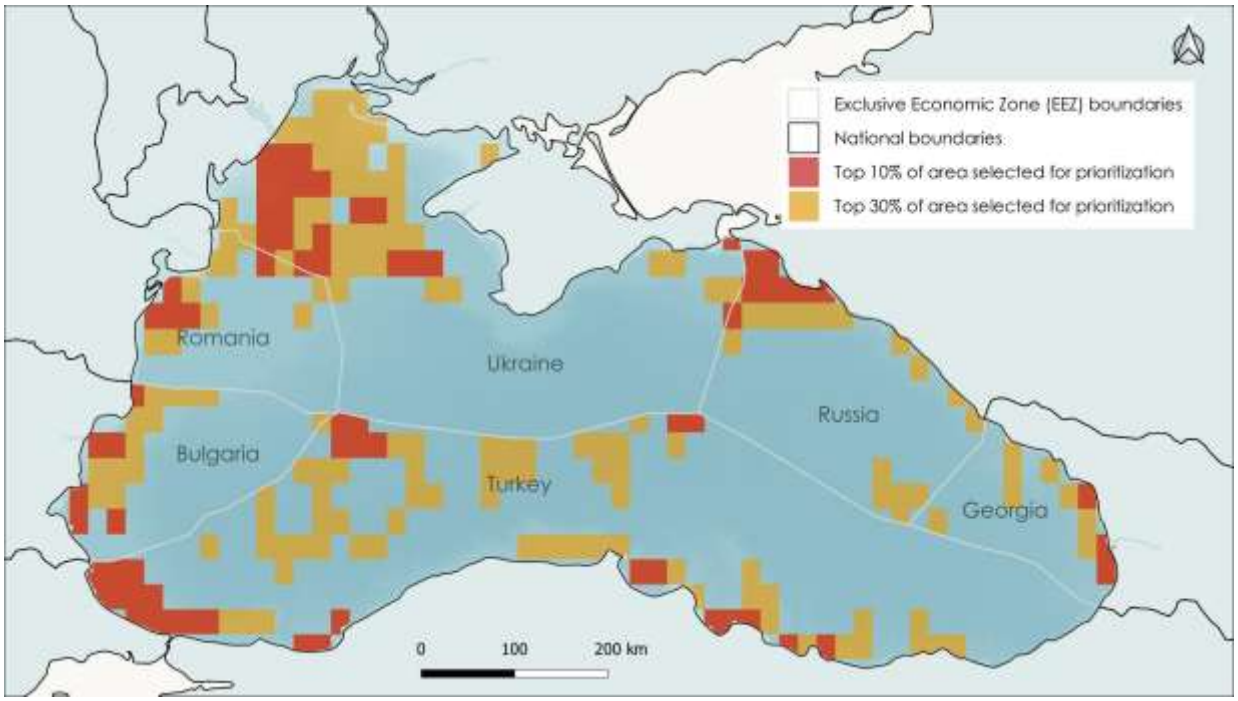
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 4.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP4.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

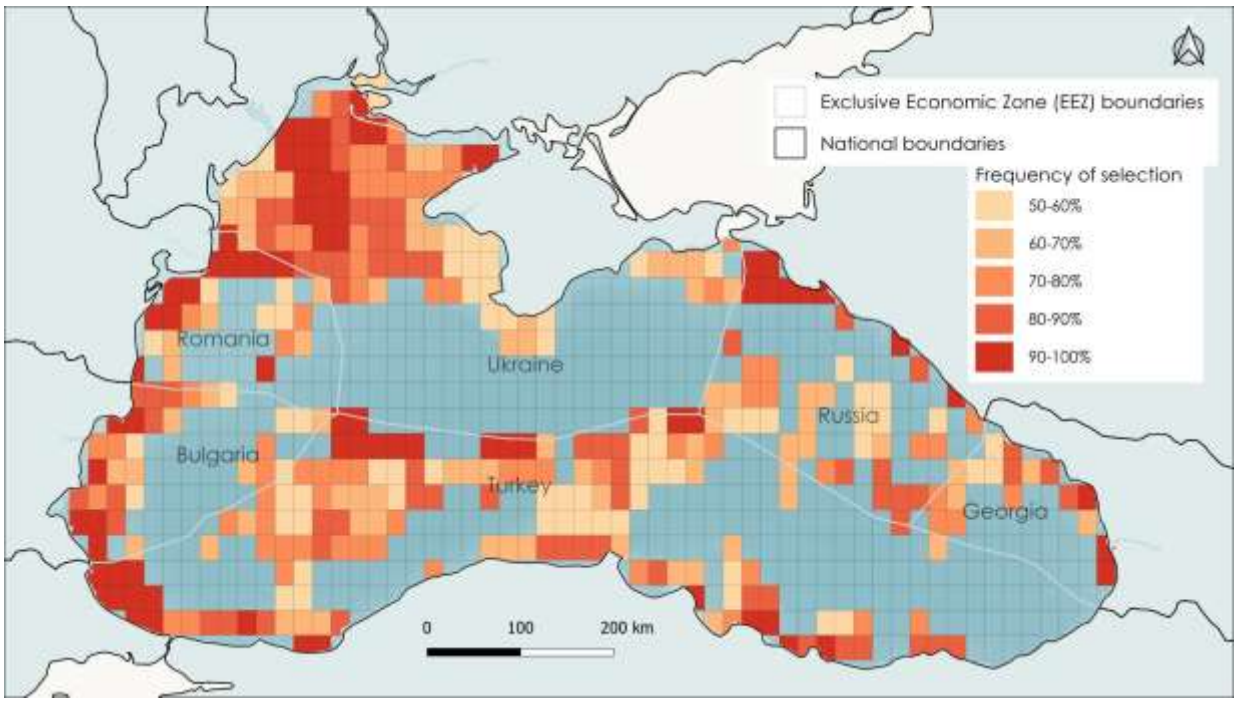
MPAs locked in – what this means & why:

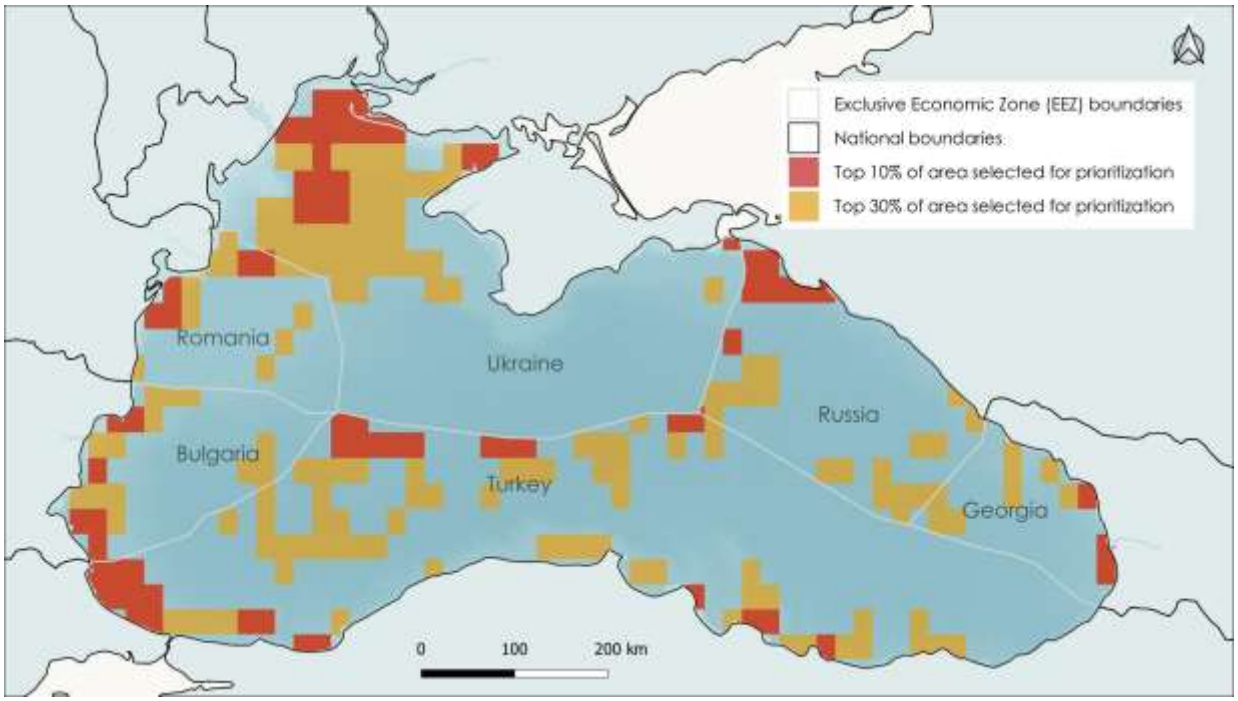
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 4.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP24.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

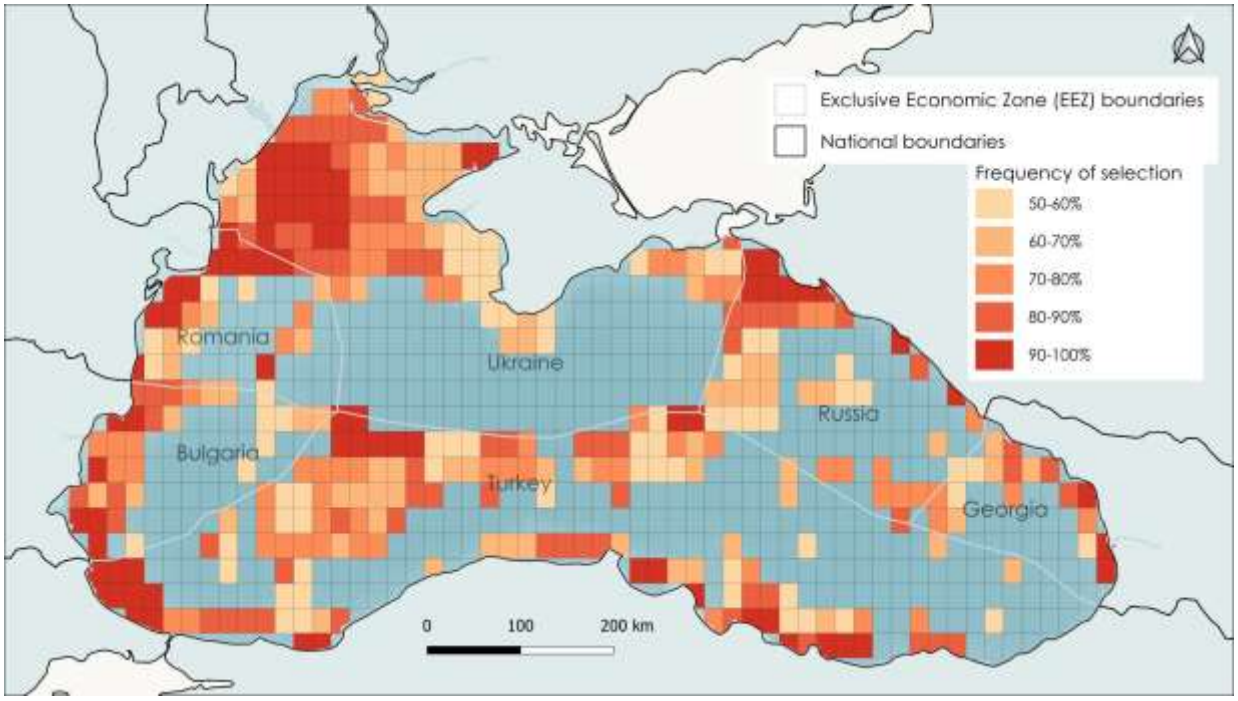
Species weights were applied to give higher conservation priority to areas supporting:

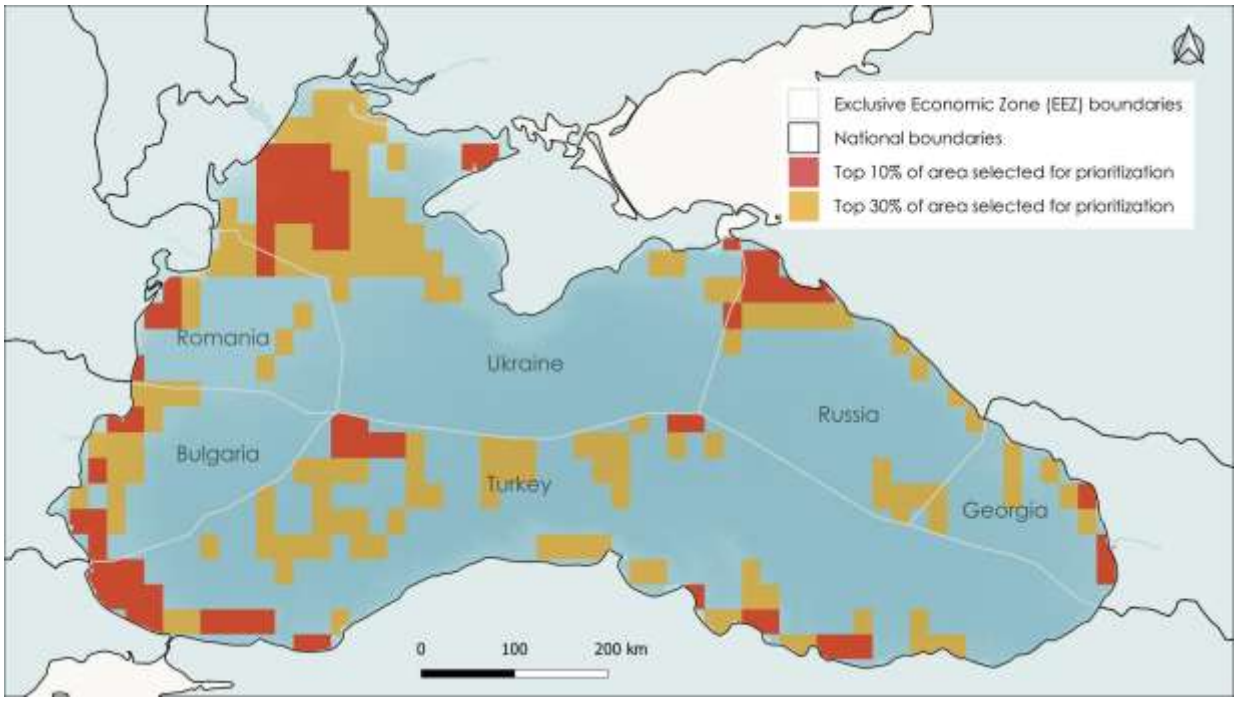
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.





RCP 8.5

Scenario: *Current, accounting for climate change*
Run variant: *No MPAs locked in - no species weights used*

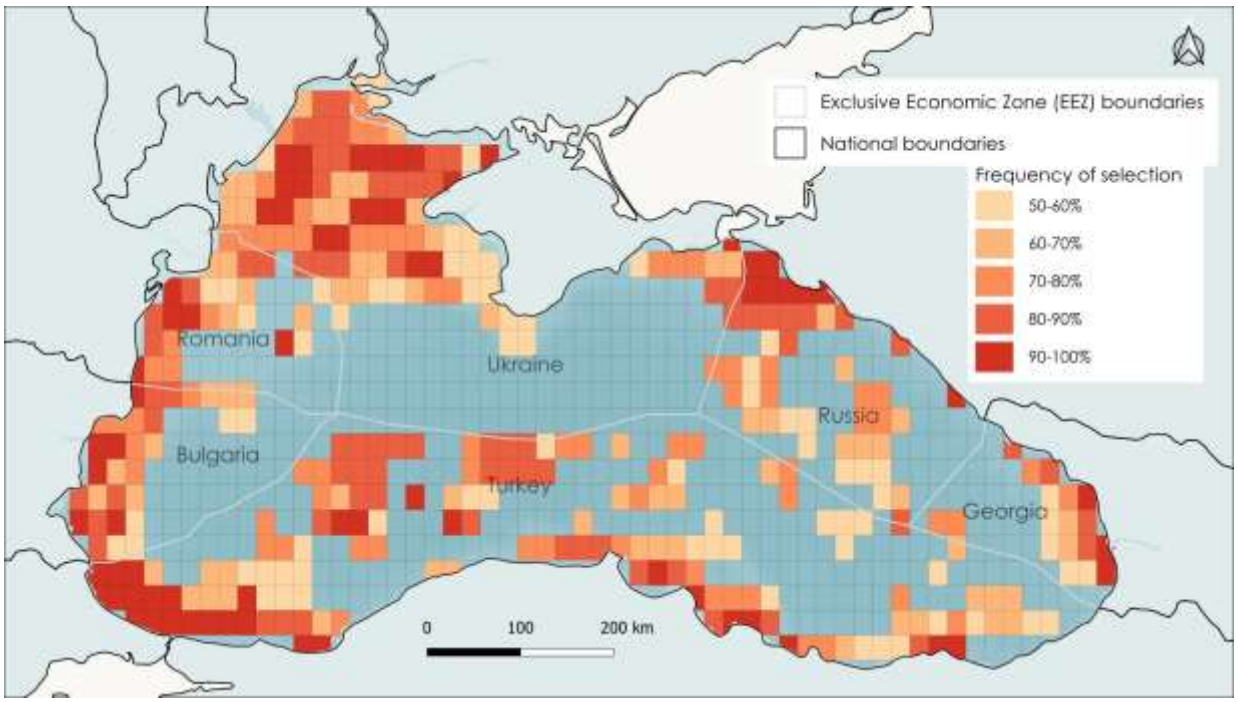
What this scenario represents
This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts.

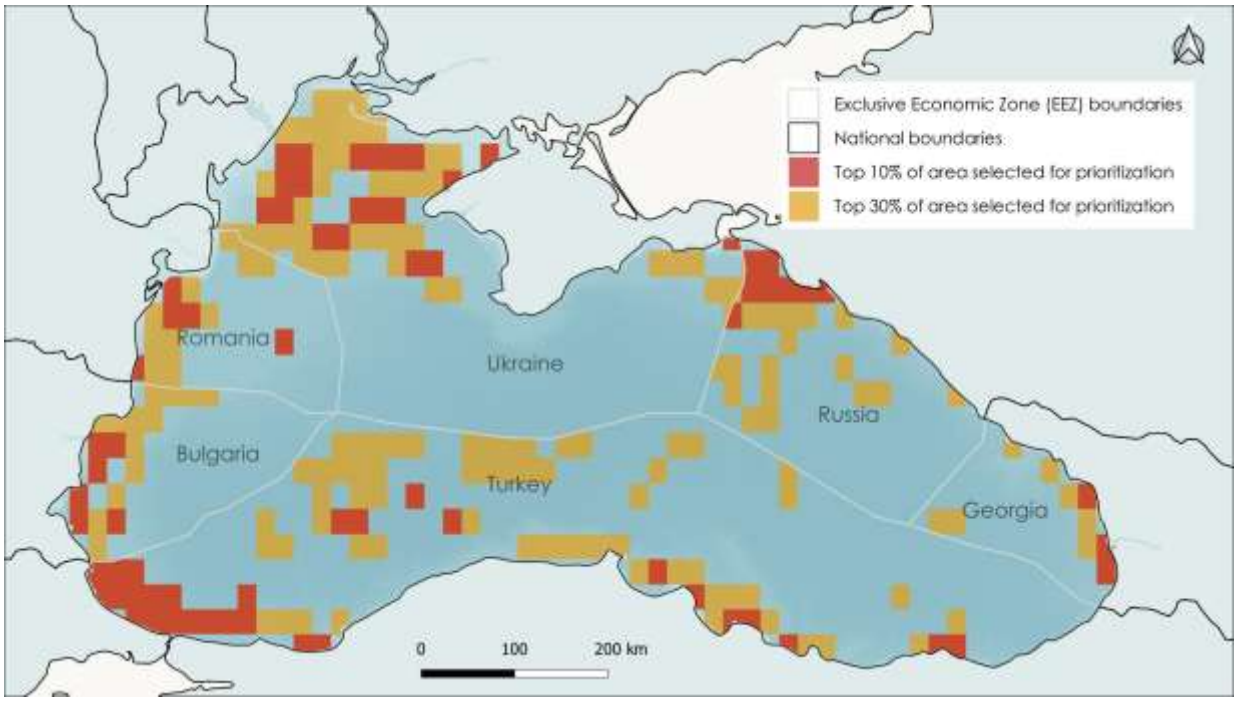
Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary
This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *No MPAs & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

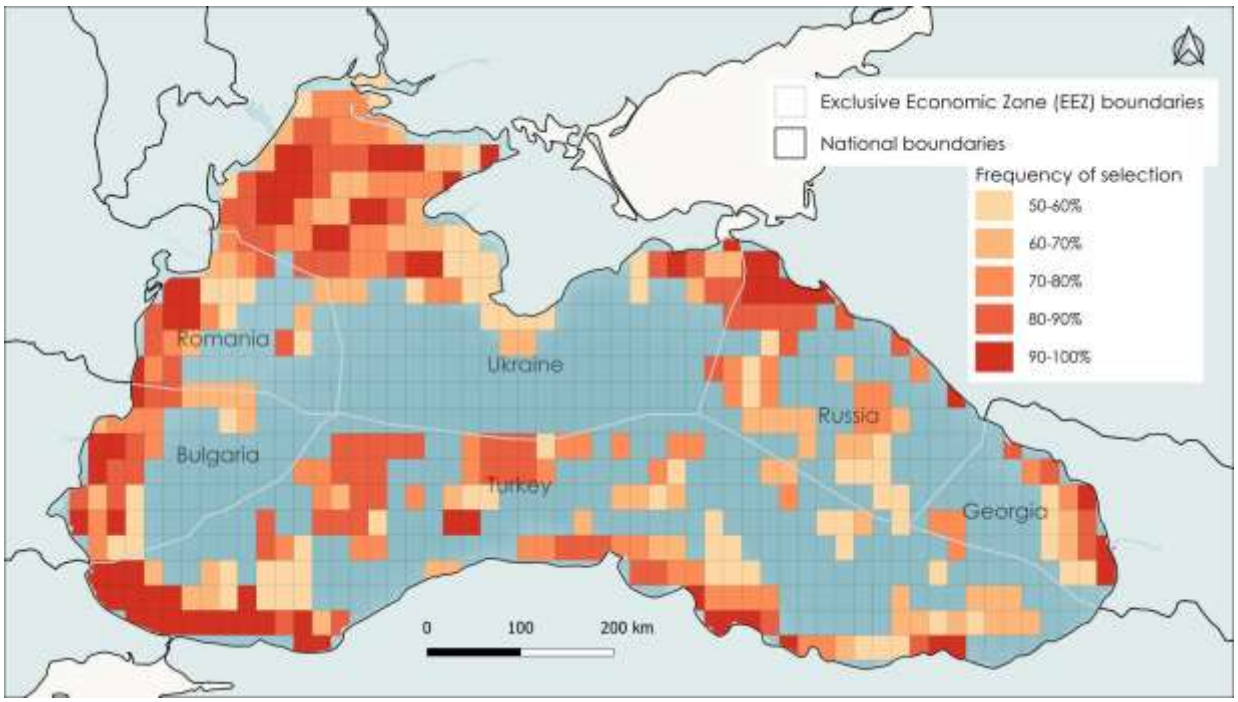
Species weights were applied to give higher conservation priority to areas supporting:

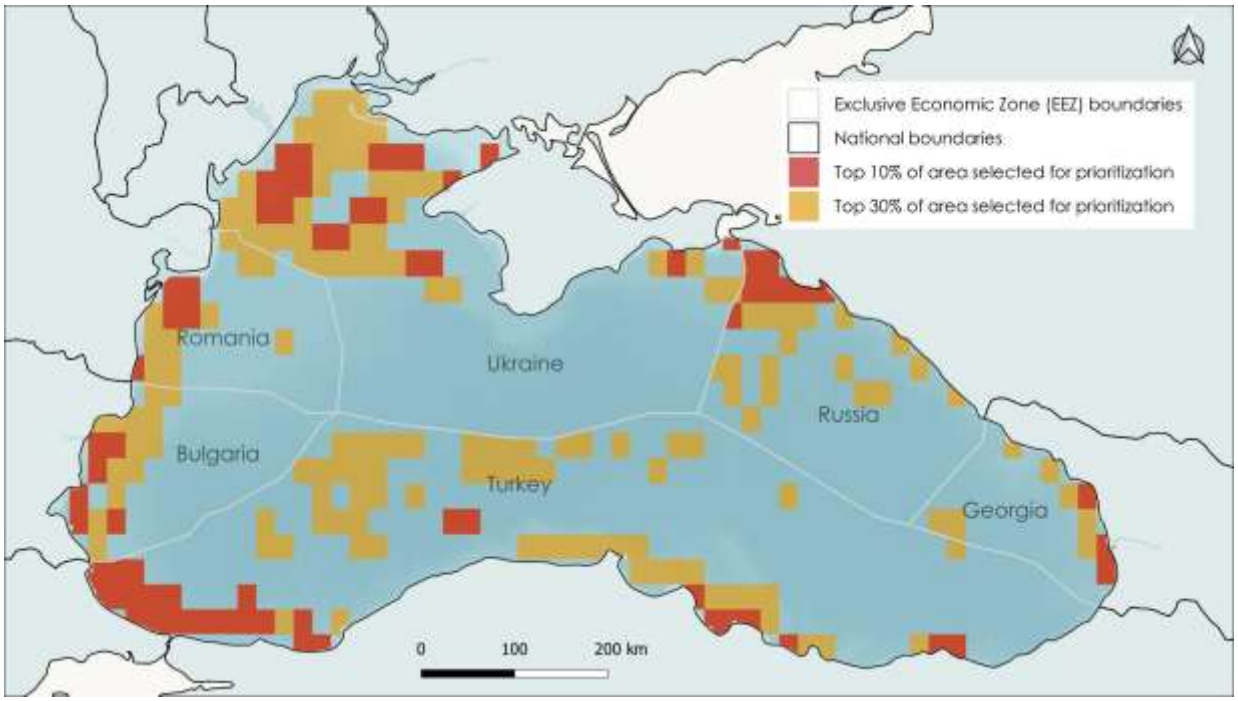
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

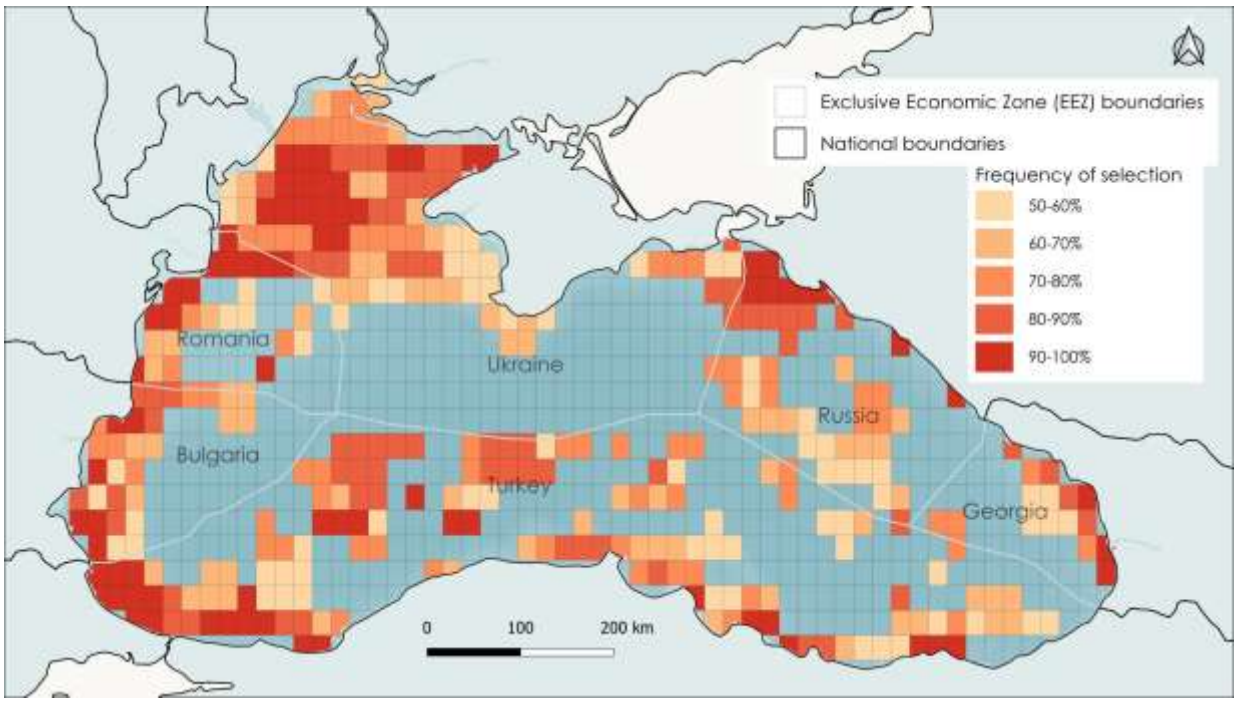
MPAs locked in – what this means & why:

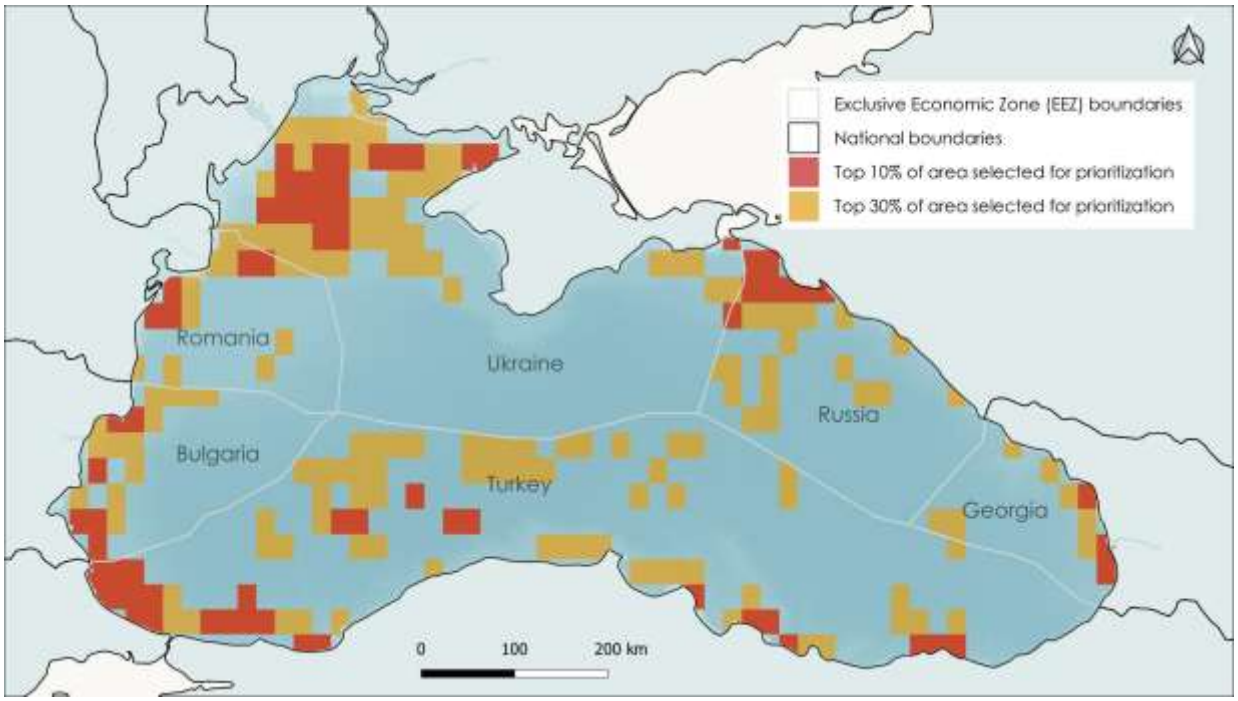
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2050) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2050.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

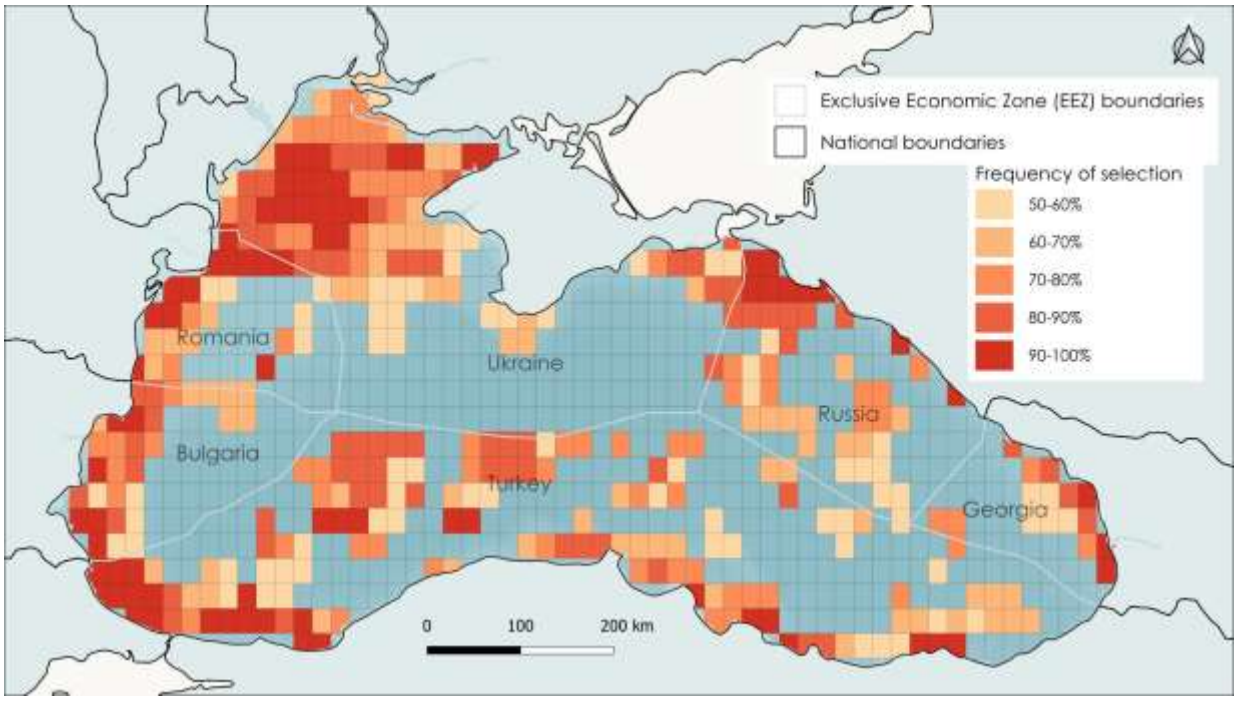
Species weights were applied to give higher conservation priority to areas supporting:

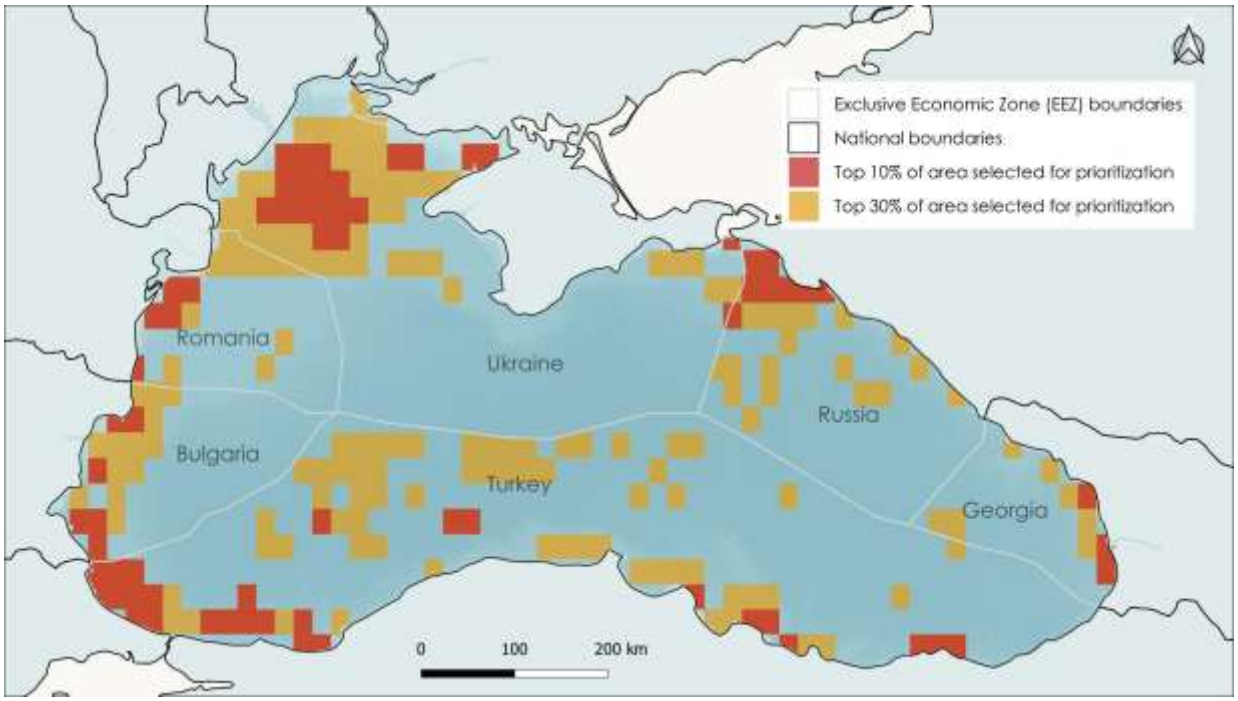
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.





Scenario: *Current, accounting for climate change*
Run variant*: No MPAs locked in - no species weights used*

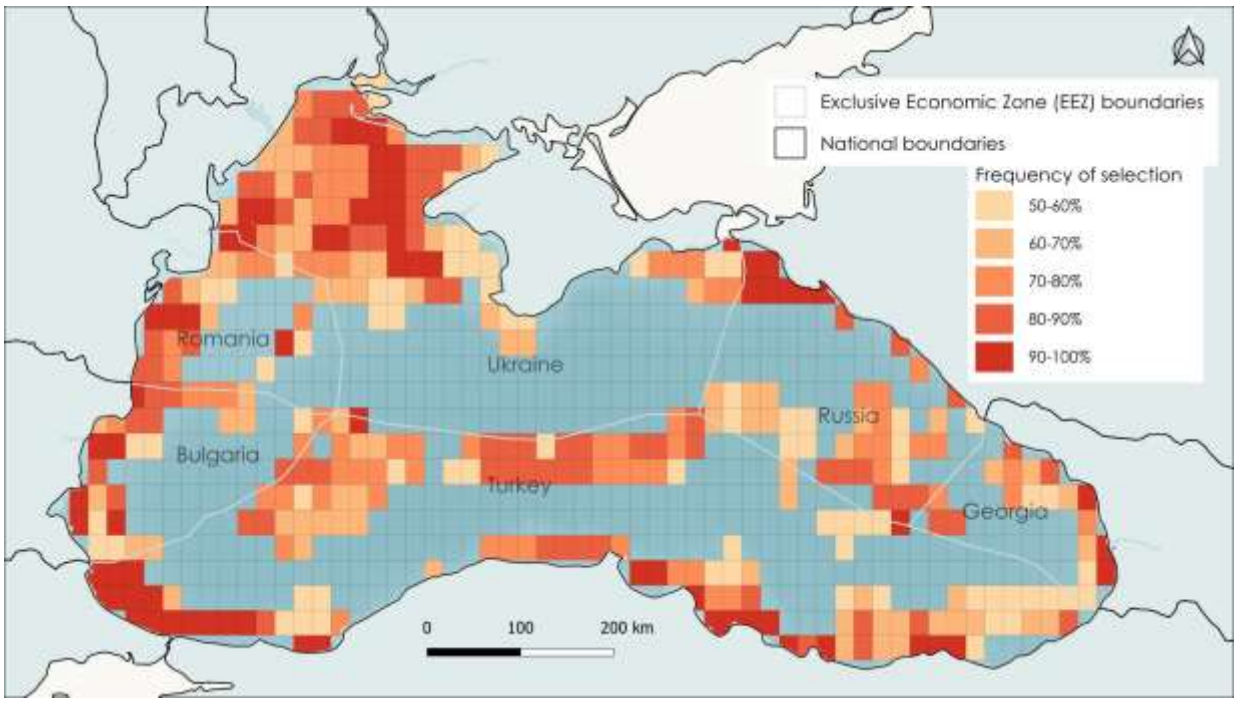
What this scenario represents
This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts.

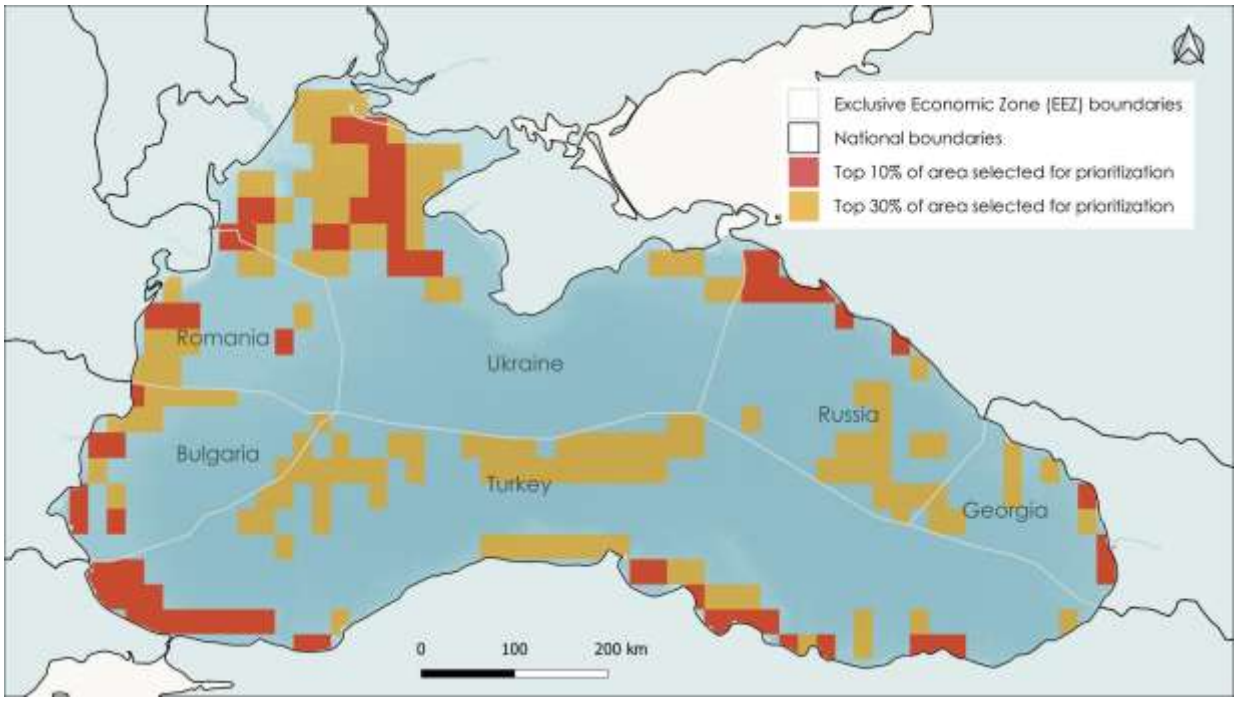
Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Summary
This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *No MPAs locked in - species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

Species weights – what they are & why they are used:

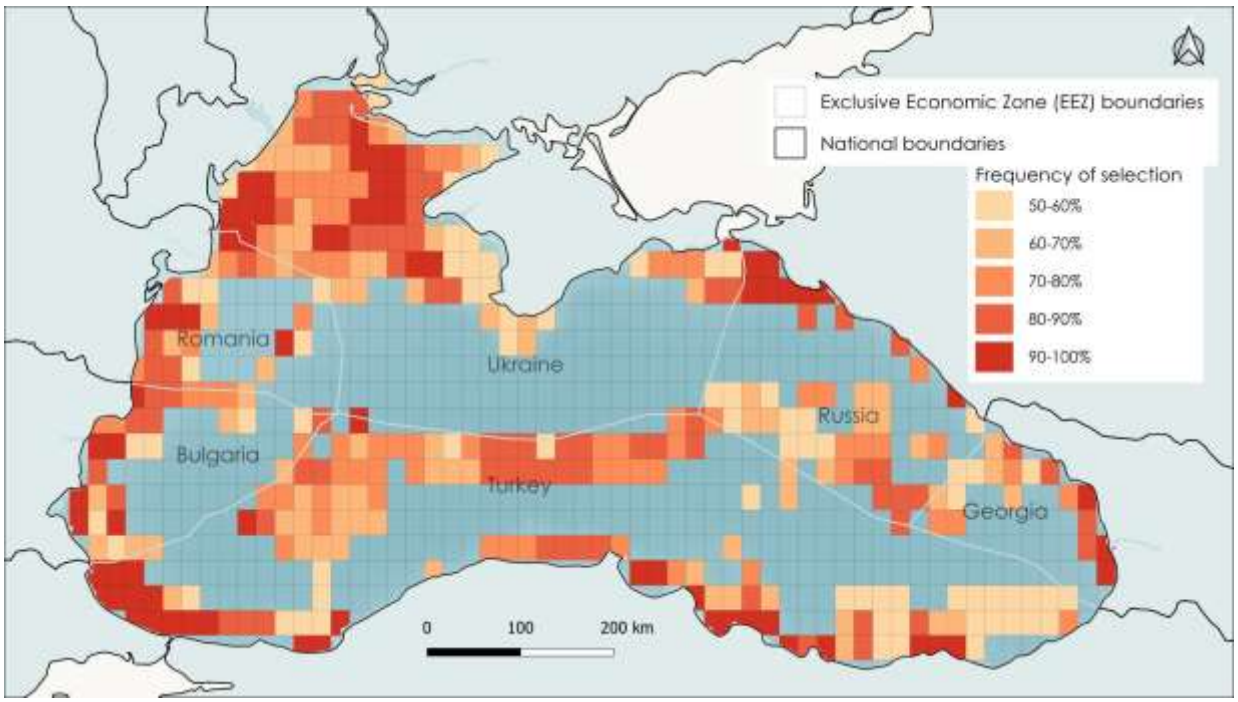
Species weights were applied to give higher conservation priority to areas supporting:

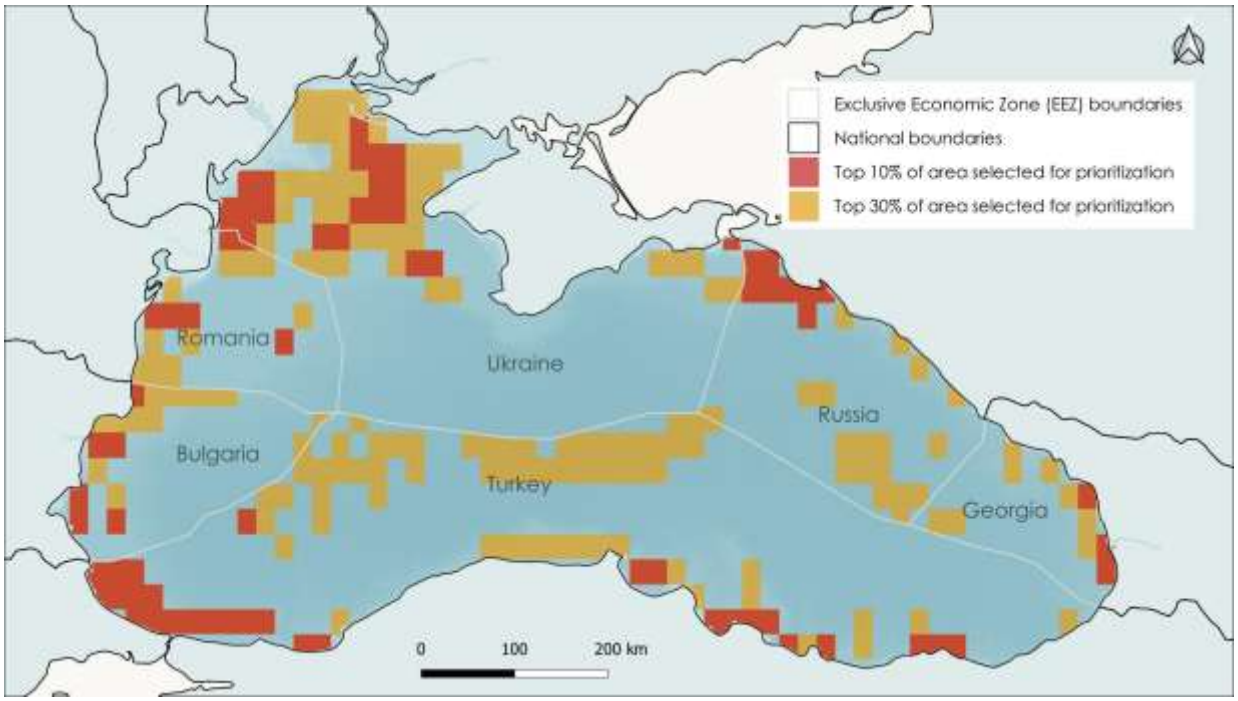
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

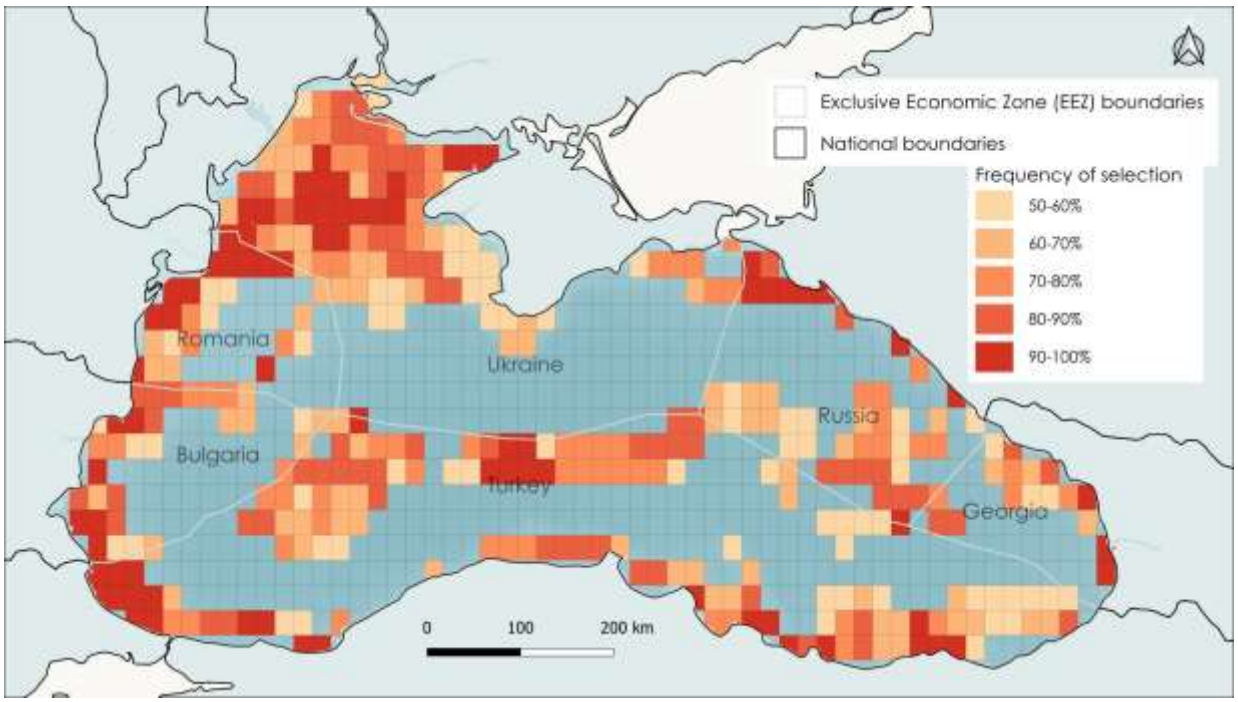
MPAs locked in – what this means & why:

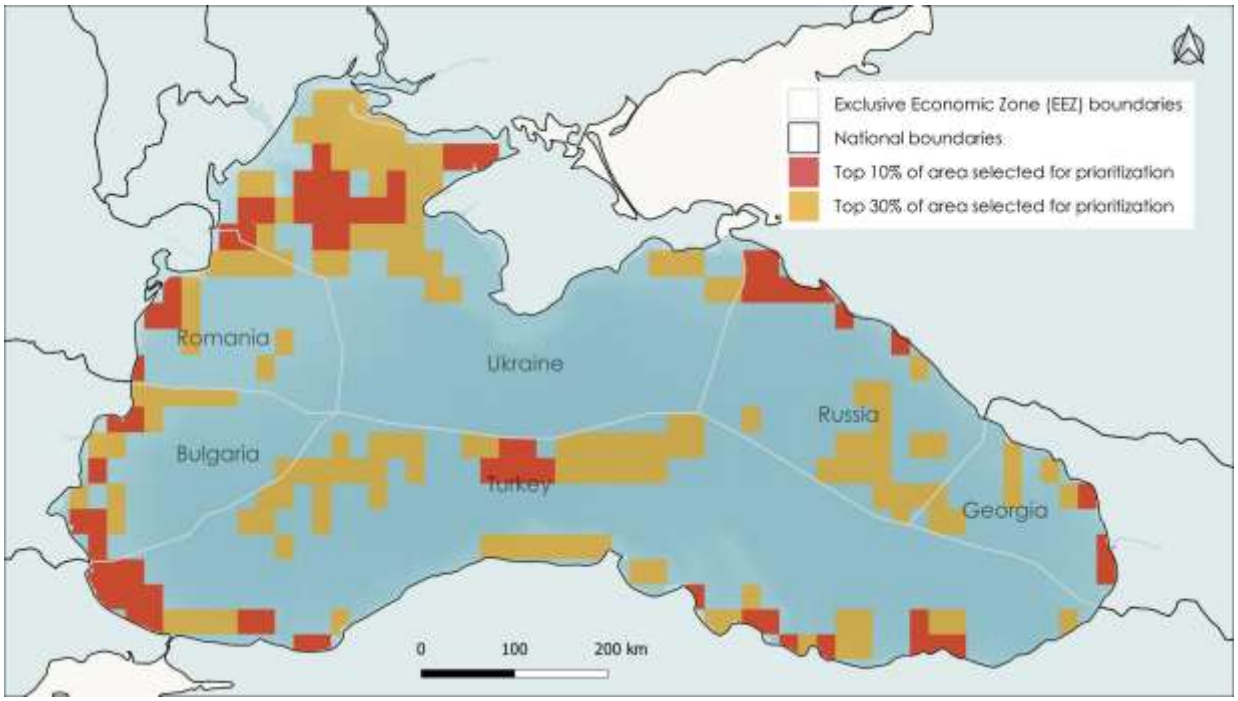
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Current, accounting for climate change*
Run variant: *MPAs locked in & species weights used*

What this scenario represents

This run identifies conservation priority areas based on current and near future (Representative Concentration Pathway 8.5 – for the year 2100) species distributions in the Black Sea and areas where human activity might pose a challenge on conservation efforts, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:

The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used

- Current species distributions: Species distributions under current environmental conditions.
- Future species distributions: Species distributions based on species distribution models projected under RCP8.5 for the year 2100.
- Habitat refugia: Areas where species are likely to persist both under present and future environmental conditions, remaining suitable under climate change, helping safeguard biodiversity in the long term.
- Socio-economic costs: Spatially explicit data on fishing effort divided by gear types (pelagic long-liners, purse seiners, trawlers, small-scale static gears), locations of major ports and offshore platforms, intensity of marine traffic and areas of heavy anchorage. These costs represent human activities that can cause conflict with conservation actions, guiding the prioritization to select areas with lower economic impact.
- Connectivity data: Data on ocean currents was used to calculate connectivity metrics and highlight critical locations of the Black Sea that play a central role in maintaining ecological connectivity, based on Google's PageRank algorithm.

MPAs locked in – what this means & why:

In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).

This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:

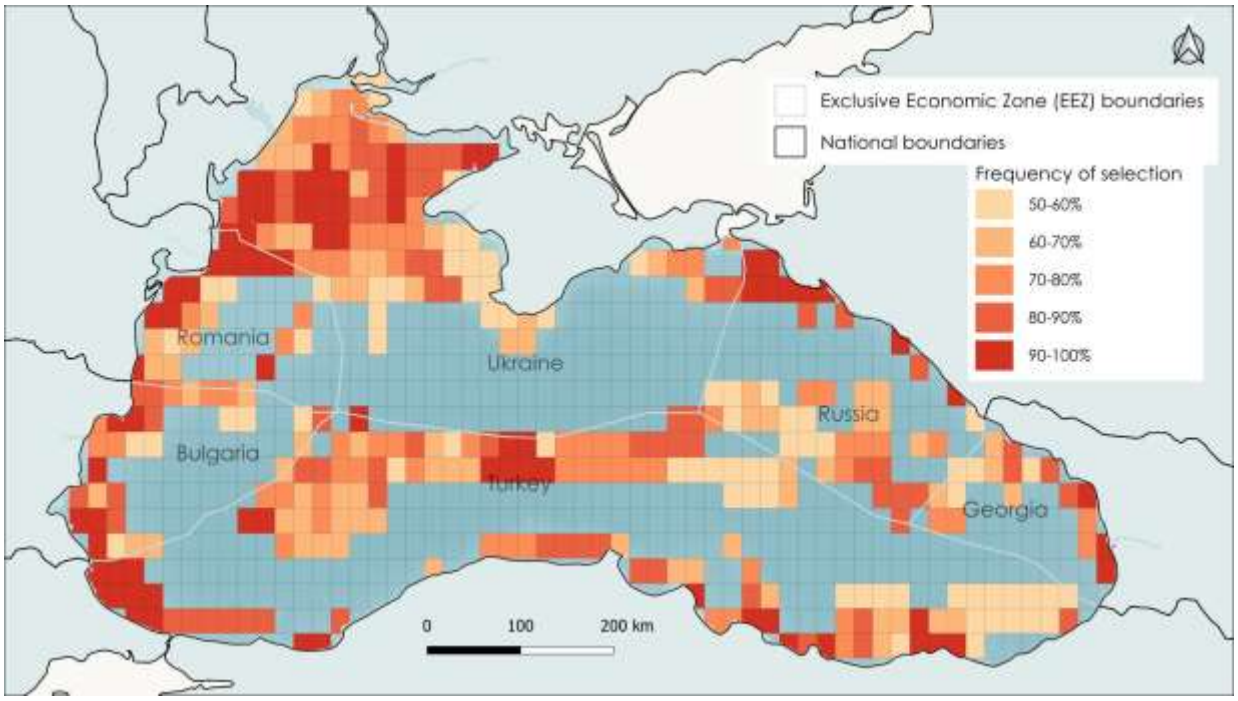
Species weights were applied to give higher conservation priority to areas supporting:

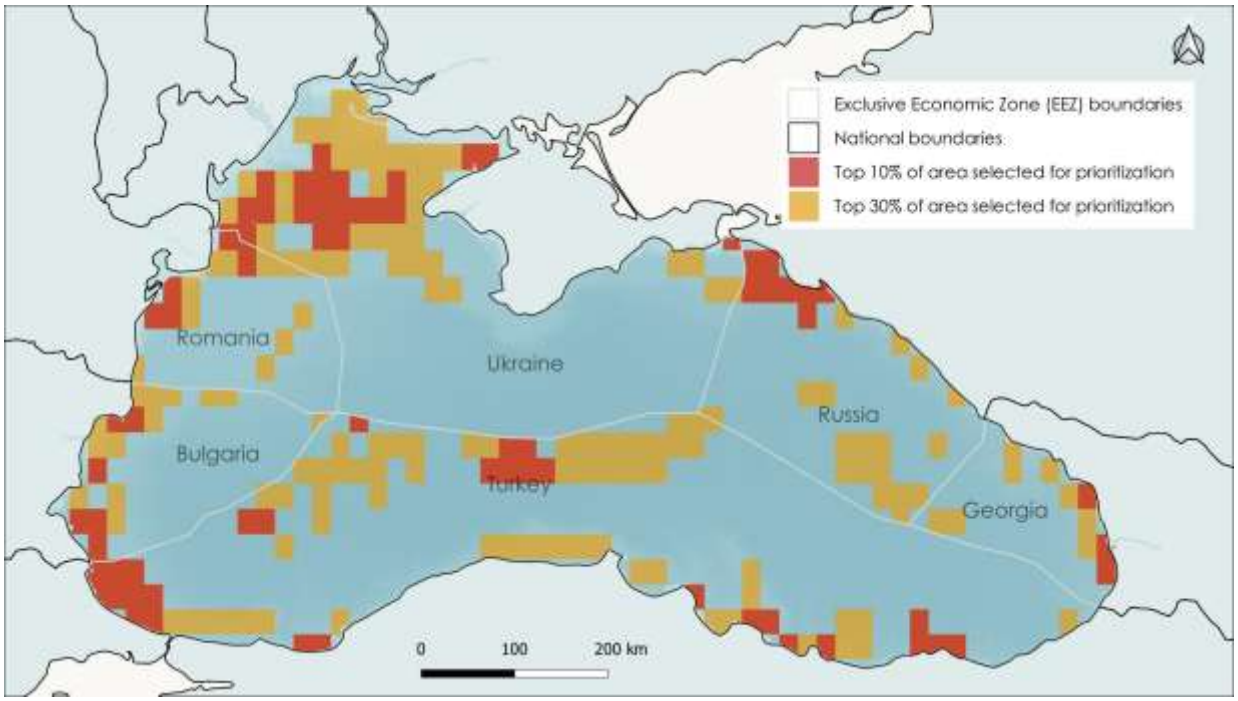
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario provides a reference view of current biodiversity priorities while simultaneously identifying areas more likely to remain suitable as climate changes, balancing biodiversity needs with socio-economic considerations, ensuring the existing MPA network is respected and emphasizing protection for the most threatened and endemic species.





Future distribution of species under climate change scenarios

RCP 2.6

Scenario: *Future – RCP2.6 2050*
Run variant: *No MPAs locked in - no species weights used*

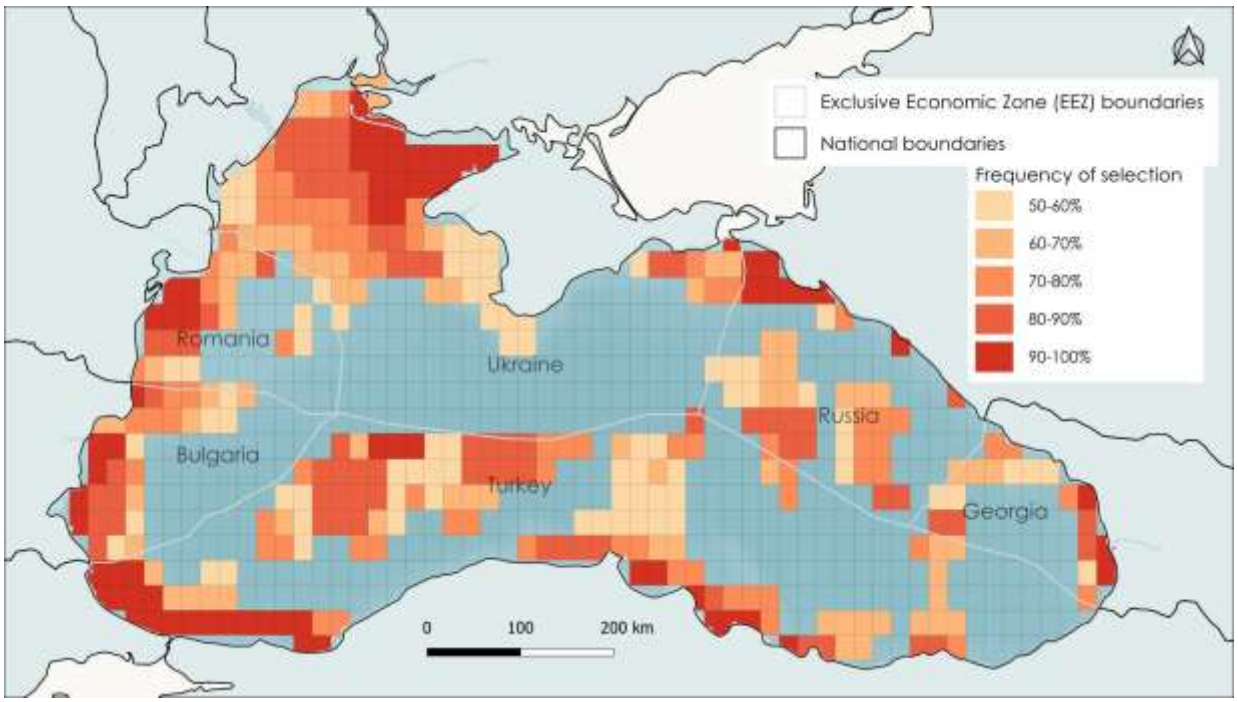
What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change.

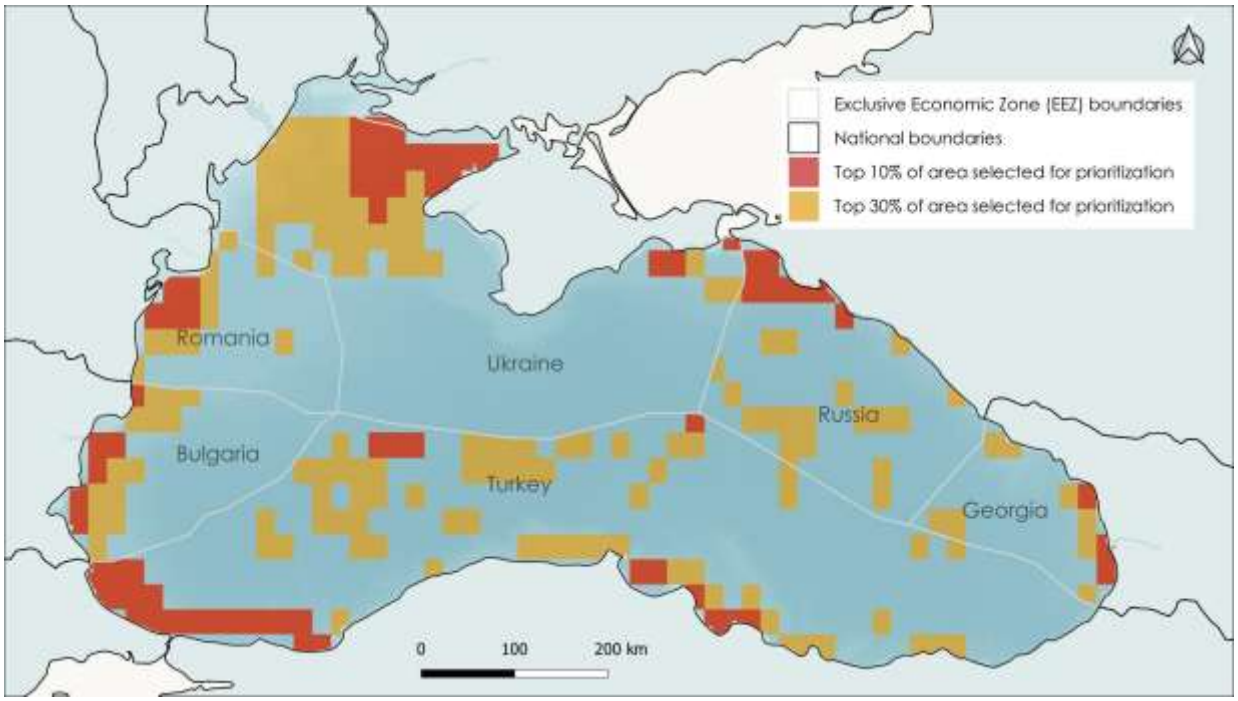
Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used:

- Future species distributions (RCP2.6 2050): Species distributions under projected climate conditions.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP2.6), taking into account purely biodiversity needs.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP2.6 2050*
Run variant: *No MPAs - species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used:

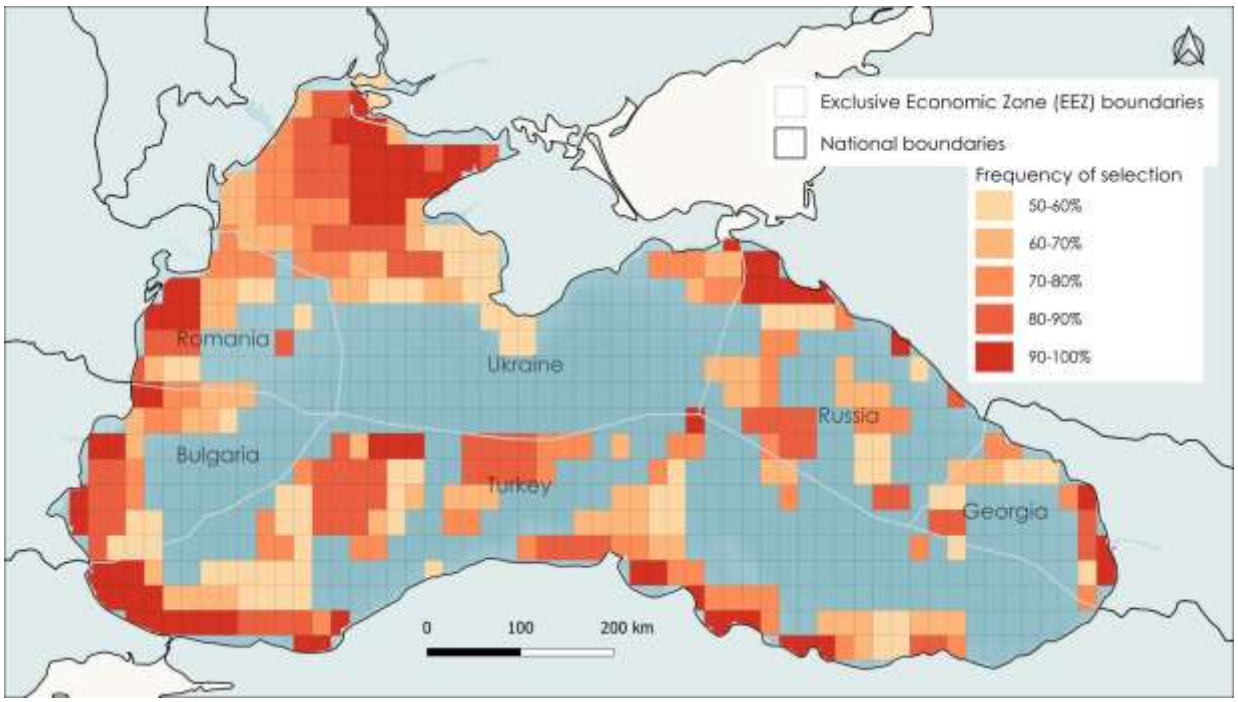
- Future species distributions (RCP2.6 2050): Species distributions under projected climate conditions.

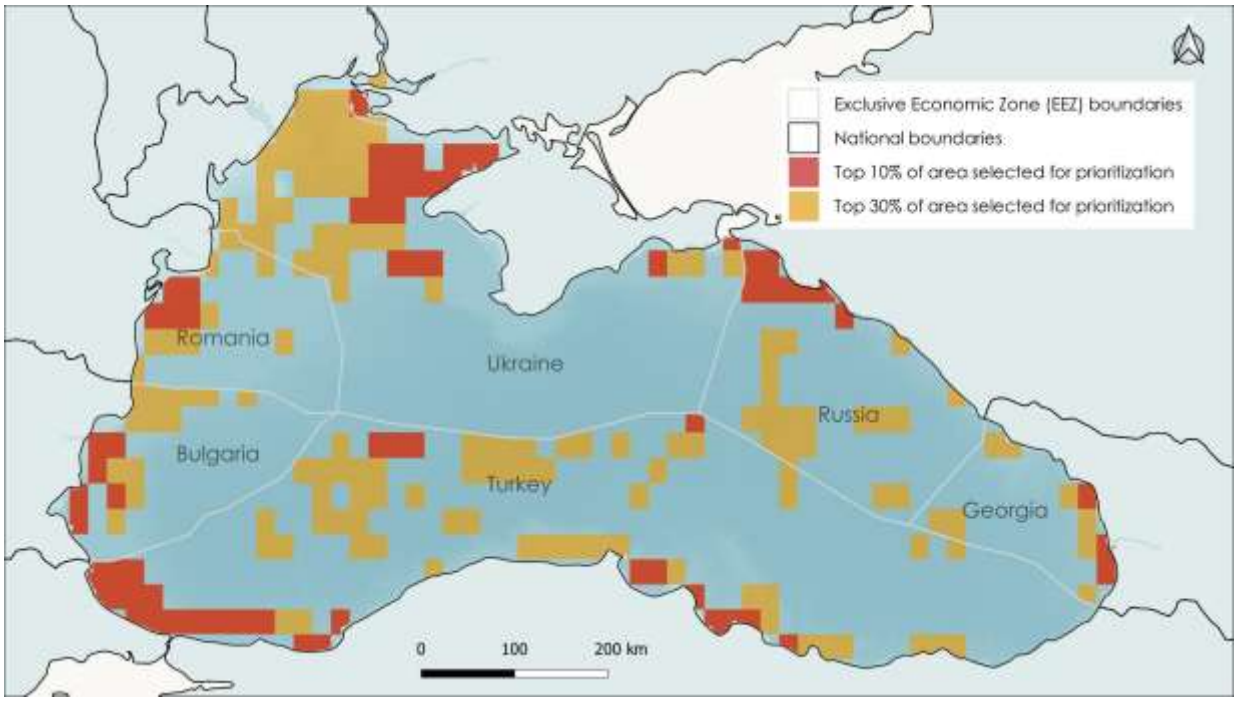
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP2.6), taking into account biodiversity needs, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP2.6 2050*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

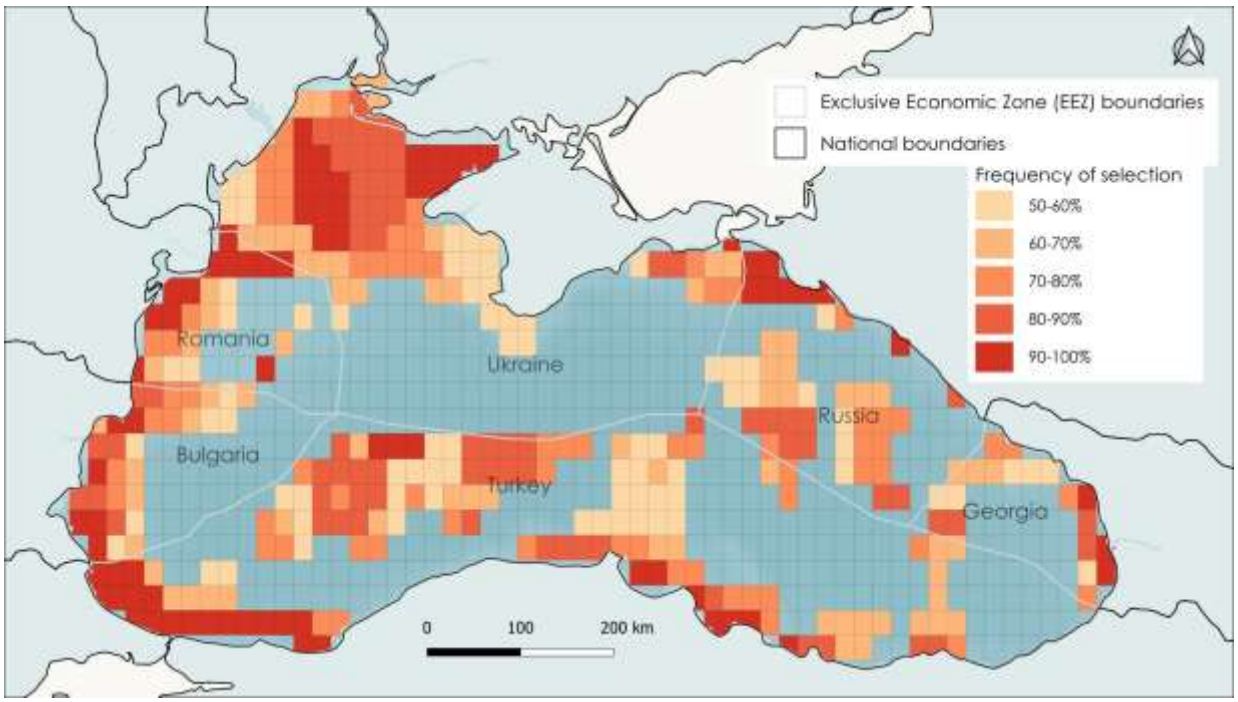
Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

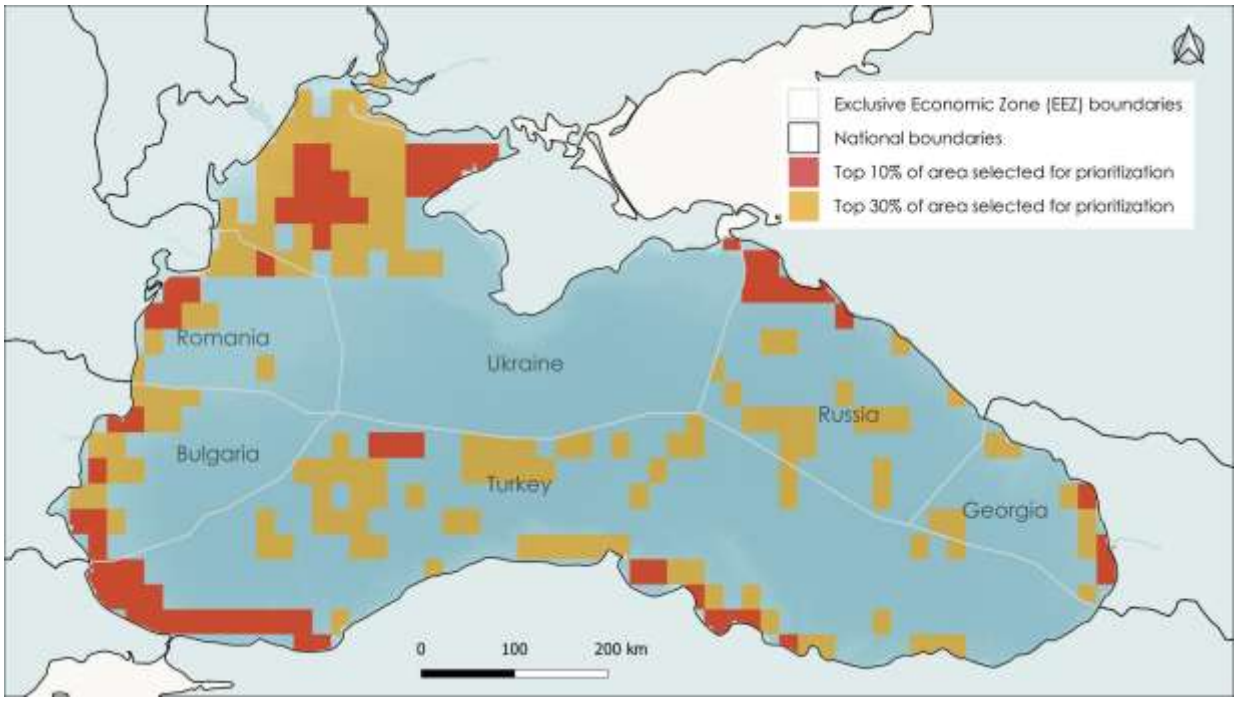
Data and inputs used:

- Future species distributions (RCP2.6 2050): Species distributions under projected climate conditions.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP2.6), taking into account biodiversity needs, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP2.6 2050*
Run variant: *MPAs locked in & species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used:

- Future species distributions (RCP2.6 2050): Species distributions under projected climate conditions.

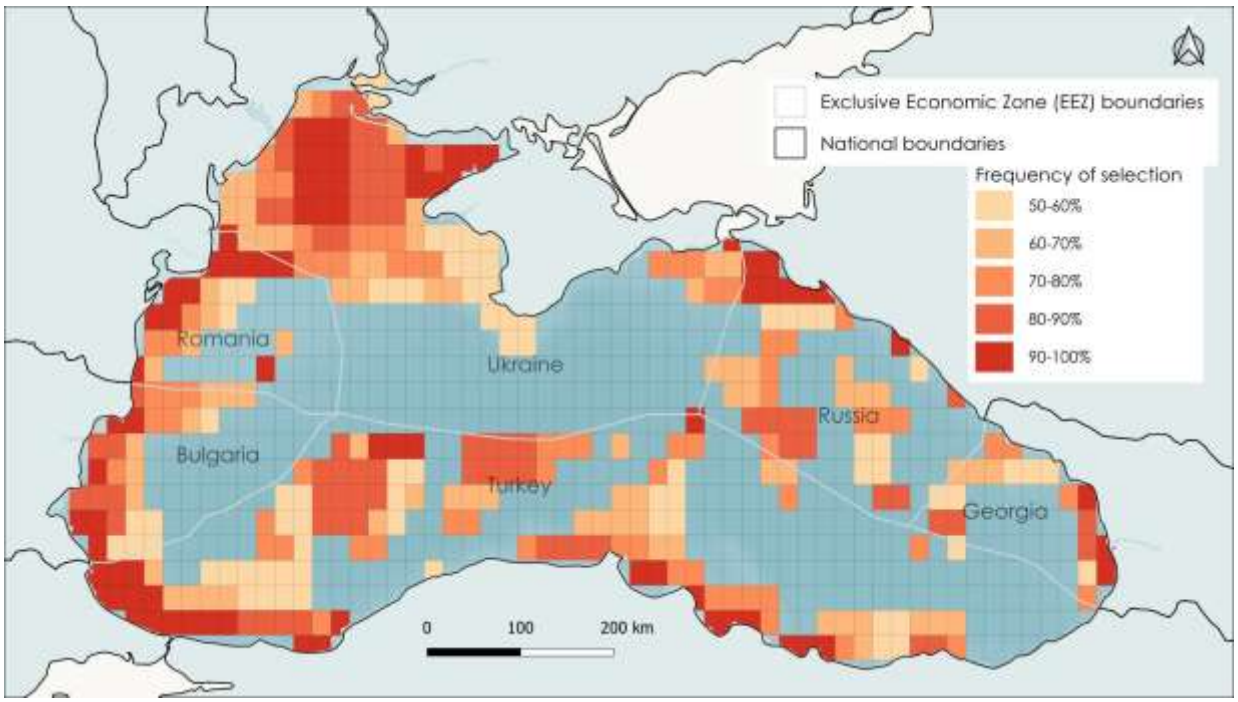
MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

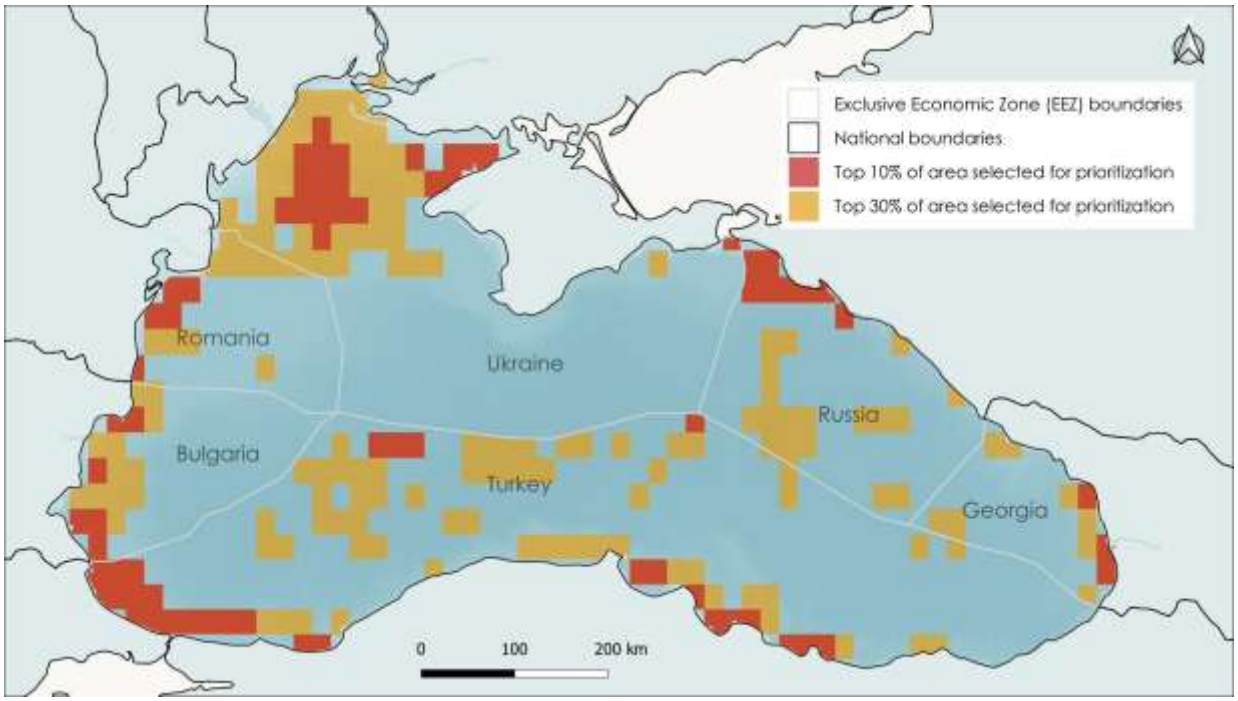
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP2.6), taking into account biodiversity needs, ensuring the existing MPA network is respected, and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP2.6 2100*
Run variant: *No MPAs locked in - no species weights used*

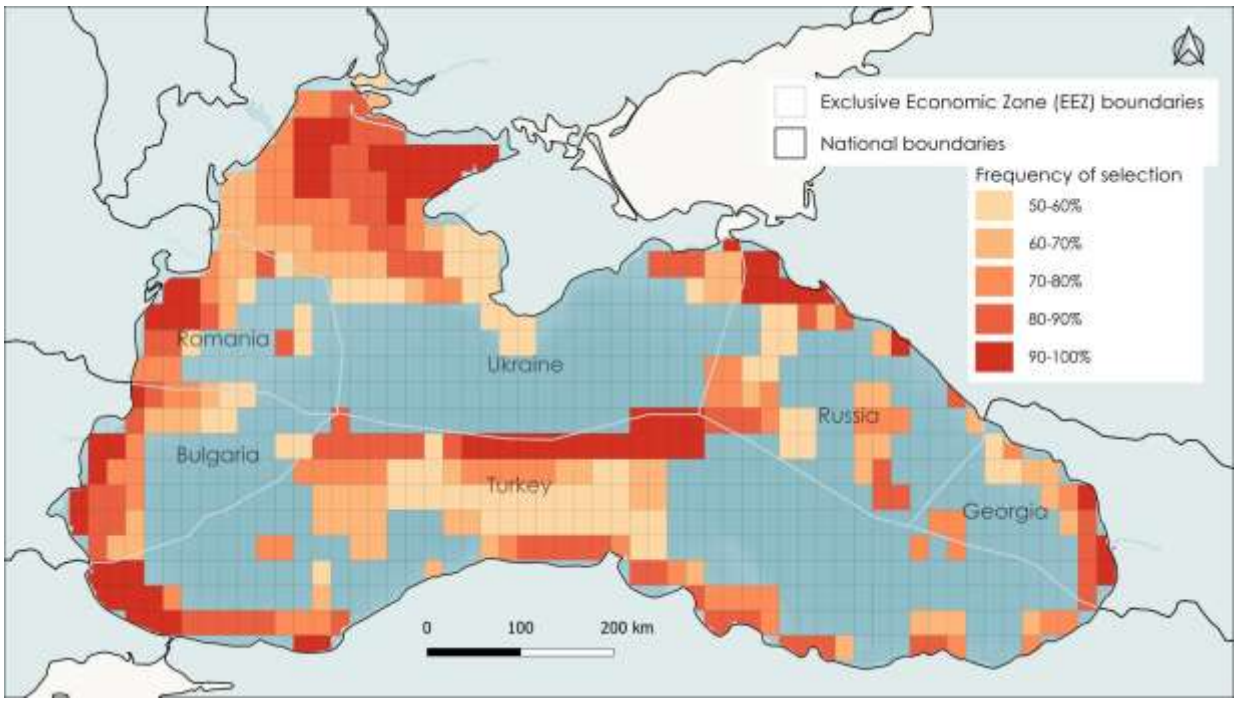
What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change.

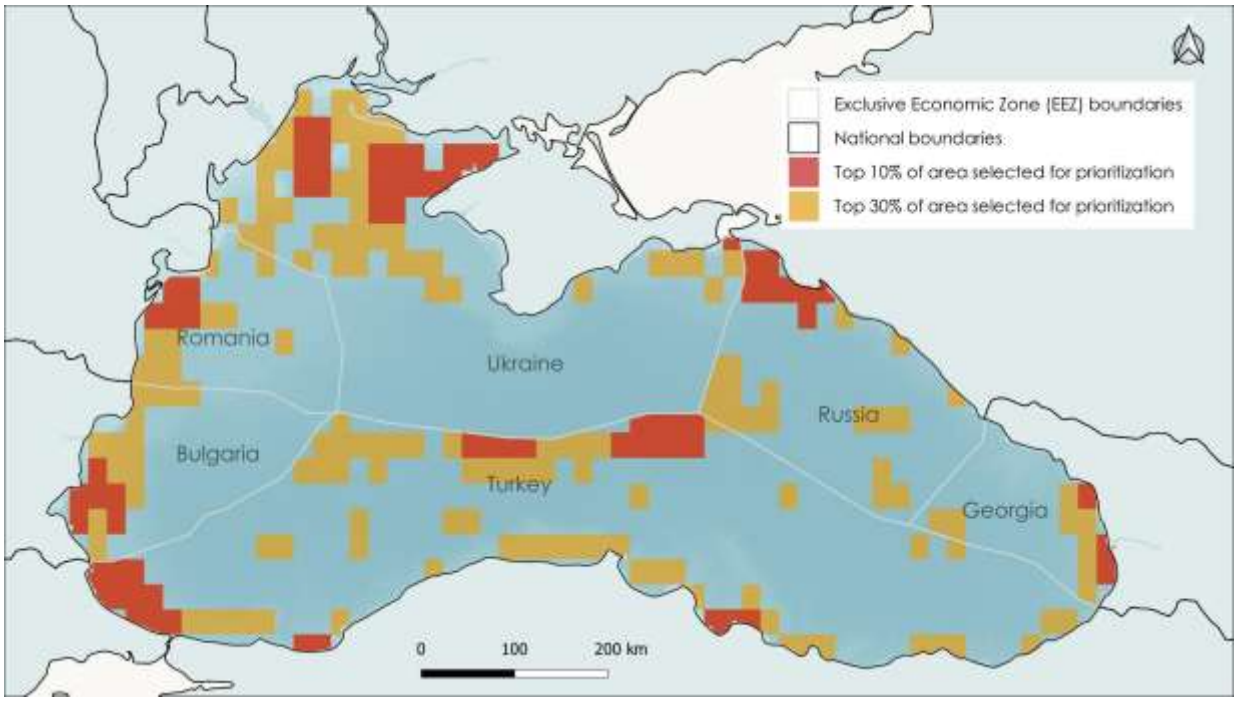
Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used:

- Future species distributions (RCP2.6 2100): Species distributions under projected climate conditions.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP2.6), taking into account purely biodiversity needs.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP2.6 2100*
Run variant: *No MPAs - species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used:

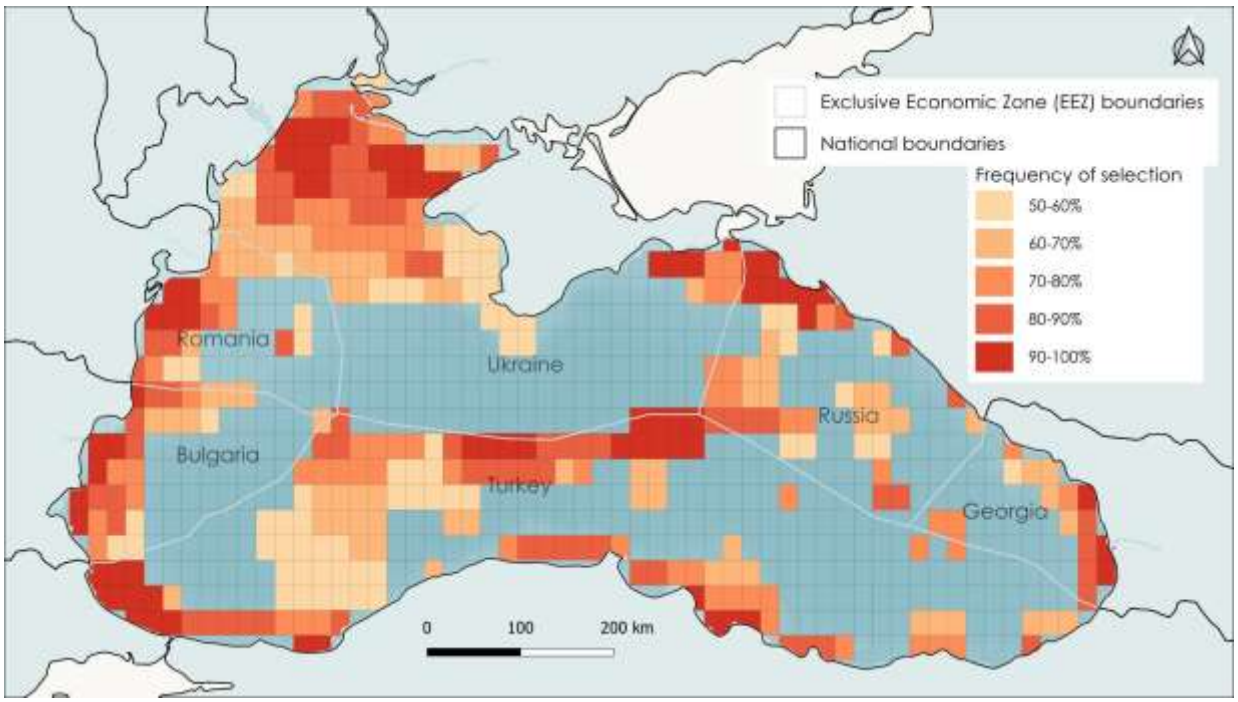
- Future species distributions (RCP2.6 2100): Species distributions under projected climate conditions.

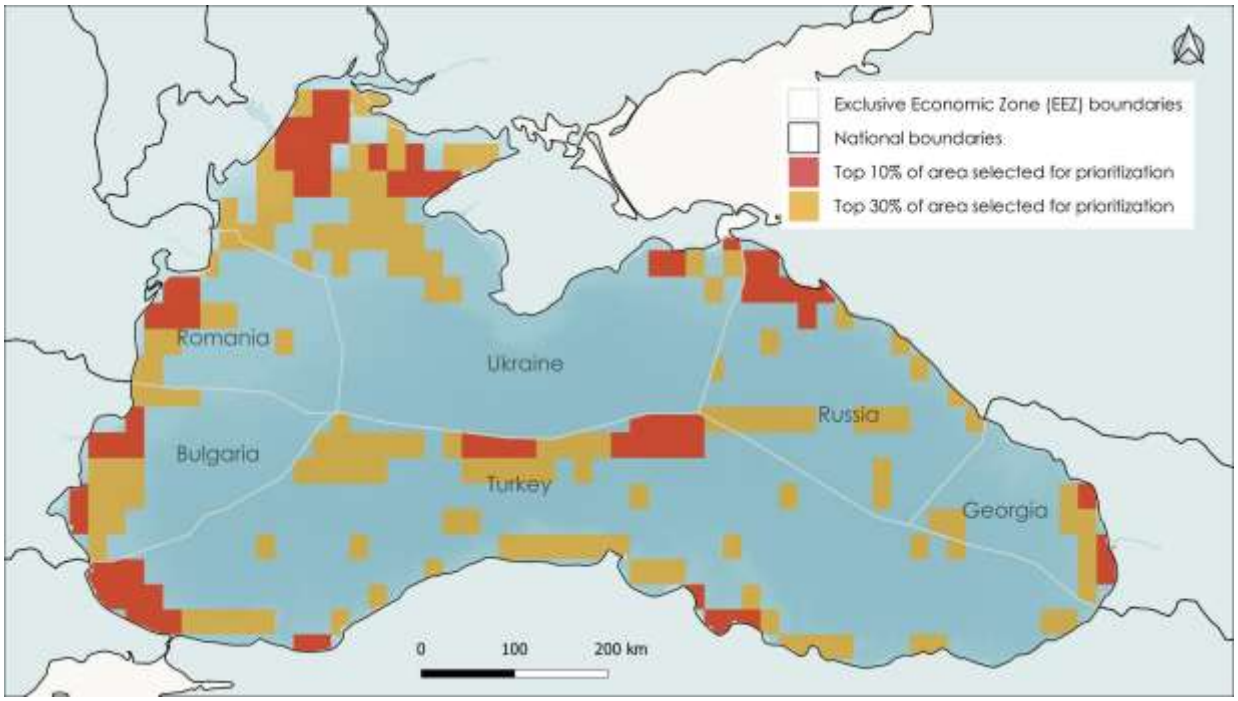
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP2.6), taking into account biodiversity needs, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP2.6 2100*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

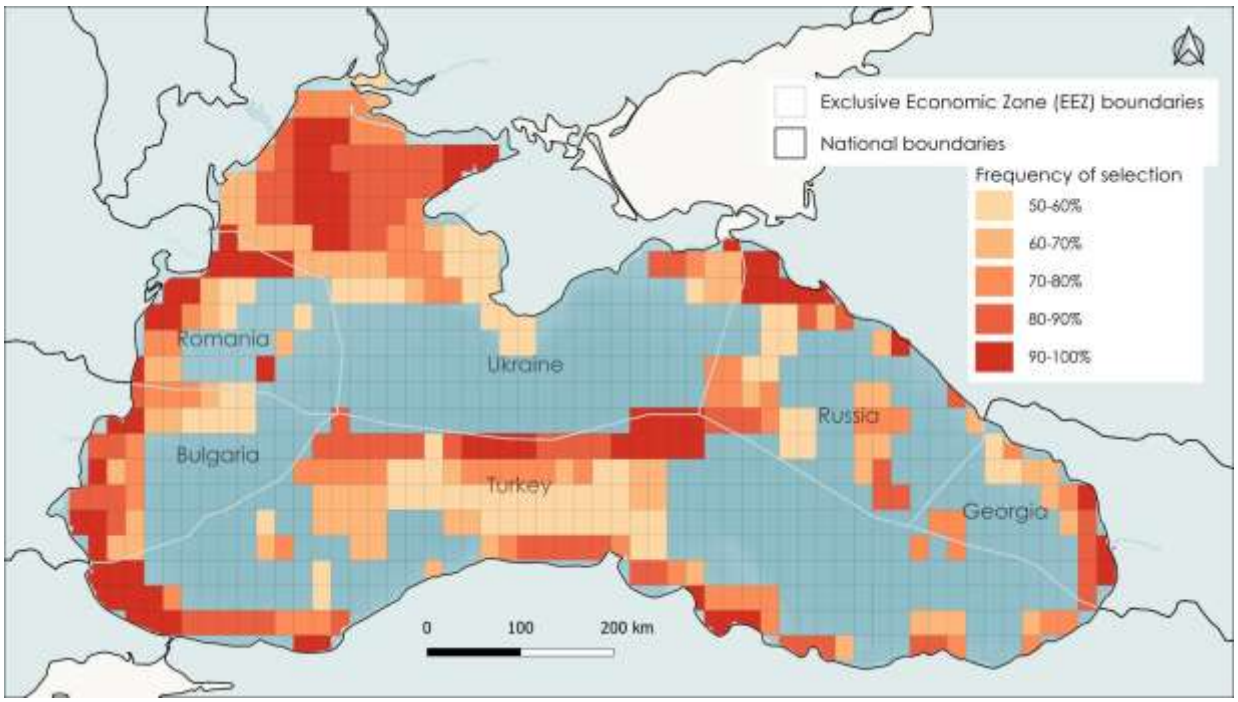
Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

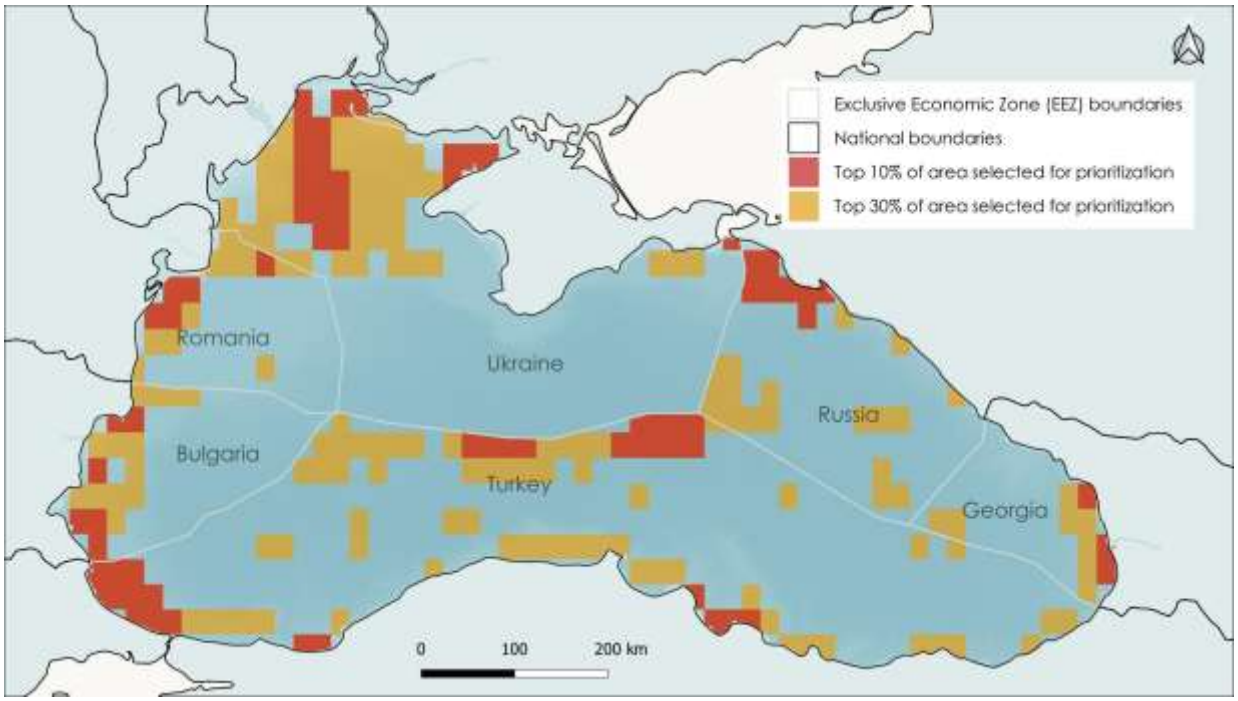
Data and inputs used:

- Future species distributions (RCP2.6 2100): Species distributions under projected climate conditions.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP2.6), taking into account biodiversity needs, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP2.6 2100*
Run variant: *MPAs locked in & species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 2.6. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP2.6, a stringent mitigation scenario aiming to limit global warming below 2 °C by 2100. It requires rapid declines in CO_2 emissions starting around 2020, significant cuts in methane and sulphur dioxide emissions, and large-scale negative emissions such as CO_2 absorption by trees.

Data and inputs used:

- Future species distributions (RCP2.6 2100): Species distributions under projected climate conditions.

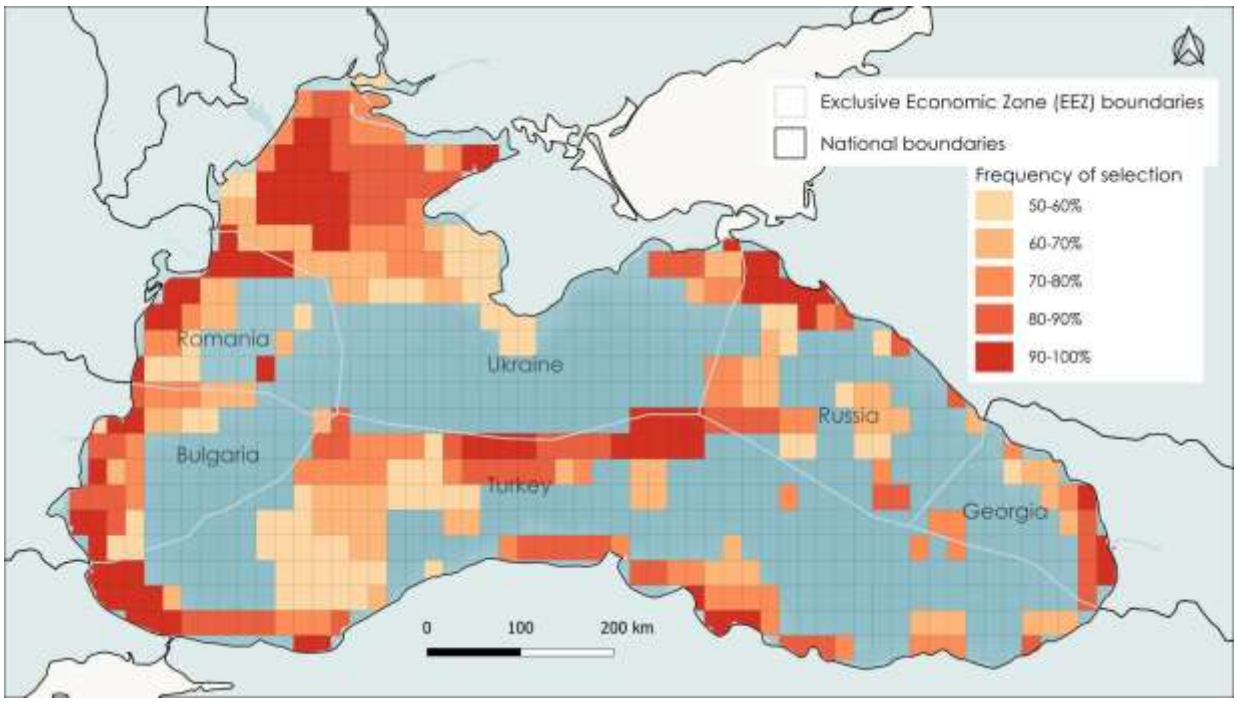
MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

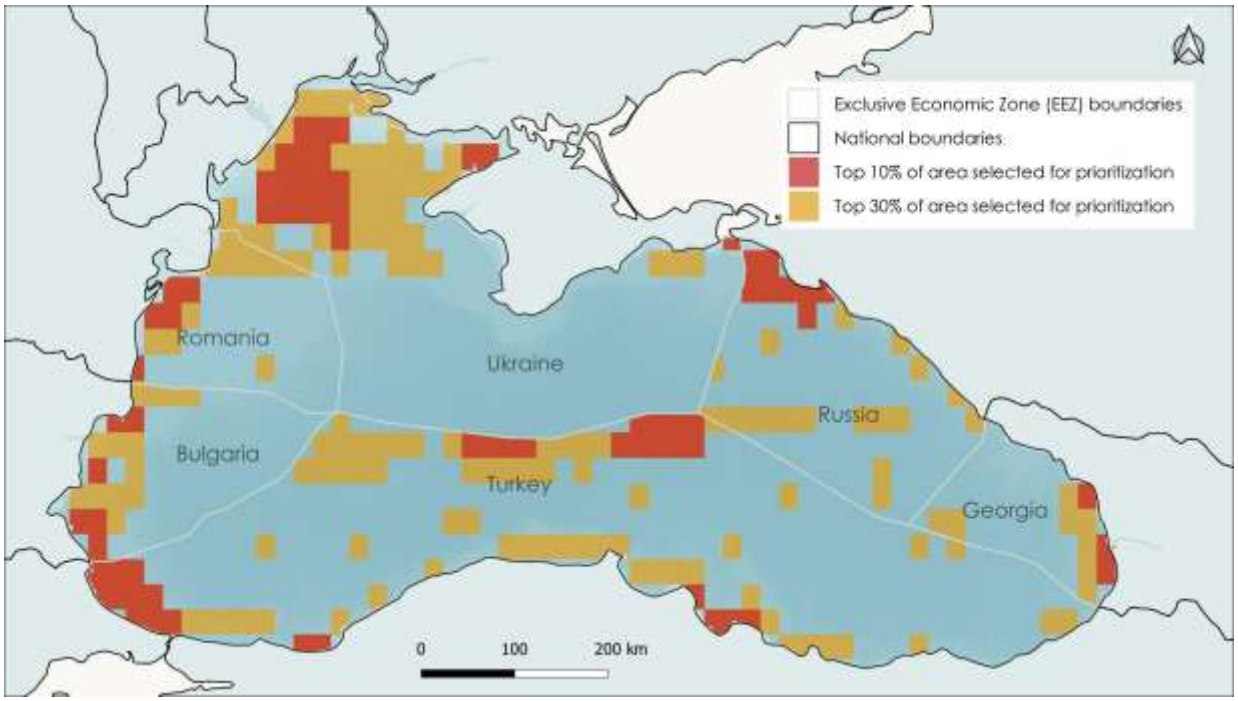
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP2.6), taking into account biodiversity needs, ensuring the existing MPA network is respected, and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

RCP 4.5

Scenario: *Future – RCP4.5 2050*
Run variant: *No MPAs locked in - no species weights used*

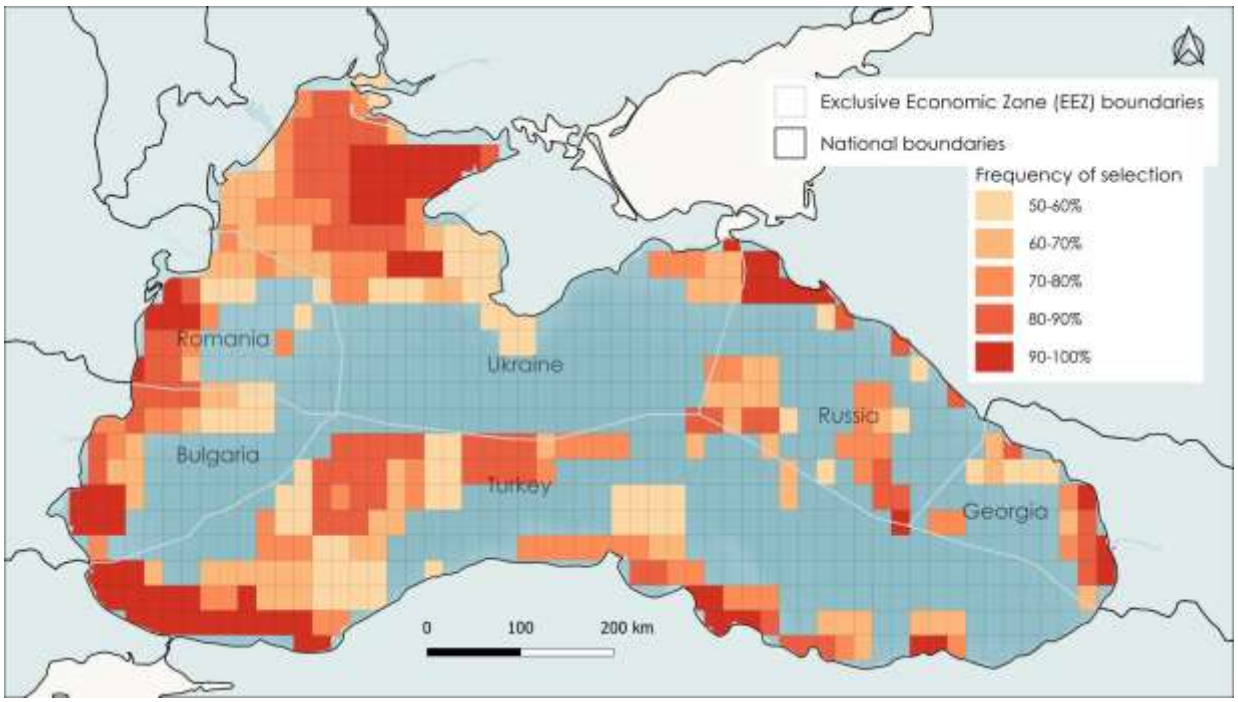
What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change.

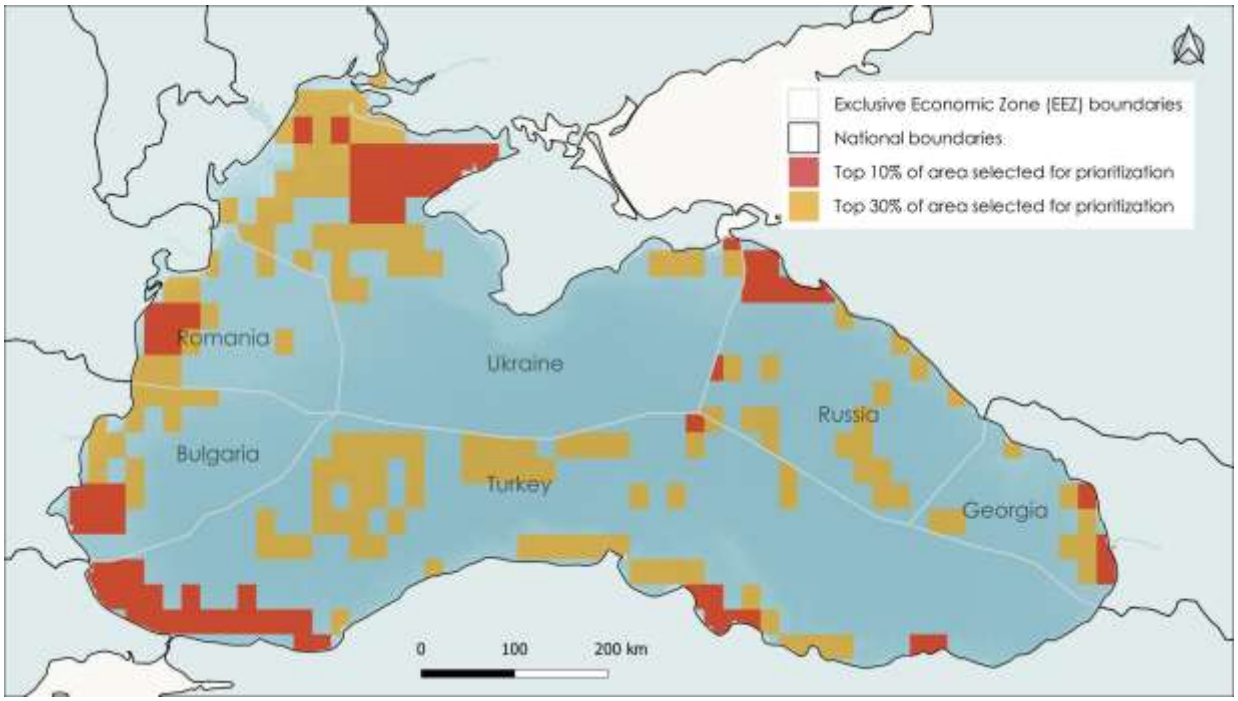
Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used:

- Future species distributions (RCP4.5 2050): Species distributions under projected climate conditions.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP4.5), taking into account purely biodiversity needs.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP4.5 2050*
Run variant: *No MPAs - species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used:

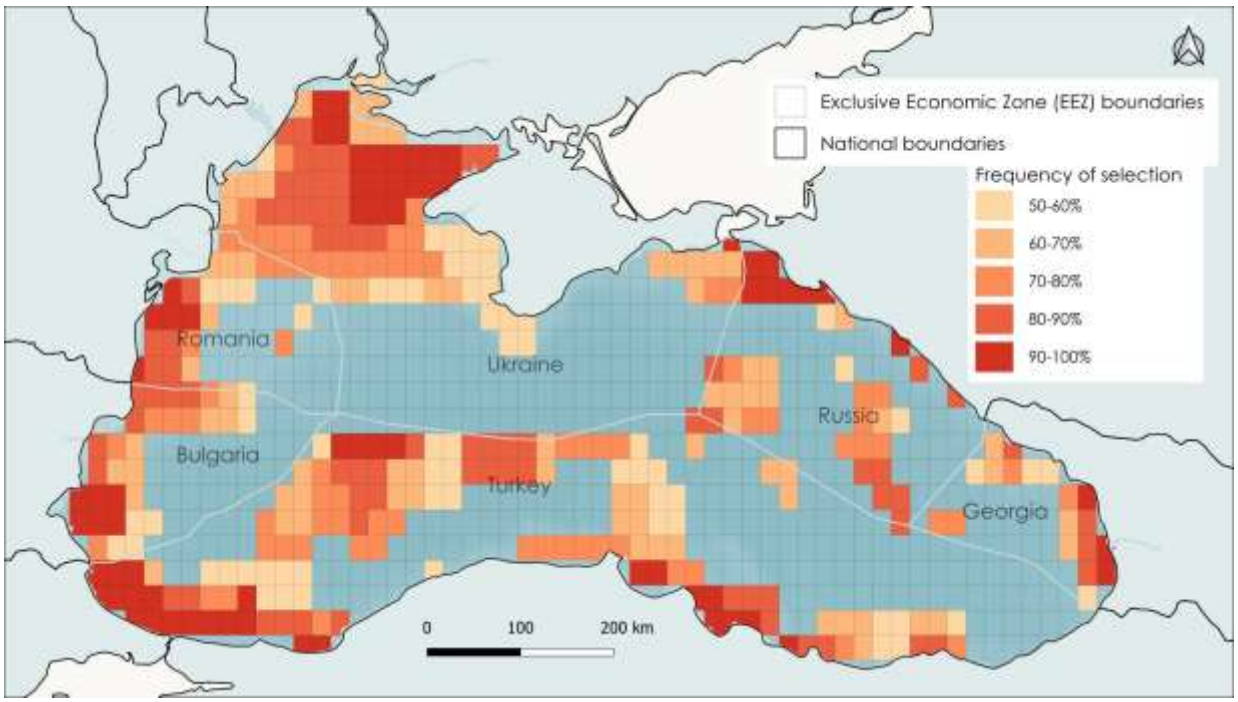
- Future species distributions (RCP4.5 2050): Species distributions under projected climate conditions.

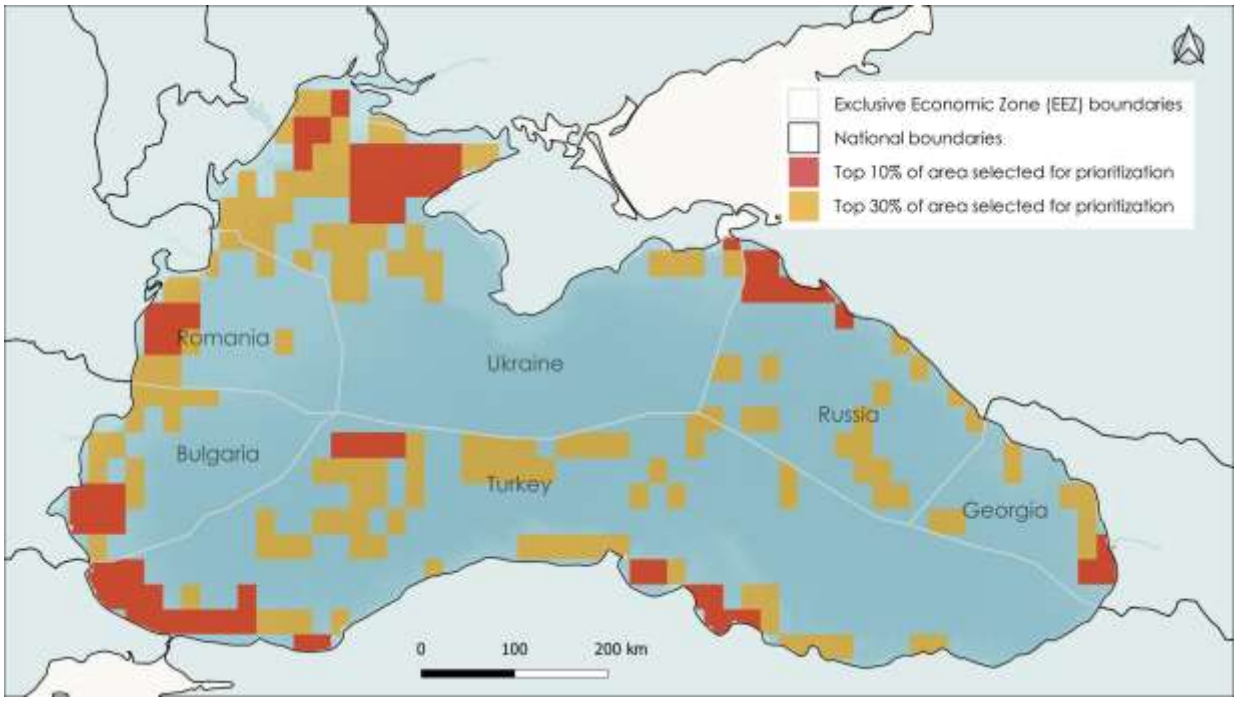
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP4.5), taking into account biodiversity needs, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP4.5 2050*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

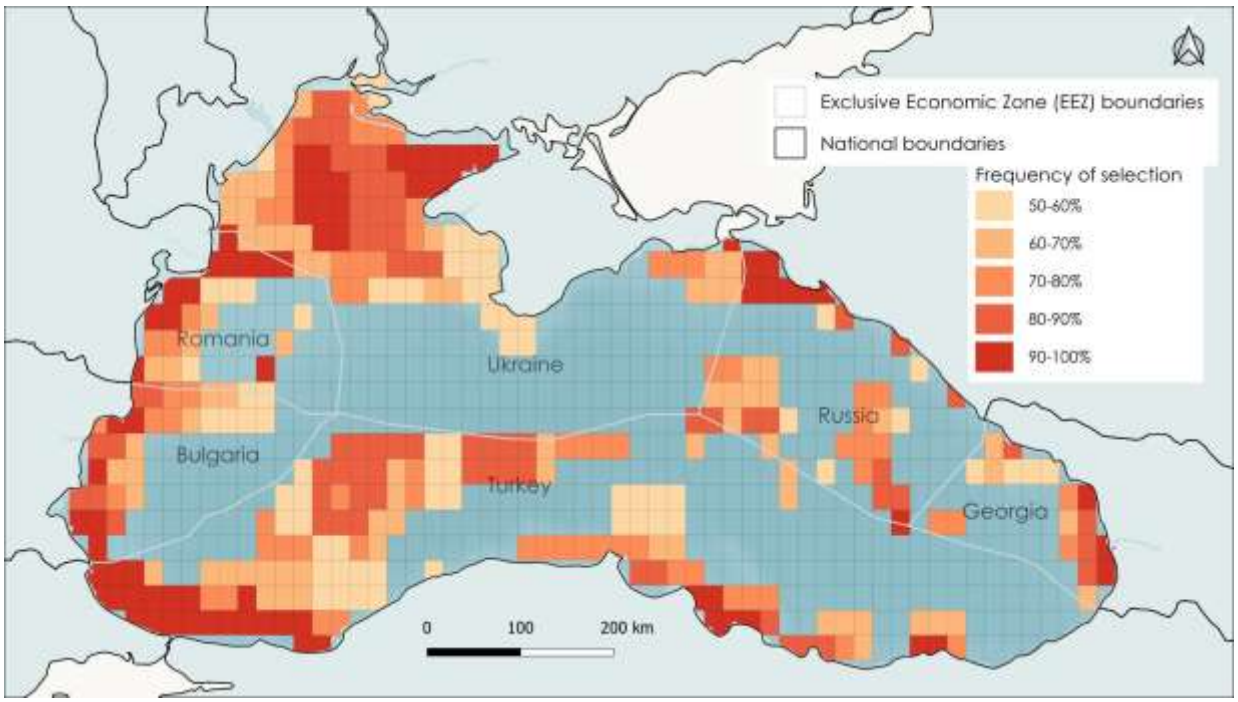
Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

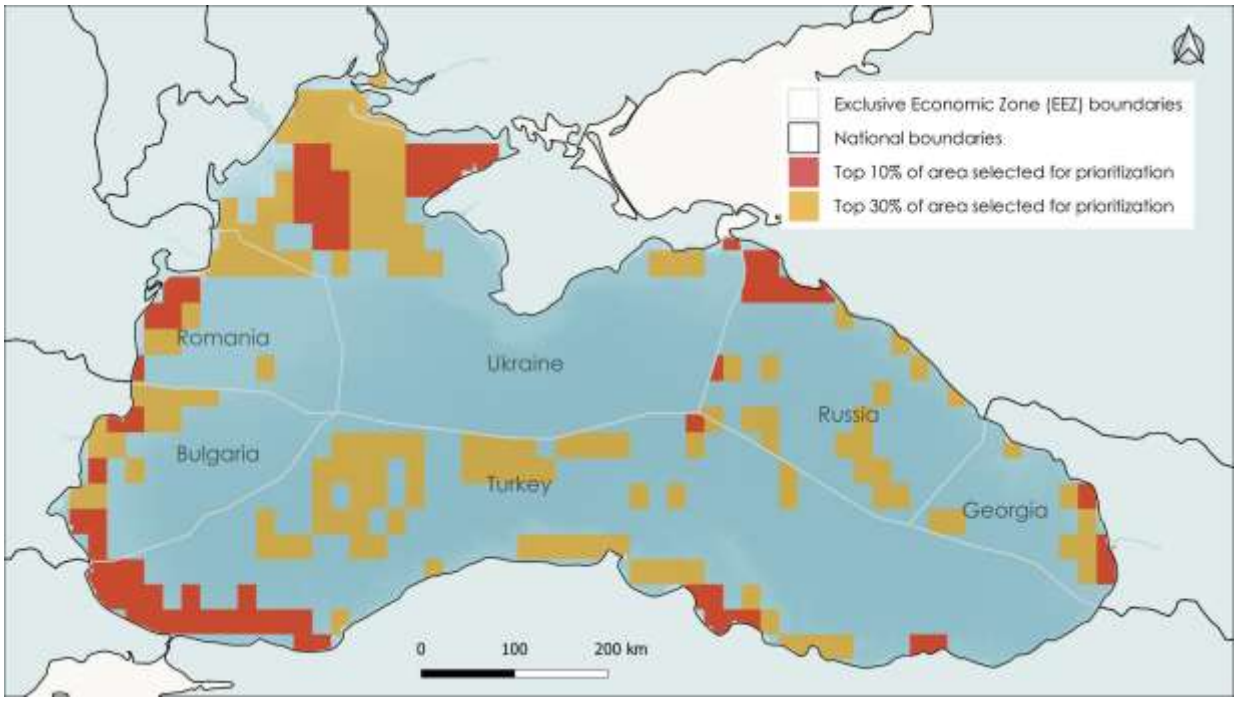
Data and inputs used:

- Future species distributions (RCP4.5 2050): Species distributions under projected climate conditions.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP4.5), taking into account biodiversity needs, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP4.5 2050*
Run variant: *MPAs locked in & species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used:

- Future species distributions (RCP4.5 2050): Species distributions under projected climate conditions.

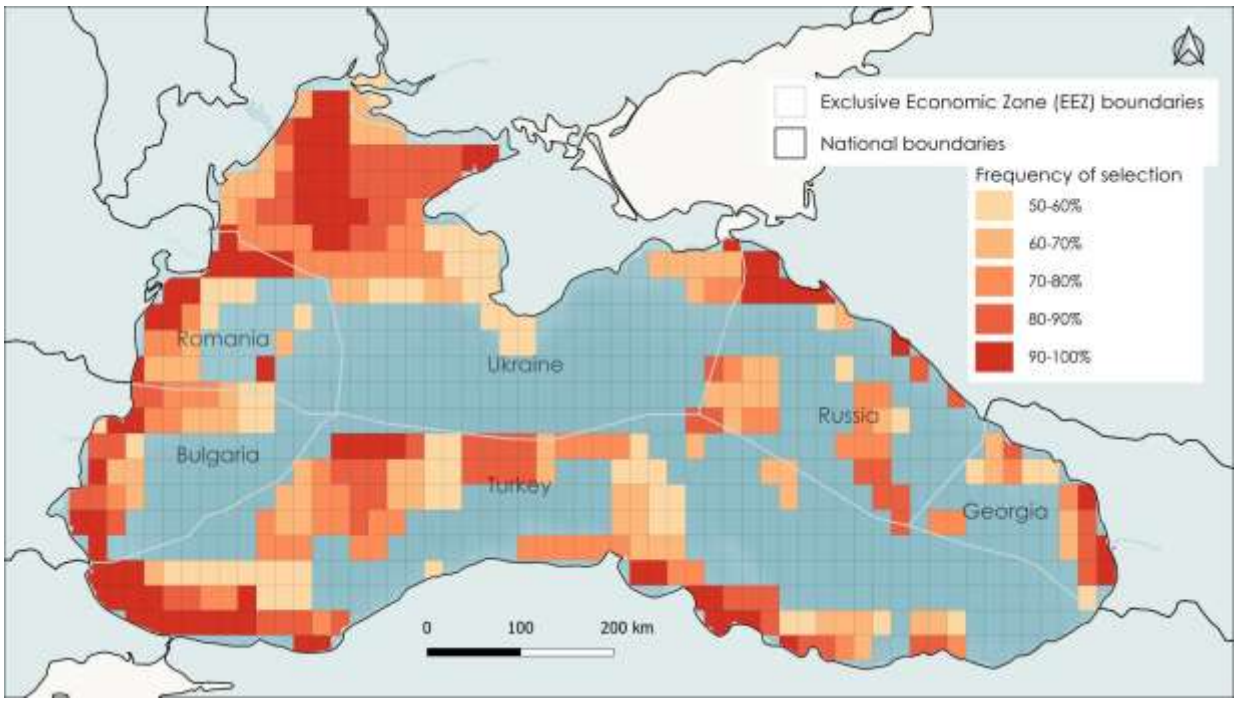
MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

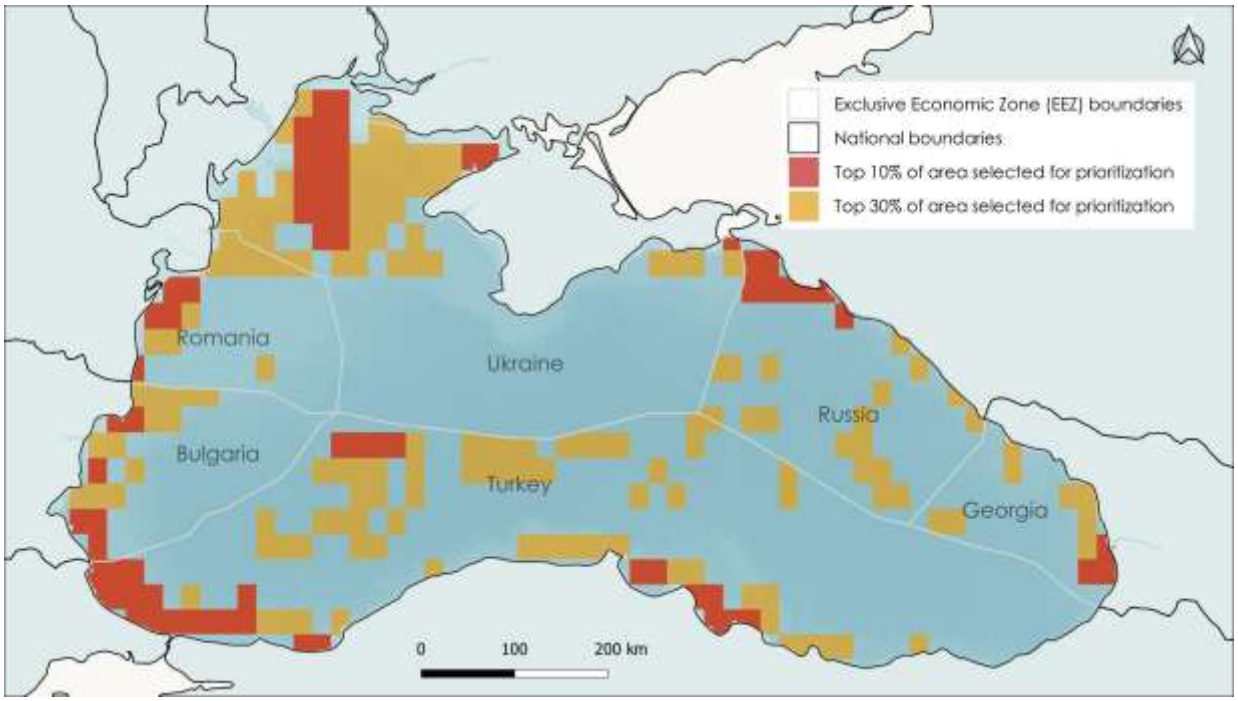
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP4.5), taking into account biodiversity needs, ensuring the existing MPA network is respected, and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP4.5 2100*
Run variant: *No MPAs locked in - no species weights used*

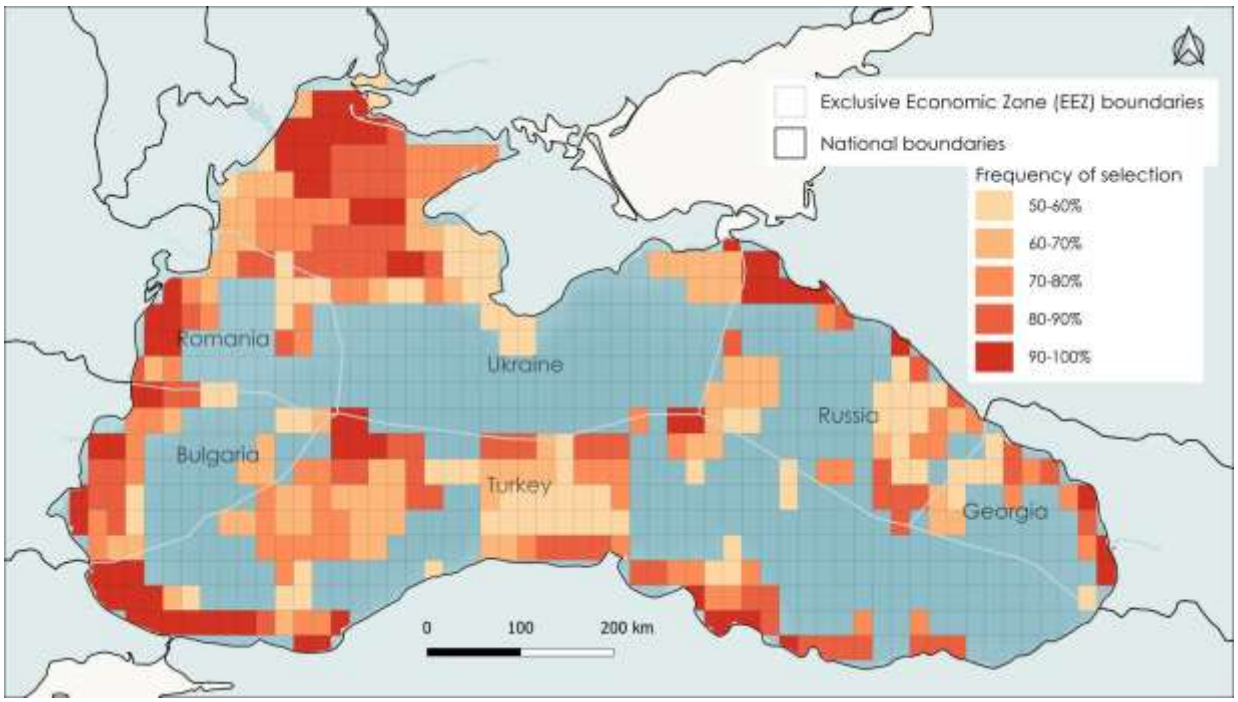
What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change.

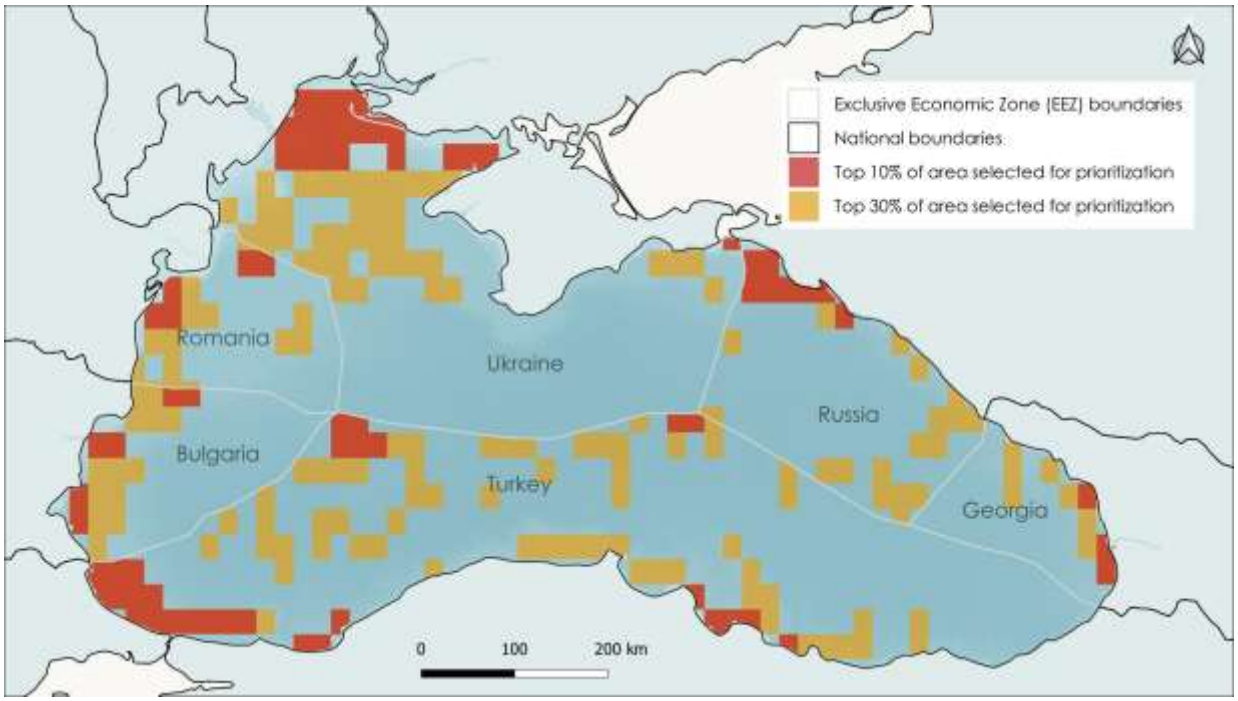
Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used:

- Future species distributions (RCP4.5 2100): Species distributions under projected climate conditions.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP4.5), taking into account purely biodiversity needs.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP4.5 2100*
Run variant: *No MPAs - species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used:

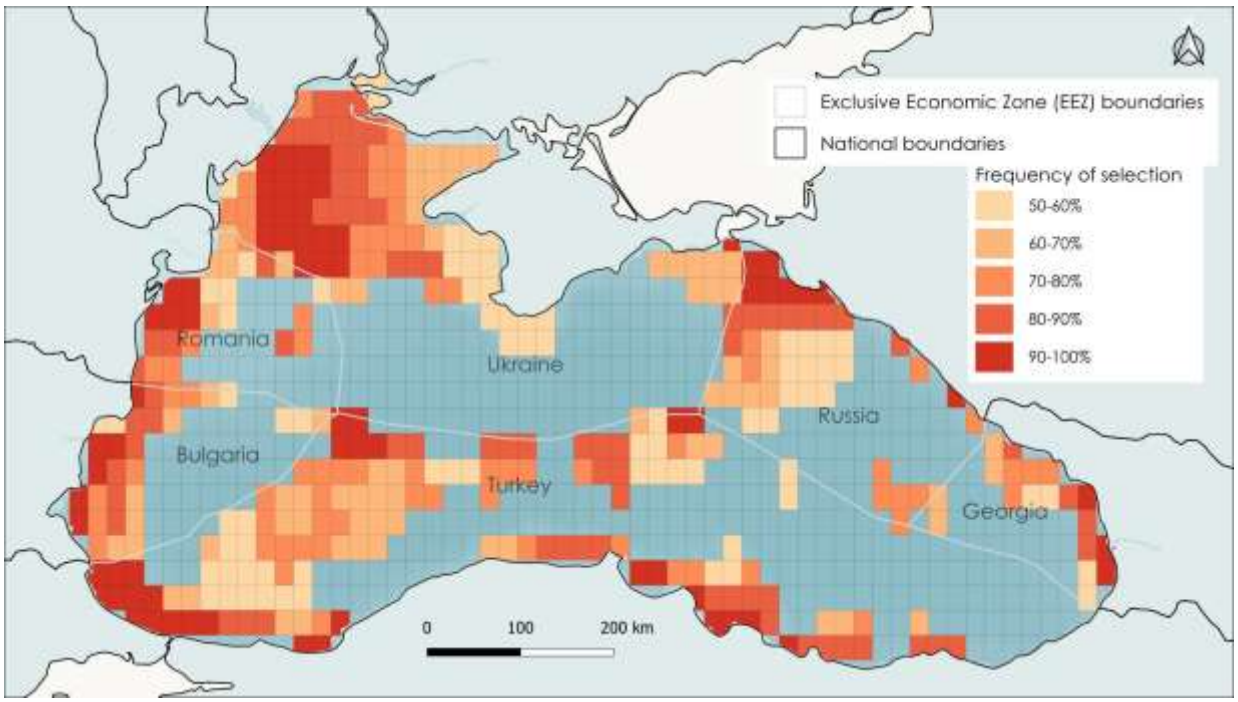
- Future species distributions (RCP4.5 2100): Species distributions under projected climate conditions.

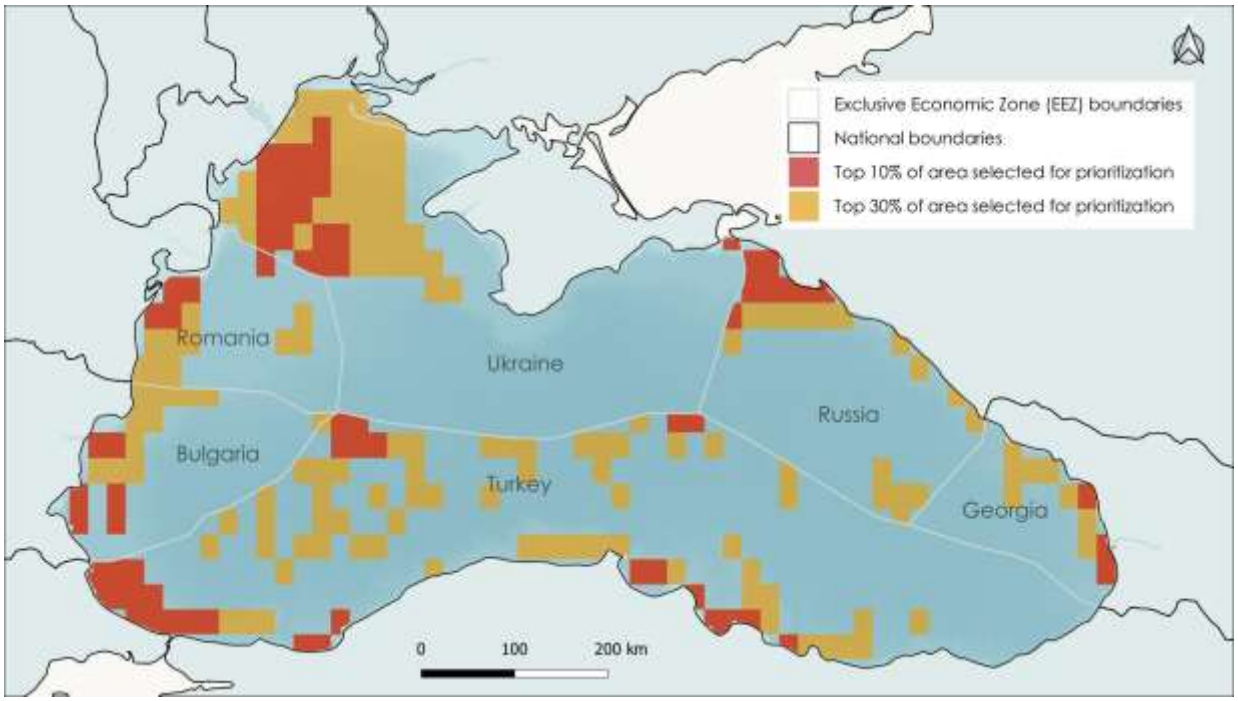
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP4.5), taking into account biodiversity needs, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP4.5 2100*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

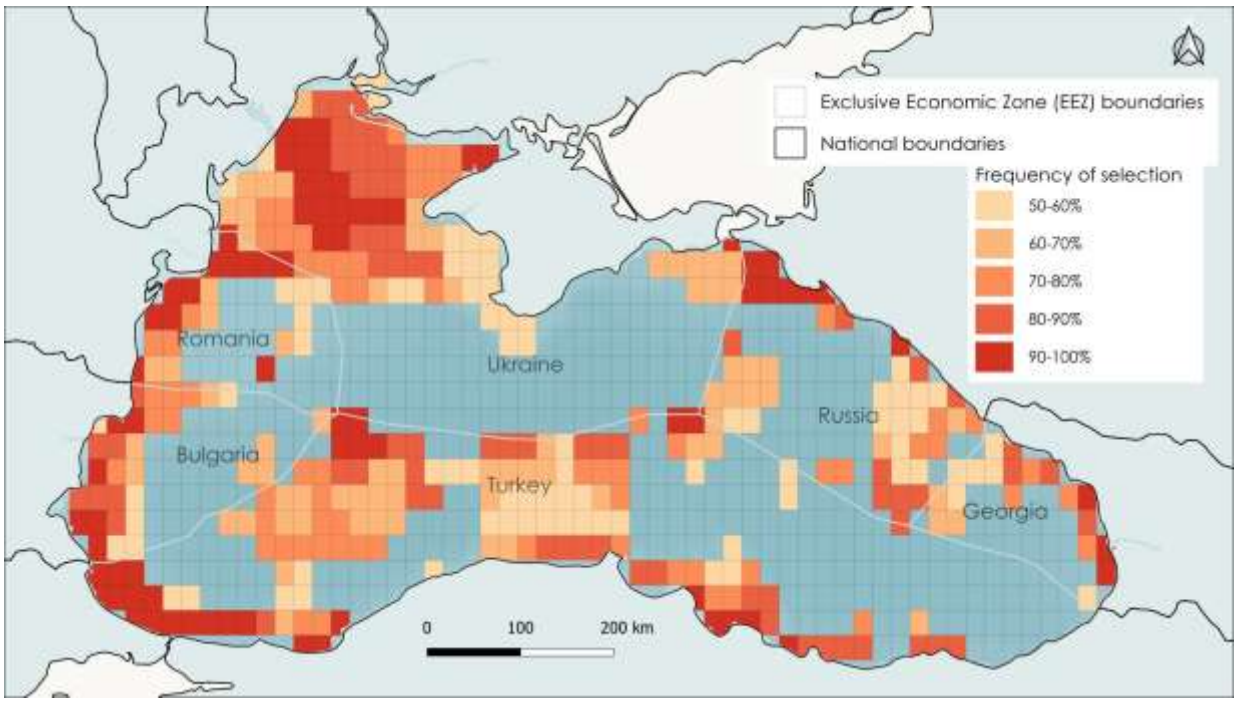
Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

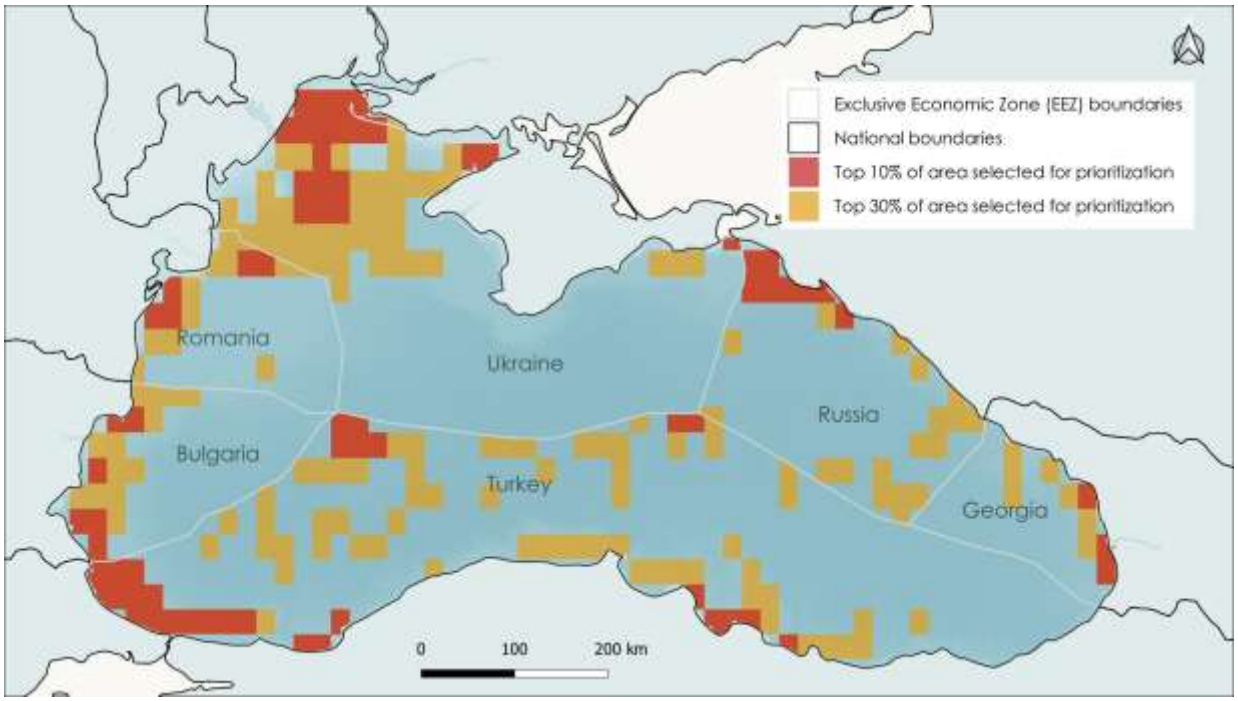
Data and inputs used:

- Future species distributions (RCP4.5 2100): Species distributions under projected climate conditions.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP4.5), taking into account biodiversity needs, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP4.5 2100*
Run variant: *MPAs locked in & species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 4.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 4.5, an intermediate scenario where CO_2 emissions peak around 2040 and then decline gradually. It involves moderate reductions in methane and sulphur dioxide emissions, along with some negative emissions measures like carbon absorption by forests. This pathway is projected to lead to a global temperature rise between 2 °C and 3 °C by 2100.

Data and inputs used:

- Future species distributions (RCP4.5 2100): Species distributions under projected climate conditions.

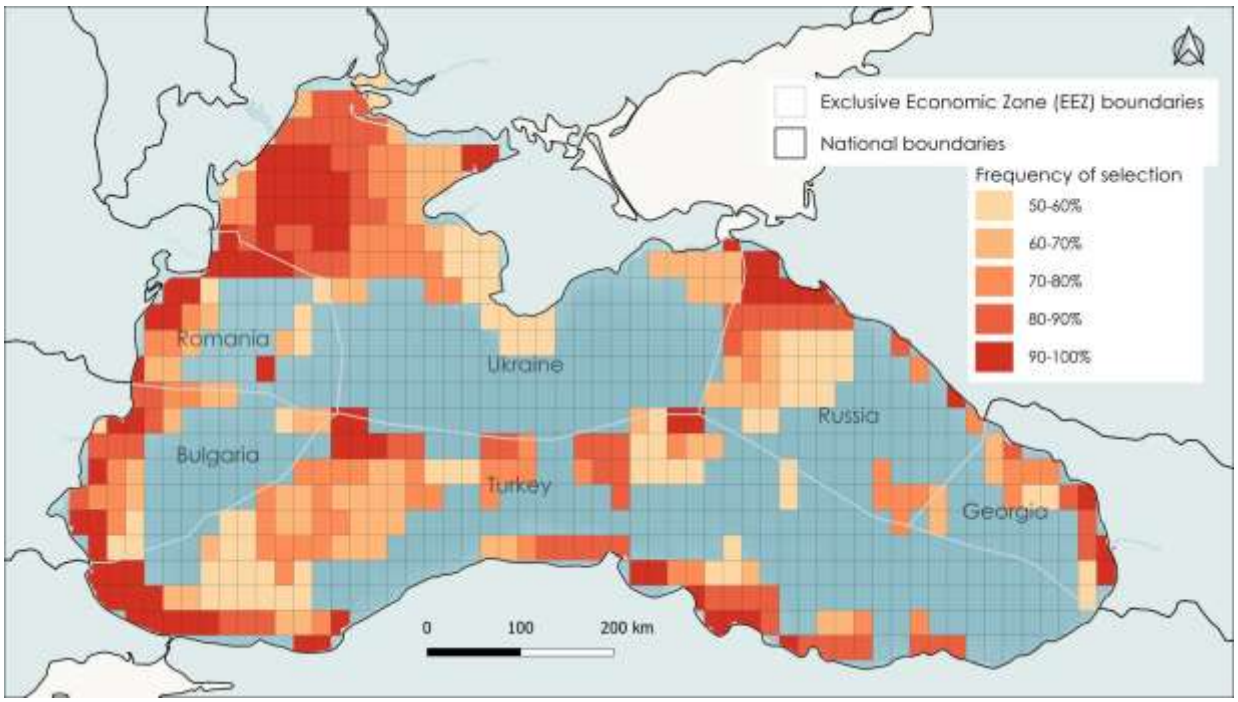
MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

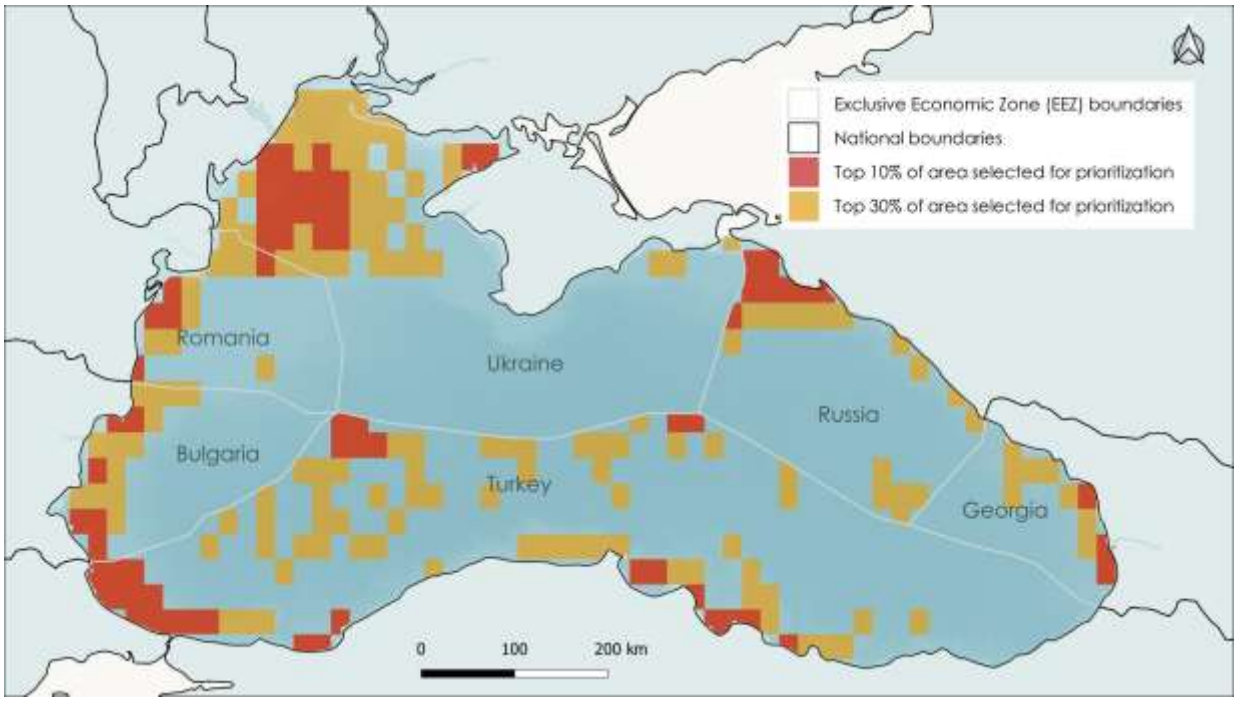
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP4.5), taking into account biodiversity needs, ensuring the existing MPA network is respected, and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

RCP 8.5

Scenario: *Future – RCP8.5 2050*
Run variant: *No MPAs locked in - no species weights used*

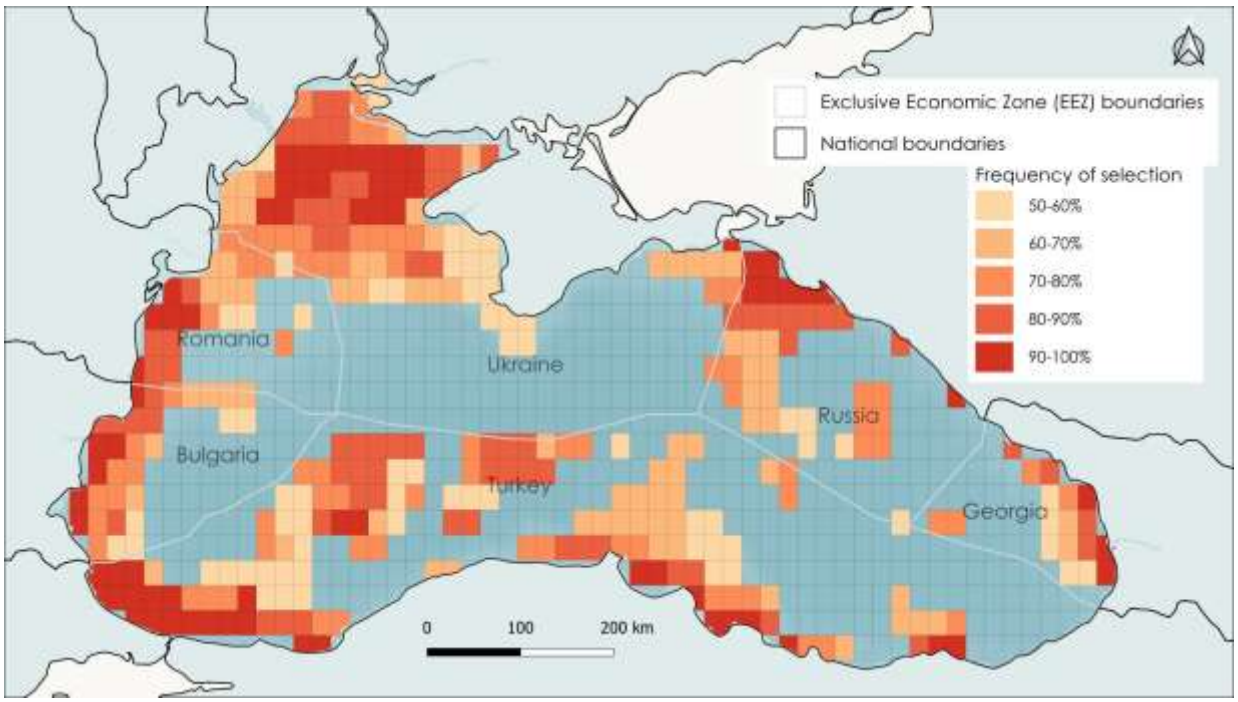
What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

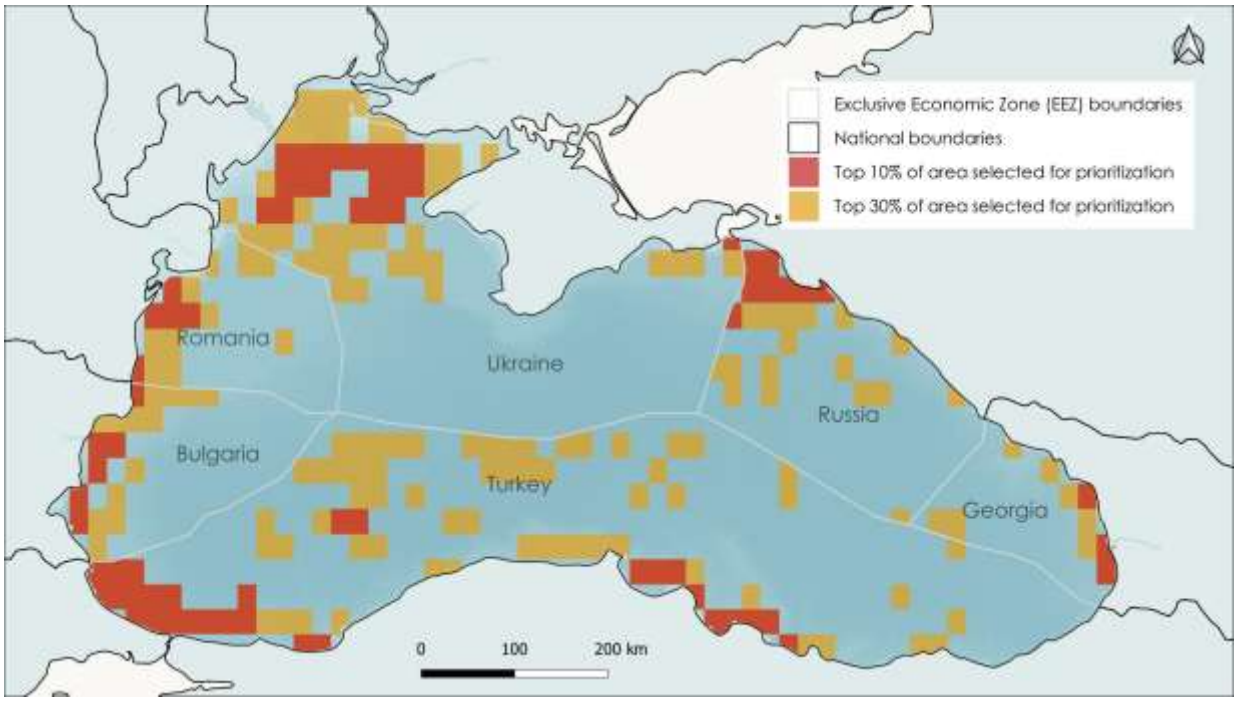
Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

- Future species distributions (RCP8.5 2050): Species distributions under projected climate conditions.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP8.5), taking into account purely biodiversity needs.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: Future – RCP8.5 2050
Run variant: No MPAs - species weights used

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

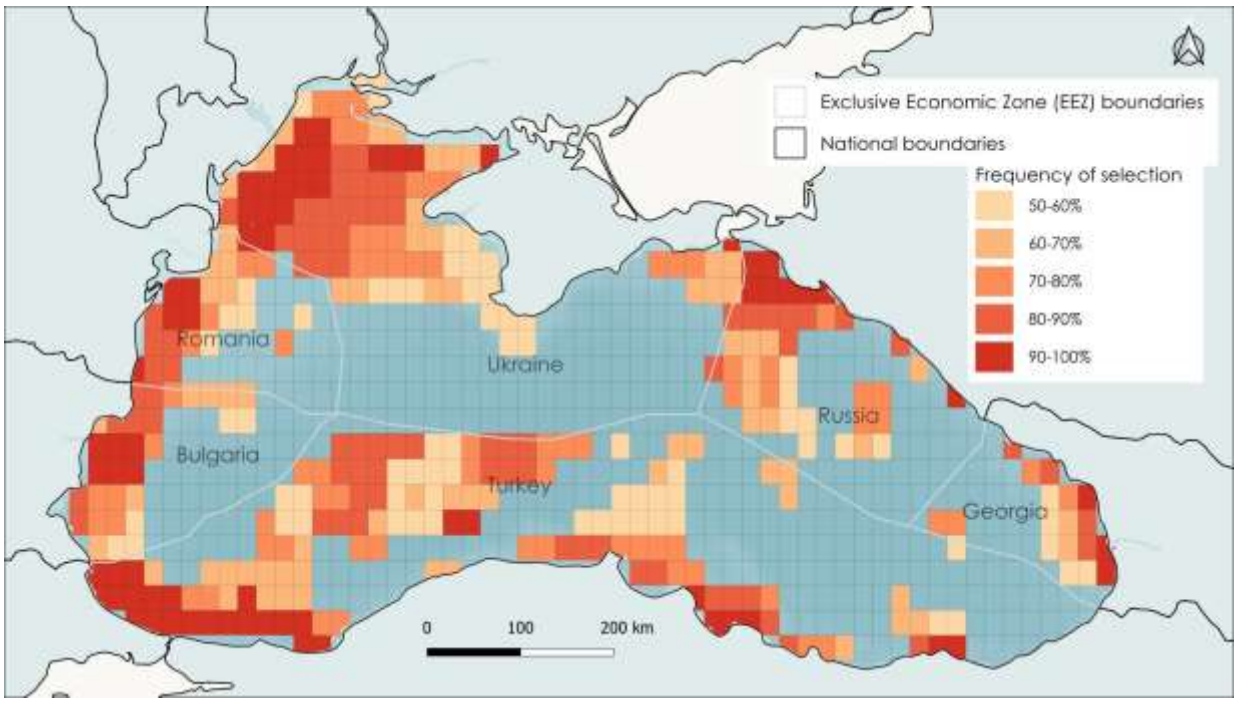
- Future species distributions (RCP8.5 2050): Species distributions under projected climate conditions.

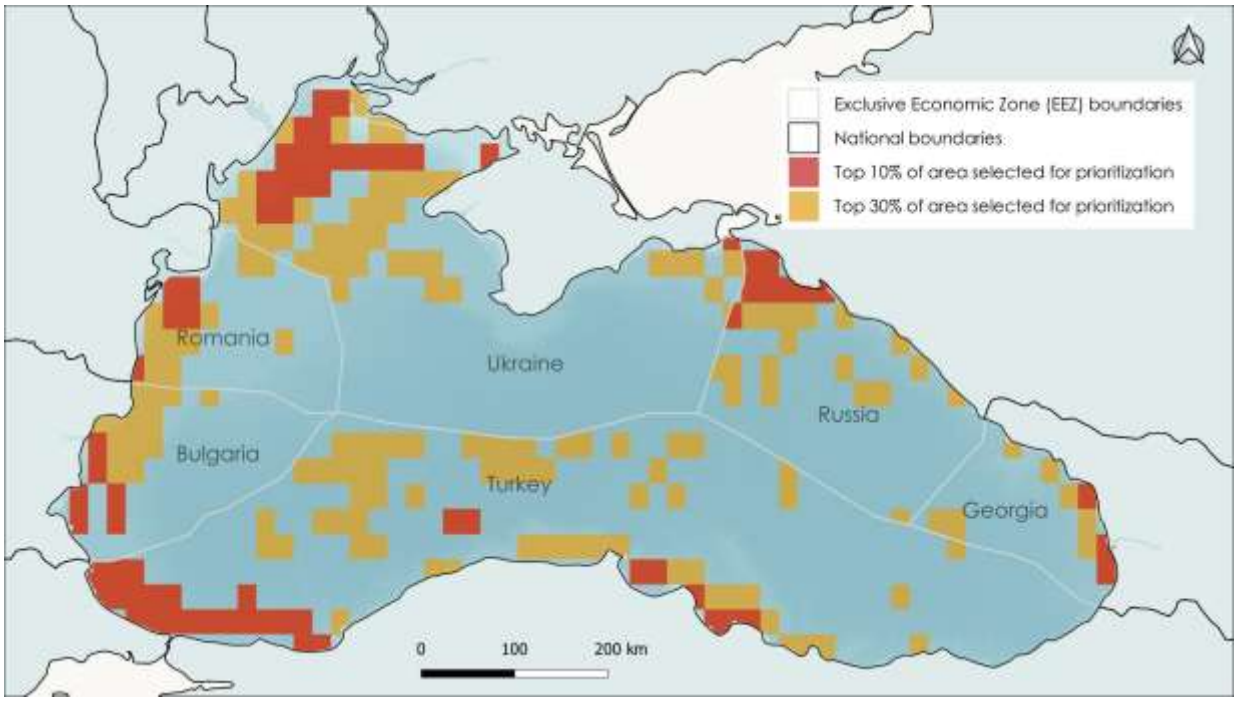
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP8.5), taking into account biodiversity needs, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP8.5 2050*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

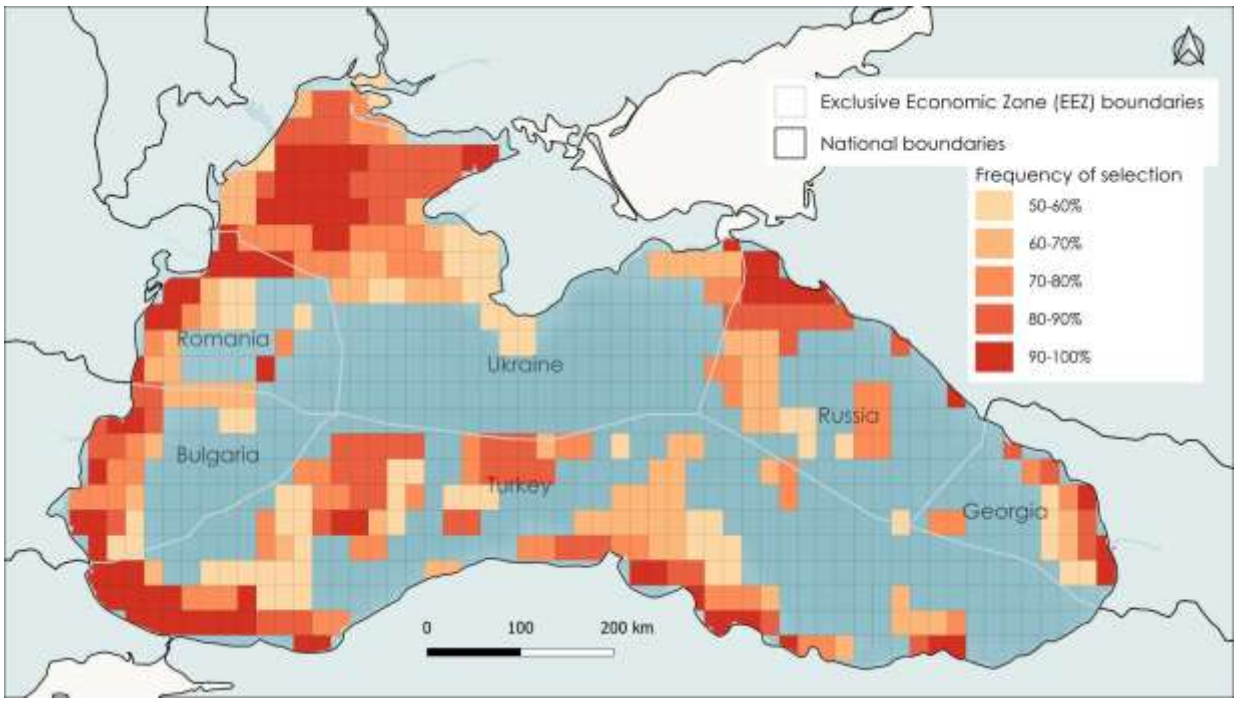
Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

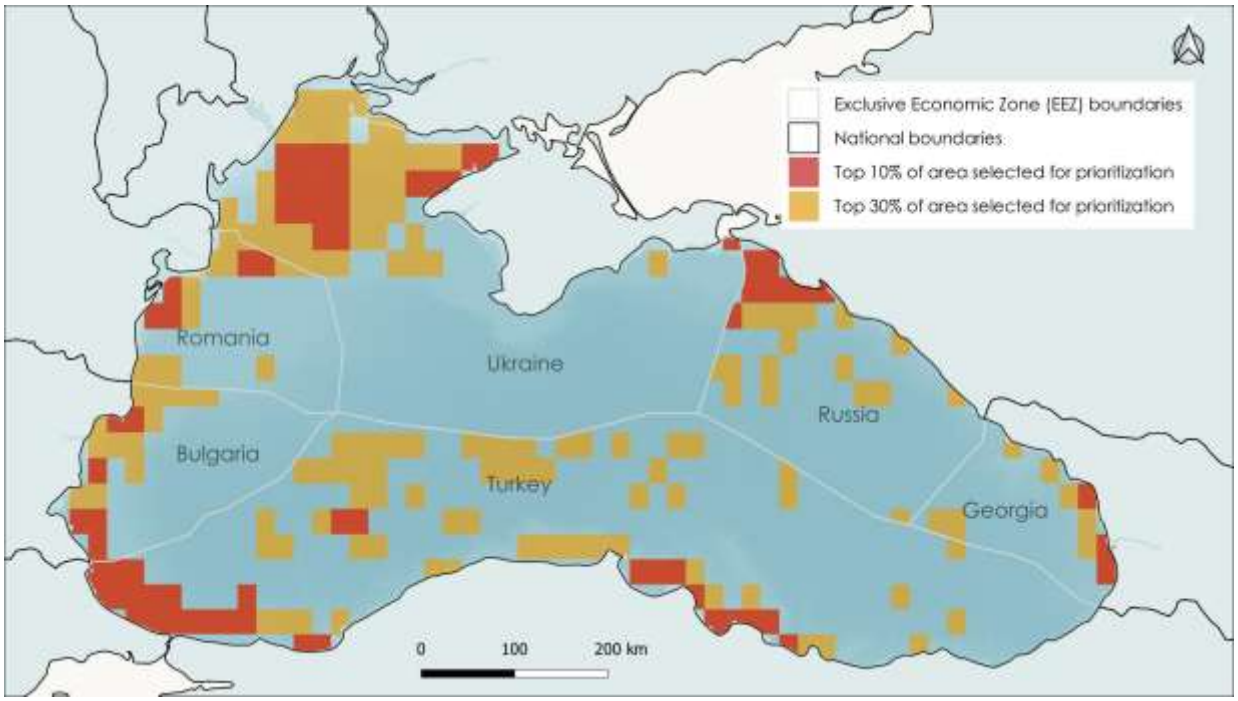
Data and inputs used:

- Future species distributions (RCP8.5 2050): Species distributions under projected climate conditions.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP8.5), taking into account biodiversity needs, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP8.5 2050*
Run variant: *MPAs locked in & species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2050, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

- Future species distributions (RCP8.5 2050): Species distributions under projected climate conditions.

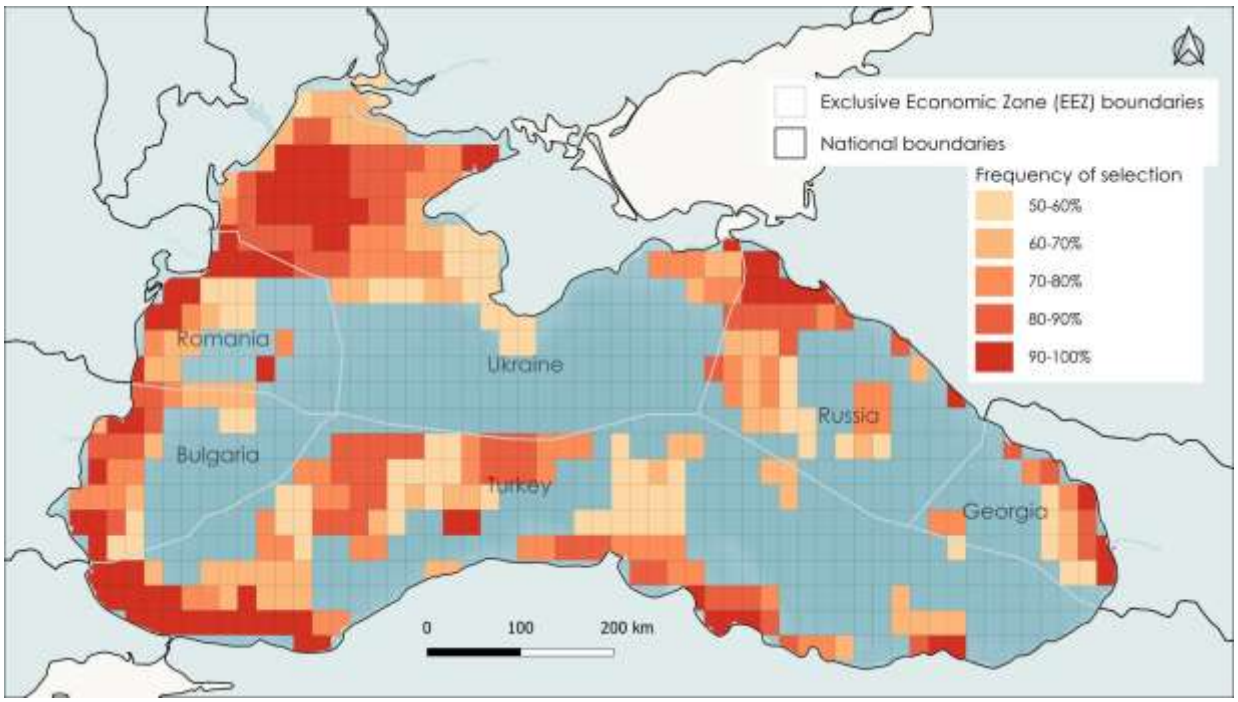
MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

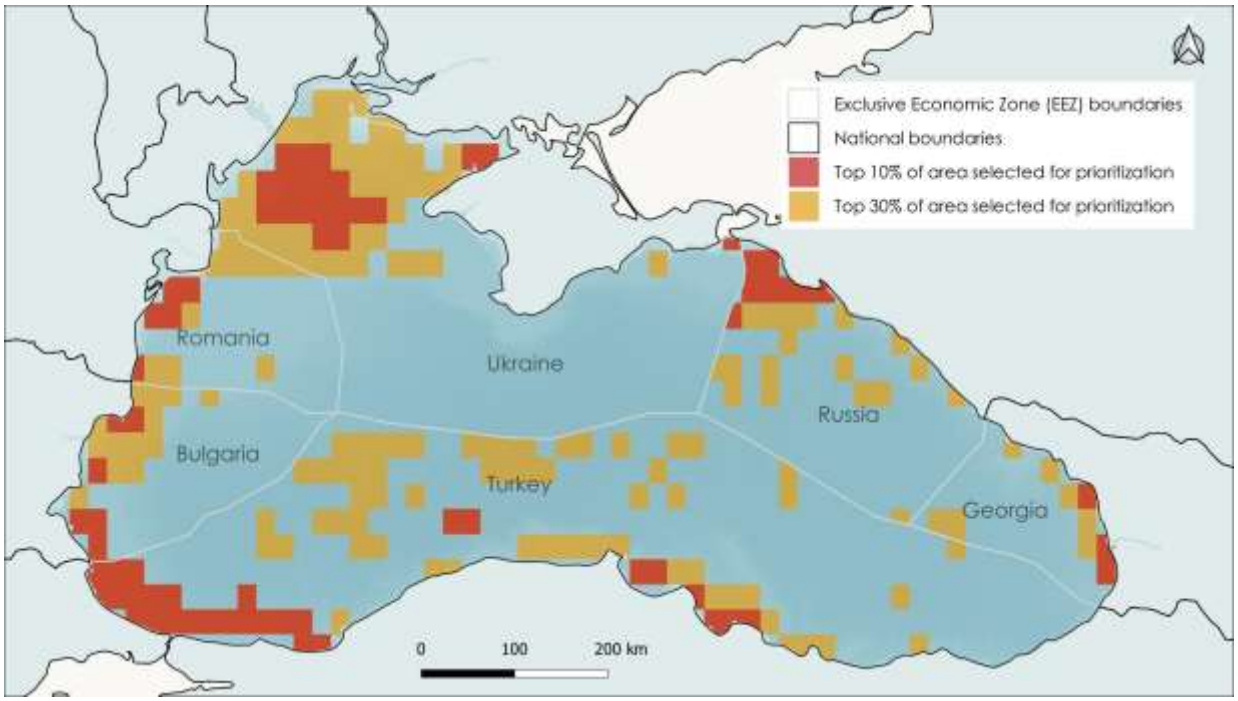
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2050 under a low-emissions climate future (RCP8.5), taking into account biodiversity needs, ensuring the existing MPA network is respected, and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP8.5 2100*
Run variant: *No MPAs locked in - no species weights used*

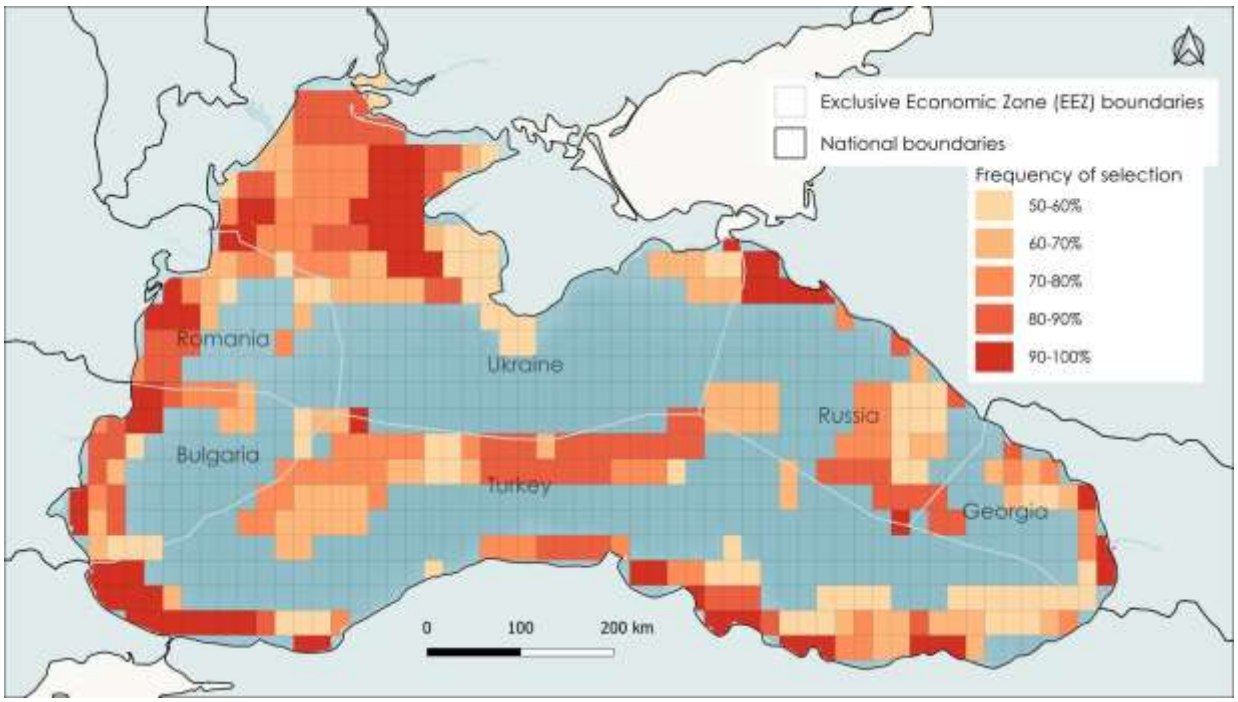
What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

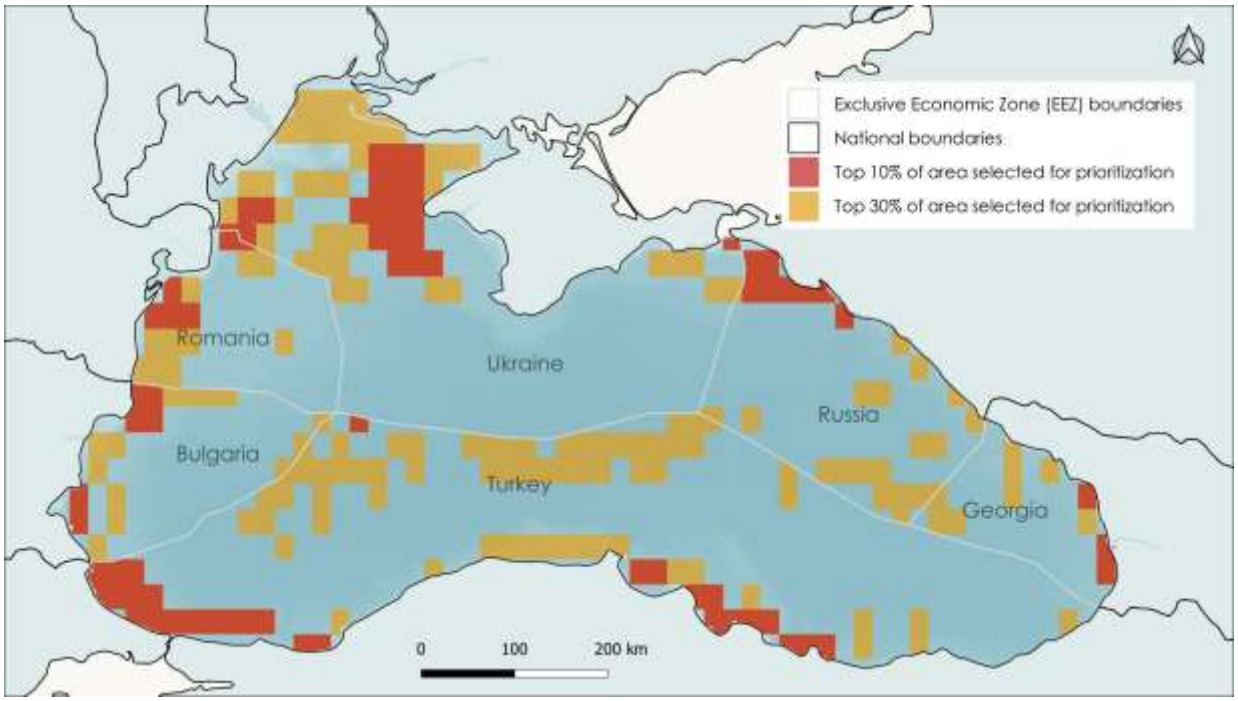
Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP8.5), taking into account purely biodiversity needs.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP8.5 2100*
Run variant: *No MPAs - species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

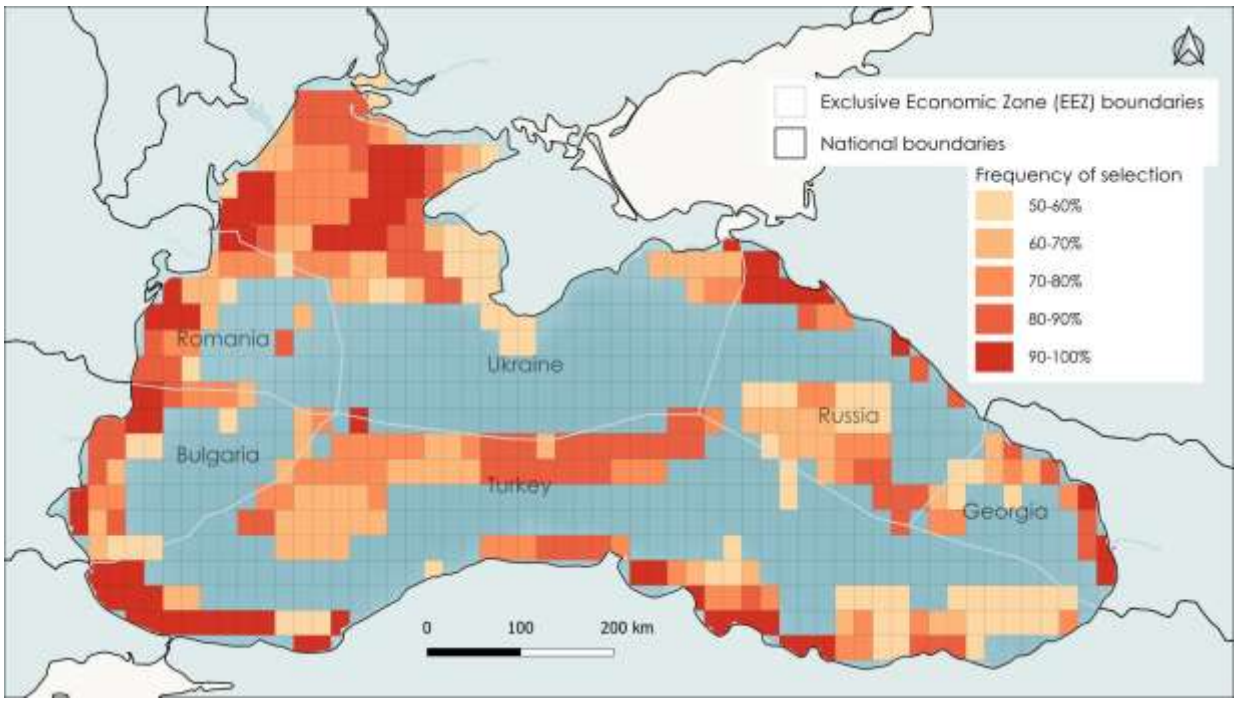
- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.

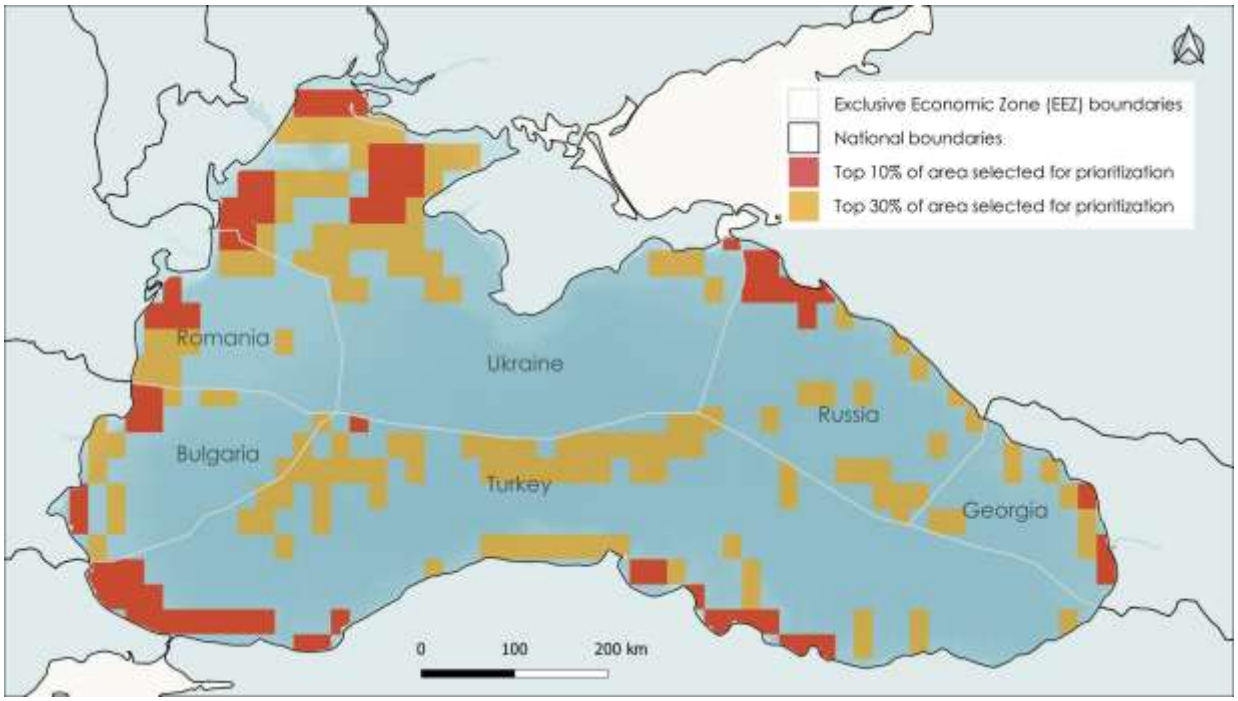
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP8.5), taking into account biodiversity needs, emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP8.5 2100*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

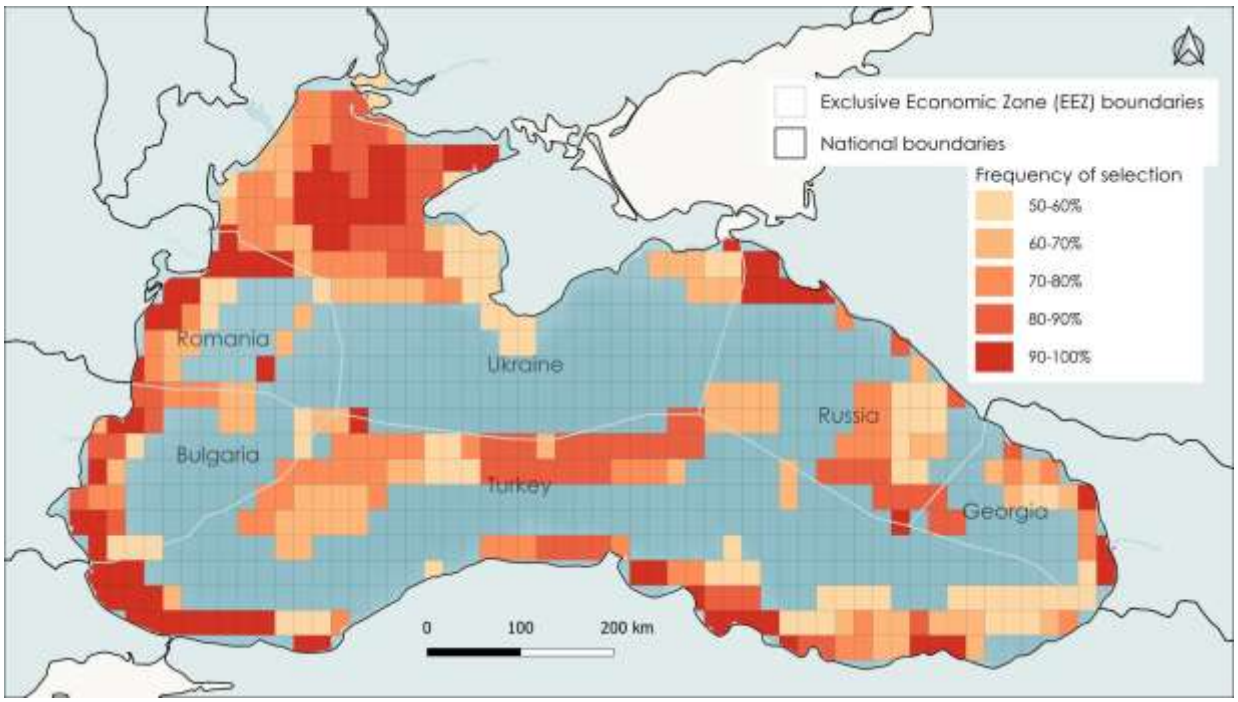
Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

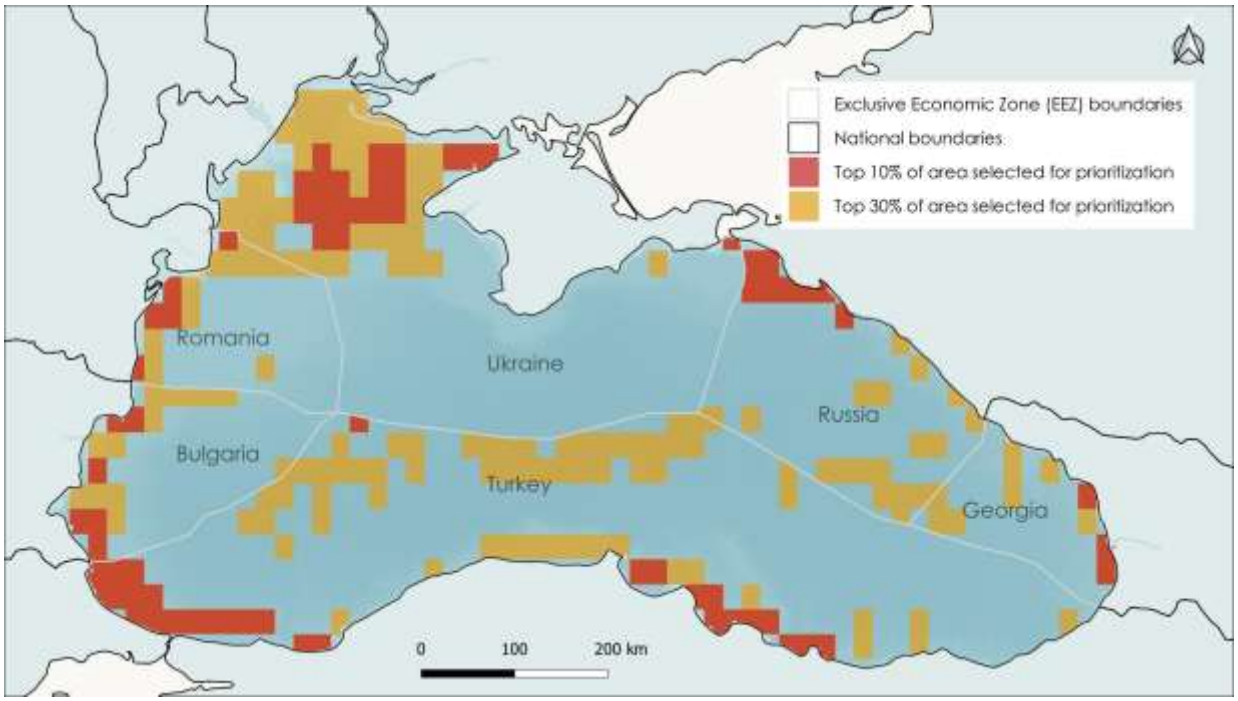
Data and inputs used:

- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP8.5), taking into account biodiversity needs, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Future – RCP8.5 2100*
Run variant: *MPAs locked in & species weights used*

What this scenario represents:
This scenario explores the future distribution of marine biodiversity in the Black Sea under projected climate change by the year 2100, using Representative Concentration Pathway 8.5. It examines how conservation priorities might shift when accounting for changing species distributions due to climate change, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.

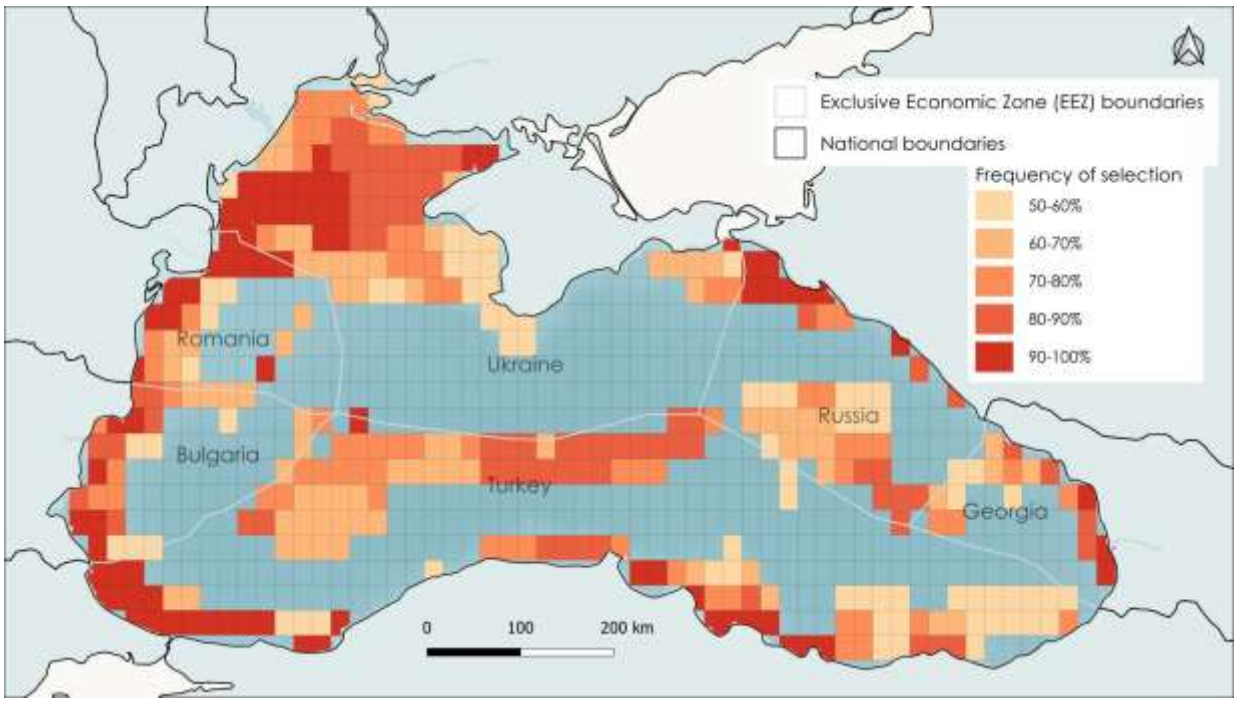
MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution ("locked in").
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

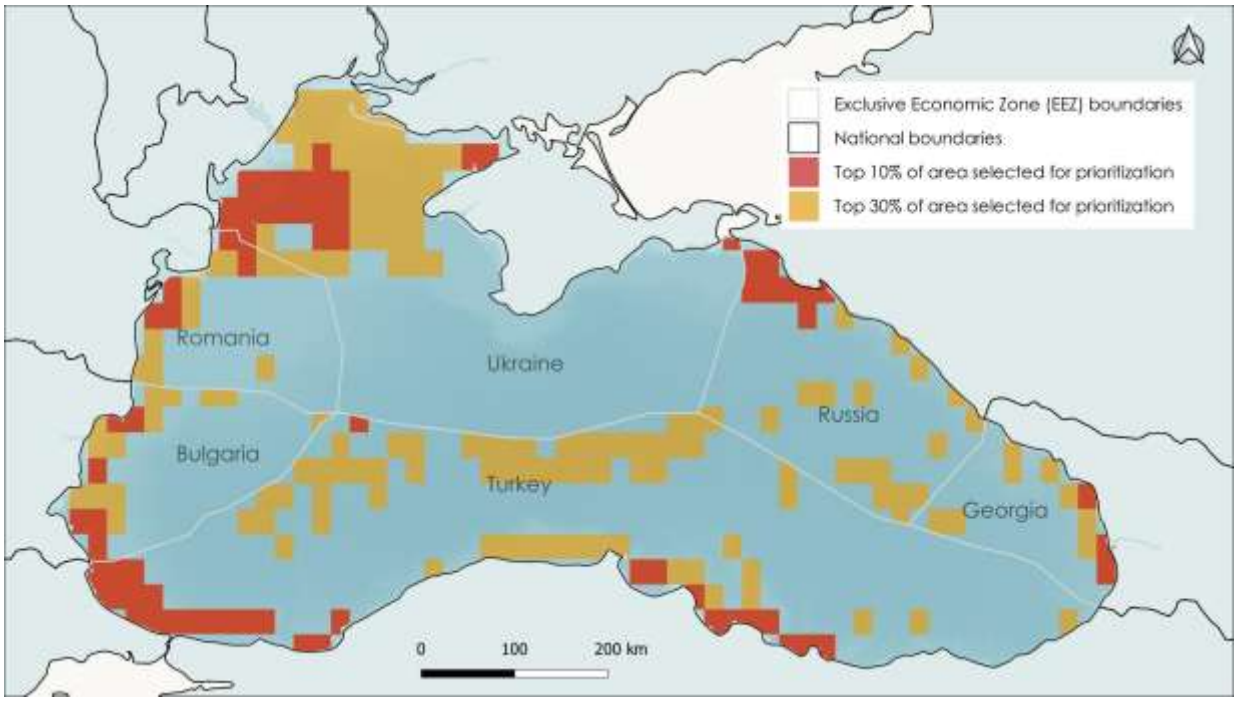
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary
This run identifies priority conservation areas for 2100 under a low-emissions climate future (RCP8.5), taking into account biodiversity needs, ensuring the existing MPA network is respected, and emphasizing protection for the most threatened and endemic species.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Severe climate change scenario

Scenario: *Worst case scenario*
Run variant: *No MPAs & no species weights used*

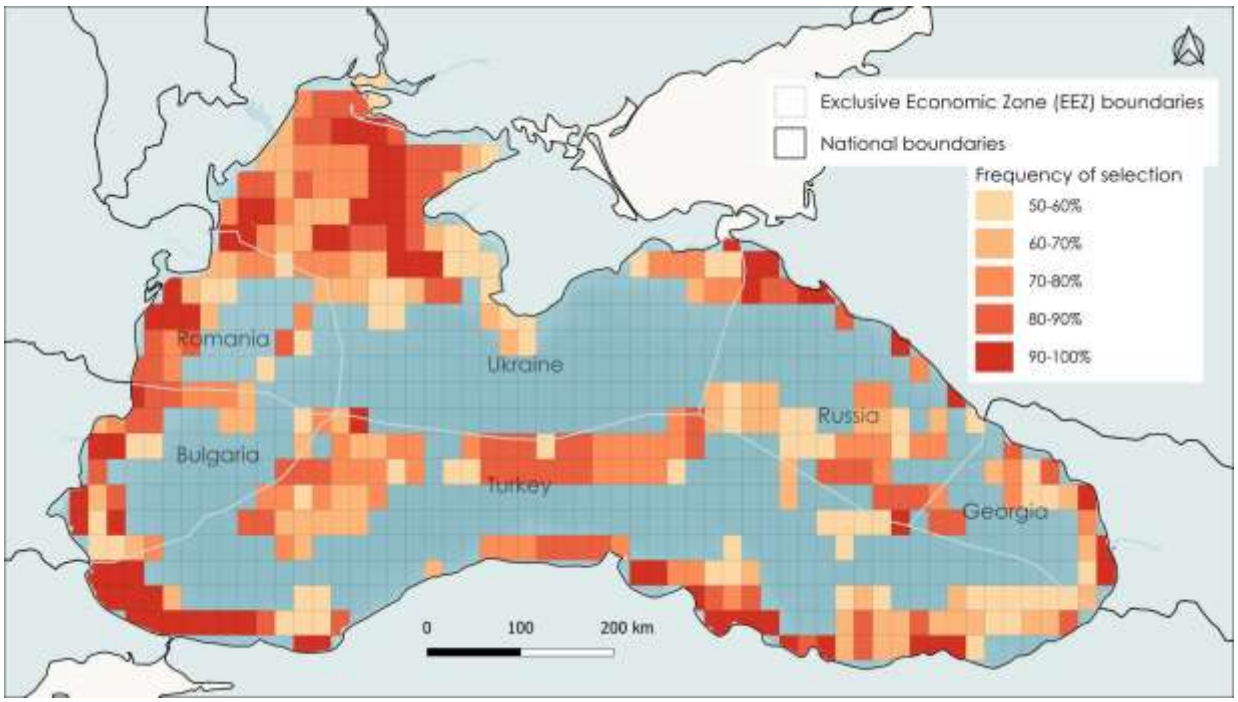
What this scenario represents:
This scenario explores conservation priorities for the Black Sea under a severe climate change future (RCP8.5 - year 2100), combining multiple climate change components to identify areas likely to remain valuable for biodiversity even under extreme warming.

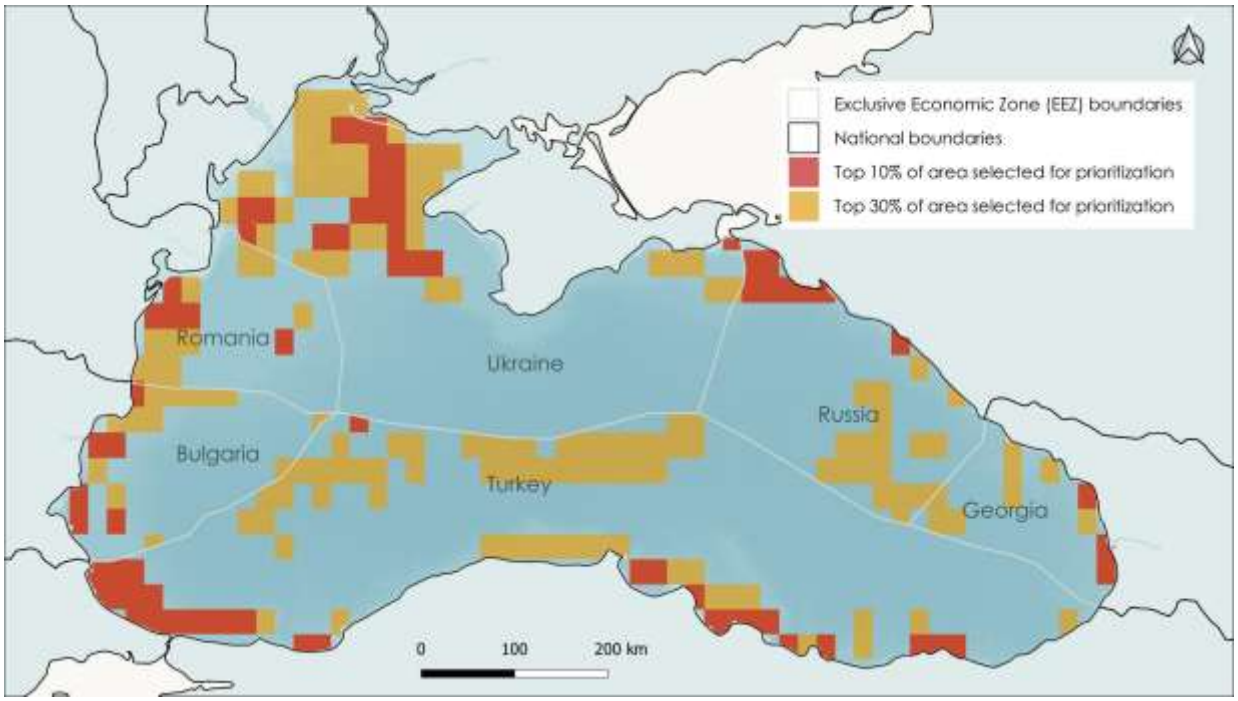
Climate scenario used:
The analysis is based on species distribution models and environmental conditions projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.
- Habitat refugia: Identified as areas where species are projected to occur both in the current period and under RCP8.5 in 2100. These overlapping zones are critical because they are more likely to remain suitable under climate change, offering stable habitat that can support biodiversity persistence.
- Climatic refugia: Climate refugia are areas that remain relatively buffered from the effects of climate change over time, enabling them to play a vital role in safeguarding biodiversity.
- Climate change metrics used as a cumulative cost layer, highlighting areas under the greatest climatic pressure:
  - Changes in the probability of local climate extremes: This metric tracks the change in frequency of extreme temperature. Areas where such extremes become much more common are considered riskier for conservation.
  - Novel Climate: Quantifies how different the climate in will be compared to the historical baseline. Areas with higher values will face conditions outside past climate variability, which can challenge species survival.
  - Standardized Local Anomalies: Measures the magnitude of projected temperature changes relative to the historical local inter-annual variability. Areas with larger values are likely to face large changes in temperature.

Summary
This scenario identifies areas that may remain critical for conservation even under severe climate change by the end of the century, balancing future biodiversity needs with information on habitat stability and extreme climate threats.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Worst case scenario*
Run variant: *No MPAs - Species weights used*

What this scenario represents:
This scenario explores conservation priorities for the Black Sea under a severe climate change future (RCP8.5 - year 2100), combining multiple climate change components to identify areas likely to remain valuable for biodiversity even under extreme warming, while giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models and environmental conditions projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.
- Habitat refugia: Identified as areas where species are projected to occur both in the current period and under RCP8.5 in 2100. These overlapping zones are critical because they are more likely to remain suitable under climate change, offering stable habitat that can support biodiversity persistence.
- Climatic refugia: Climate refugia are areas that remain relatively buffered from the effects of climate change over time, enabling them to play a vital role in safeguarding biodiversity.
- Climate change metrics used as a cumulative cost layer, highlighting areas under the greatest climatic pressure:
    - Changes in the probability of local climate extremes: This metric tracks the change in frequency of extreme temperature. Areas where such extremes become much more common are considered riskier for conservation.
    - Novel Climate: Quantifies how different the climate in will be compared to the historical baseline. Areas with higher values will face conditions outside past climate variability, which can challenge species survival.
    - Standardized Local Anomalies: Measures the magnitude of projected temperature changes relative to the historical local inter-annual variability. Areas with larger values are likely to face large changes in temperature.

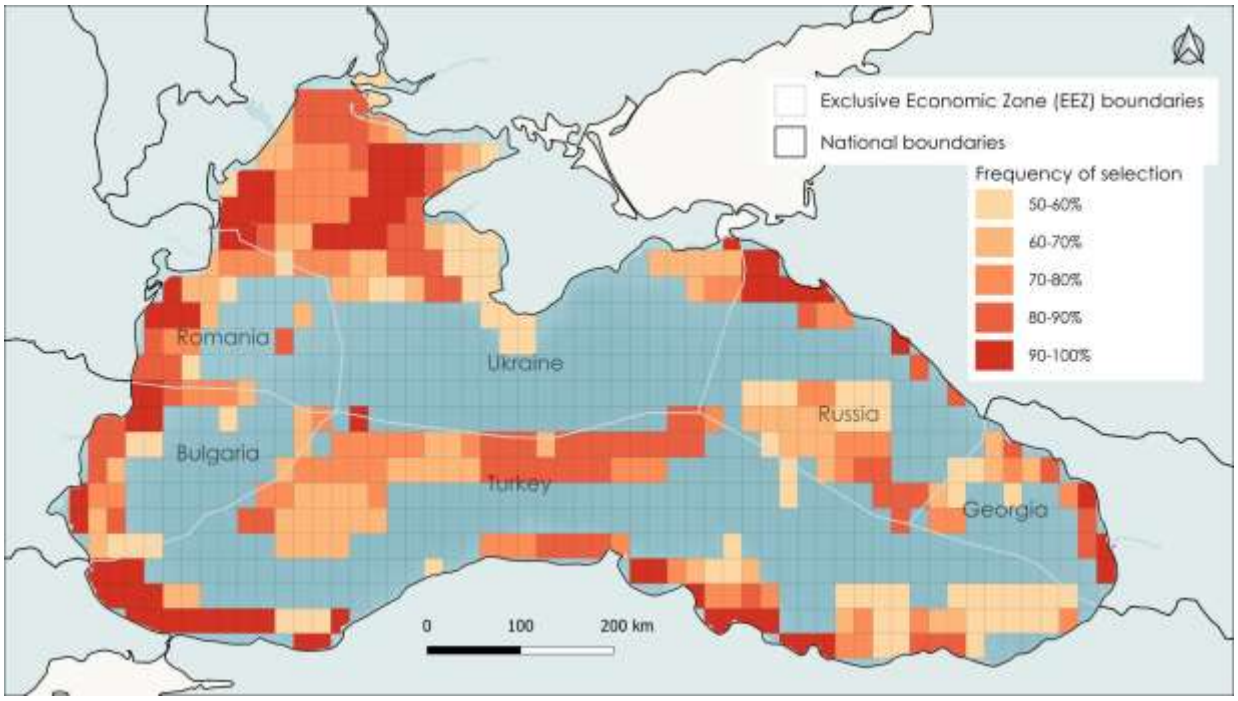
Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

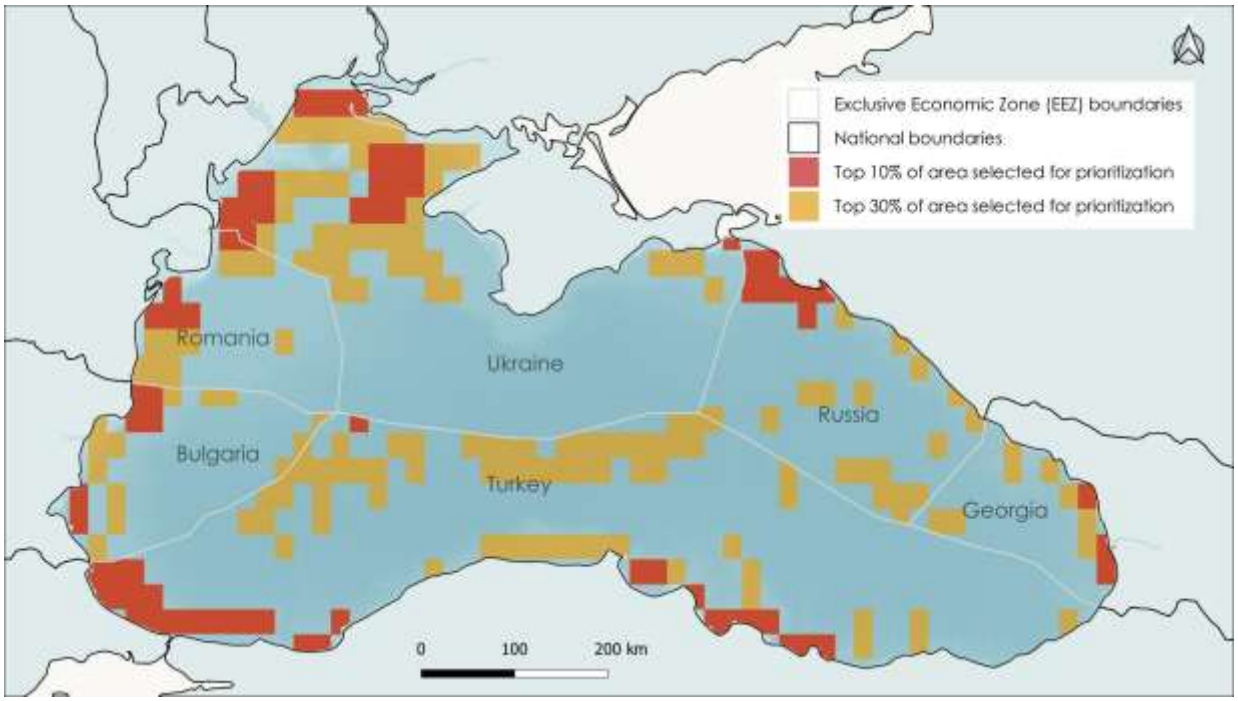
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario identifies areas that may remain critical for conservation even under severe climate change by the end of the century, balancing future biodiversity needs with information on habitat stability and extreme climate threats, emphasizing protection for the most threatened and endemic species.





Scenario: *Worst case scenario*
Run variant: *MPAs locked in - no species weights used*

What this scenario represents:
This scenario explores conservation priorities for the Black Sea under a severe climate change future (RCP8.5 - year 2100), combining multiple climate change components to identify areas likely to remain valuable for biodiversity even under extreme warming, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution.

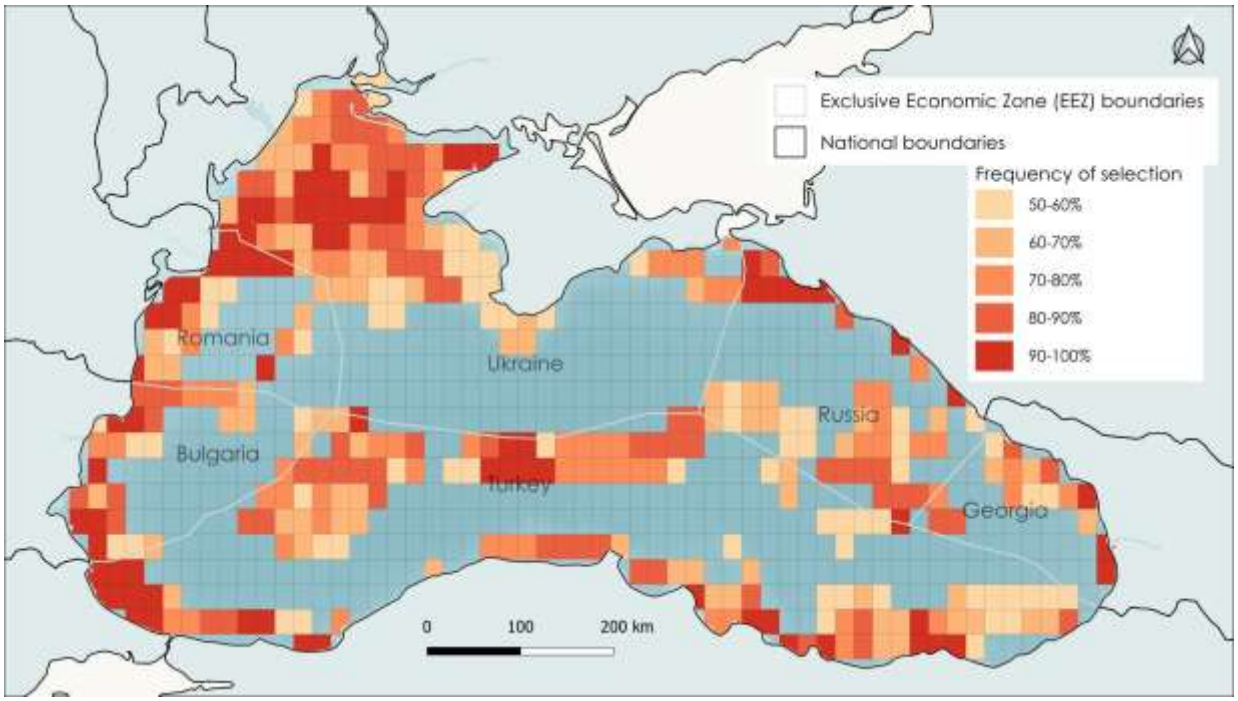
Climate scenario used:
The analysis is based on species distribution models and environmental conditions projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

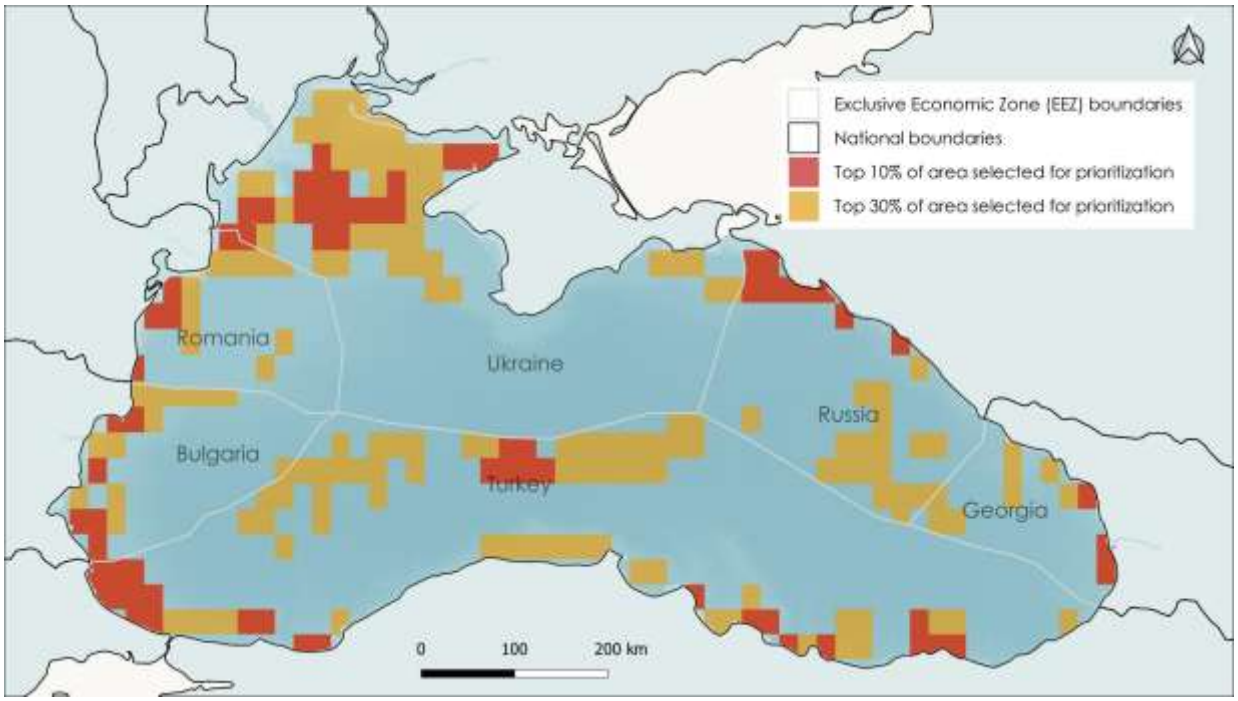
Data and inputs used:

- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.
- Habitat refugia: Identified as areas where species are projected to occur both in the current period and under RCP8.5 in 2100. These overlapping zones are critical because they are more likely to remain suitable under climate change, offering stable habitat that can support biodiversity persistence.
- Climatic refugia: Climate refugia are areas that remain relatively buffered from the effects of climate change over time, enabling them to play a vital role in safeguarding biodiversity.
- Climate change metrics used as a cumulative cost layer, highlighting areas under the greatest climatic pressure:
  - Changes in the probability of local climate extremes: This metric tracks the change in frequency of extreme temperature. Areas where such extremes become much more common are considered riskier for conservation.
  - Novel Climate: Quantifies how different the climate in will be compared to the historical baseline. Areas with higher values will face conditions outside past climate variability, which can challenge species survival.
  - Standardized Local Anomalies: Measures the magnitude of projected temperature changes relative to the historical local inter-annual variability. Areas with larger values are likely to face large changes in temperature.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Summary
This scenario identifies areas that may remain critical for conservation even under severe climate change by the end of the century, balancing future biodiversity needs with information on habitat stability and extreme climate threats, ensuring the existing MPA network is respected.


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Frequency of selection
50-60%
60-70%
70-80%
80-90%
90-100%
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km


Exclusive Economic Zone (EEZ) boundaries
National boundaries
Top 10% of area selected for prioritization
Top 30% of area selected for prioritization
Romania
Ukraine
Russia
Bulgaria
Turkey
Georgia
0
100
200 km

Scenario: *Worst case scenario*
Run variant: *MPAs locked in & species weights used*

What this scenario represents:
This scenario explores conservation priorities for the Black Sea under a severe climate change future (RCP8.5 - year 2100), combining multiple climate change components to identify areas likely to remain valuable for biodiversity even under extreme warming, while ensuring existing Marine Protected Areas (MPAs) remain part of the solution and giving higher priority to species of greater conservation concern.

Climate scenario used:
The analysis is based on species distribution models and environmental conditions projected under RCP 8.5, a high-emissions scenario where greenhouse gas emissions continue to increase throughout the century. This pathway assumes limited climate action and results in substantial warming and sea level rise by 2100, posing significant risks to ecosystems and human societies.

Data and inputs used:

- Future species distributions (RCP8.5 2100): Species distributions under projected climate conditions.
- Habitat refugia: Identified as areas where species are projected to occur both in the current period and under RCP8.5 in 2100. These overlapping zones are critical because they are more likely to remain suitable under climate change, offering stable habitat that can support biodiversity persistence.
- Climatic refugia: Climate refugia are areas that remain relatively buffered from the effects of climate change over time, enabling them to play a vital role in safeguarding biodiversity.
- Climate change metrics used as a cumulative cost layer, highlighting areas under the greatest climatic pressure:
  - Changes in the probability of local climate extremes: This metric tracks the change in frequency of extreme temperature. Areas where such extremes become much more common are considered riskier for conservation.
  - Novel Climate: Quantifies how different the climate in will be compared to the historical baseline. Areas with higher values will face conditions outside past climate variability, which can challenge species survival.
  - Standardized Local Anomalies: Measures the magnitude of projected temperature changes relative to the historical local inter-annual variability. Areas with larger values are likely to face large changes in temperature.

MPAs locked in – what this means & why:
In this run, the spatial prioritization was constrained so that all existing Marine Protected Areas (MPAs) are retained in the final solution (“locked in”).
This approach respects current conservation commitments and ensures that the network builds on areas already recognized as important for biodiversity.

Species weights – what they are & why they are used:
Species weights were applied to give higher conservation priority to areas supporting:

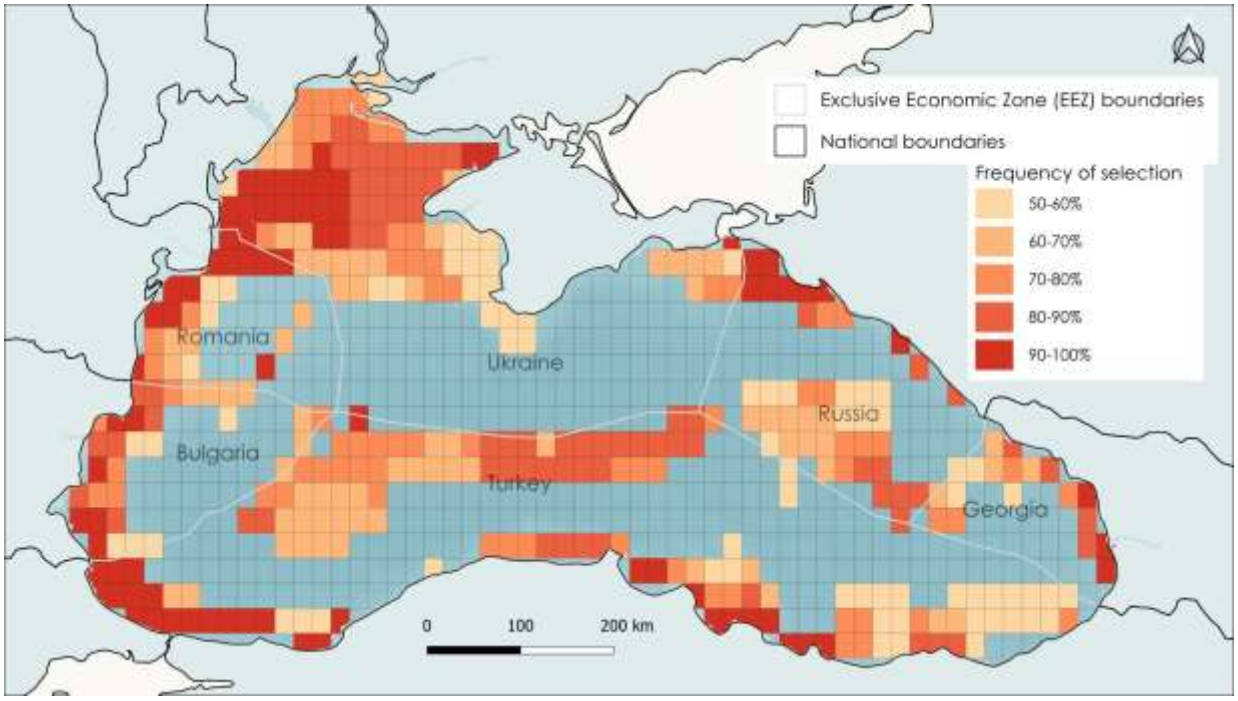
- Threatened species on the IUCN Red List (the more threatened the higher the weight).
- Species endemic to the Black Sea.

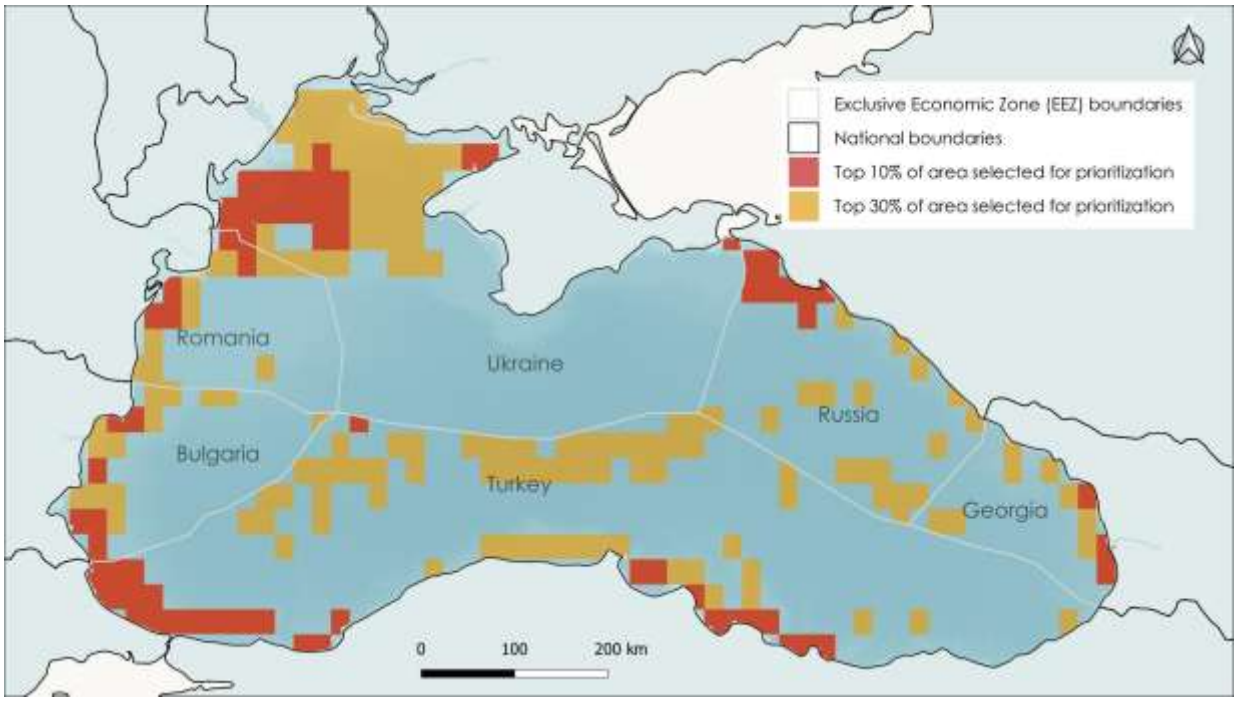
- Species listed under Annexes of Directive 92/43/EEC.
- Species present in Black Sea Important Marine Mammal Areas (IMMAs).

These weights were combined to reflect the relative importance of each species, so that conservation planning focuses more strongly on the species most in need of protection.

Summary

This scenario identifies areas that may remain critical for conservation even under severe climate change by the end of the century, balancing future biodiversity needs with information on habitat stability and extreme climate threats, ensuring the existing MPA network is respected, and emphasizing protection for the most threatened and endemic species.





References

Adam, C., Doxa, A., Nagkoulis, N., Papazekou, M., Mazaris, A. D., & Katsanevakis, S. (2024). *priorCON: Graph Community Detection Methods into Systematic Conservation Planning* (p. 0.1.5) [Dataset]. https://doi.org/10.32614/CRAN.package.priorCON

Ball, I. R., Possingham, H. P., & Watts, M. E. (2009). Marxan and Relatives: Software for Spatial Conservation Prioritization. In A. Moilanen, K. A. Wilson, & H. P. Possingham (Eds.), *Spatial Conservation Prioritization* (pp. 185–195). Oxford University PressOxford. https://doi.org/10.1093/oso/9780199547760.003.0014

Billionnet, A. (2013). Mathematical optimization ideas for biodiversity conservation. *European Journal of Operational Research*, *231*(3), 514–534. https://doi.org/10.1016/j.ejor.2013.03.025

Brin, S., & Page, L. (1998). The anatomy of a large-scale hypertextual Web search engine. *Computer Networks and ISDN Systems*, *30*(1–7), 107–117. https://doi.org/10.1016/S0169-7552(98)00110-X

Doxa, A., Adam, C., Nagkoulis, N., Mazaris, A. D., & Katsanevakis, S. (2025). prior3D: An R package for three-dimensional conservation prioritization. *Ecological Modelling*, *499*, 110919. https://doi.org/10.1016/j.ecolmodel.2024.110919

European Marine Observation and Data Network (EMODnet). https://emodnet.ec.europa.eu/en

European Union. (1992). *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora*. *Official Journal of the European Communities*, L206, 7–50. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31992L0043

Global Fishing Watch. https://globalfishingwatch.org/

Gurobi Optimization LLC (2025) Gurobi Optimizer Reference Manual. https://www.gurobi.com.

Hanson, J. O., Schuster, R., Strimas-Mackey, M., Morrell, N., Edwards, B. P. M., Arcese, P., Bennett, J. R., & Possingham, H. P. (2025). Systematic conservation prioritization with the prioritizr R package. *Conservation Biology*, *39*(1), e14376. https://doi.org/10.1111/cobi.14376

IUCN. 2025. The IUCN Red List of Threatened Species. Version 2025-1. https://www.iucnredlist.org. Accessed June 2025.

IUCN-MMPATF (2025) Global Dataset of Important Marine Mammal Areas (IUCN-IMMA). June 2025. Made available under agreement on terms of use by the IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force and made available at: www.marinemammalhabitat.org/imma-eatlas

Kaschner, K., Kesner-Reyes, K., Garilao, C., Segschneider, J., Rius-Barile, J. Rees, T., & Froese, R. (2019, October). AquaMaps: Predicted range maps for aquatic species. Retrieved from https://www.aquamaps.org.

Margules, C. R., & Pressey, R. L. (2000). Systematic conservation planning. *Nature*, *405*(6783), 243–253. https://doi.org/10.1038/35012251

Margules, C. R., & Sarkar, S. (2007). *Systematic conservation planning*. Cambridge University Press.

Moilanen, A., Wilson, K. A., & Possingham, H. P. (2009). *Spatial conservation prioritization: Quantitative methods and computational tools*. Oxford University Press.

Nagkoulis, N., Adam, C., Mamoutos, I., Katsanevakis, S., & Mazaris, A. D. (2025). An ecological connectivity dataset for Black Sea obtained from sea currents. *Data in Brief*, *58*, 111268. https://doi.org/10.1016/j.dib.2024.111268

National Geospatial Intelligence Agency. 2019. "World Port Index." Accessed from https://msi.nga.mil/NGAPortal/MSI.portal?_nfpb=true&_pageLabel=msi_portal_page_62&pubCode=0015. Accessed through Resource Watch, (June 2025). www.resourcewatch.org.

Ribeiro, B. R., & Atadeu, M. (2019). Systematic conservation planning: Trends and patterns among highly-cited papers. *Journal for Nature Conservation*, *50*, 125714. https://doi.org/10.1016/j.jnc.2019.125714

Rodrigues, A. S., Orestes Cerdeira, J., & Gaston, K. J. (2000). Flexibility, efficiency, and accountability: Adapting reserve selection algorithms to more complex conservation problems. *Ecography*, *23*(5), 565–574. https://doi.org/10.1111/j.1600-0587.2000.tb00175.x

Photo credit: Cover by © Galin Komitov 2022

MARMAPS – Open environmental eFolio for joint maritime spatial planning and conservation of the valuable Black Sea Basin marine ecosystems

Aristotle University of Thessaloniki
https://marmaps.bsnn.org
2025