Unravelling climate-driven habitat suitability for pelagic fish in European seas

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Pelagic fish species hold immense ecological and economic significance in European seas, playing a vital role in the region's marine ecosystem and contributing significantly to the local economy. Understanding their migration patterns and habitat preferences is crucial for developing sustainable fisheries management strategies that balance resource utilisation and environmental protection. This study employed a novel mechanistic niche modelling approach to predict the distribution of three commercially important pelagic fish species in European seas: Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), and European seabass (*Dicentrarchus labrax*).

This study investigated the impact of climate change on pelagic fish habitat suitability in European seas using habitat suitability models and climate prediction data. This was done by employing a mechanistic modelling approach as per Westmeijer *et al.* (2019) by incorporating a mathematical description of the species' niche to predict suitable habitats based on their interactions with environmental factors. Specifically, the study focused on three economically important pelagic fish species with distinct regional distributions. Species-specific response curves for temperature and salinity were then derived from a thorough review of existing literature and expert knowledge to capture the unique habitat preferences of each species. Employing fuzzy logic principles, which permit habitat suitability values to span any real number between 0 and 1, the models considered both worst-case and best-case scenarios to explore the full spectrum of habitat conditions and their influence on fish distribution. These insights were integrated into the mechanistic models, allowing for predicting habitat suitability indices (HSI) under various conditions. The HSI produced provided a holistic view of the habitat suitability across European seas and allowed for comparisons between different species and scenarios. To assess the impact of climate change on these species, the study utilised climate prediction data for temperature and salinity from Bio-ORACLE (www.bio-oracle.org). What-if scenarios based on the five Shared Socioeconomic Pathways (i.e., SSP126, SSP245, SSP370, SSP460 and SSP585) were used to simulate the habitat suitability of the selected species between 2020 and 2090. We validated our models with fish occurrence data from various literature and OBIS data (www.obis.org).

The study's findings reveal substantial alterations in habitat suitability for all three target species under the SSP585 climate change scenario (worst-case scenario), which predicts the most extreme temperature and salinity shifts. Currently, based on the temperature only, the average suitability index for Atlantic mackerel is 0.419 but decreases respectively to 0.292 and 0.413 for the worst-case (SSP585) and best-case scenario (SSP119). As expected, all three fish species have a northward shift in habitat suitability driven by thermal changes. Notably, a 1°C rise in temperature is projected to cause the *S. scombrus* suitable habitats to shift 315 kilometres northward, aligning with the findings of Chust *et al.*, (2023) who observed a similar acclimatisation pattern for *S. scombrus*. Climate change-induced salinity and temperature changes are driving complex and contrasting shifts in fish distribution. While salinity shifts push fish southward, temperature increases favour northward expansions. Additionally, regional disparities in habitat suitability are evident, with the Mediterranean Sea, once a stronghold for *S. scombrus*, becoming unsuitable due to projected sea-surface temperature increases.

The developed mechanistic niche modelling approach provides valuable insights into the intricate relationship between pelagic fish species, environmental conditions, and habitat suitability. The HSI offers a powerful tool for visualising and predicting potential distribution shifts under climate change scenarios, enabling proactive management strategies that adapt to the challenges posed by a changing environment and promote the sustainable exploitation of pelagic fisheries in European Seas.

References

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Climate Change; Mechanistic Niche Modelling; Pelagic Fish; Habitat Suitability; Species-specific Response Curves