



## Navigating Climate and Policy Shifts: Habitat Suitability Modelling for North Sea Pelagic Fisheries in a Changing World

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Understanding the habitats of commercially important pelagic fish is essential for their sustainable management. Pelagic fish species are not only economically significant but also play crucial ecological roles in marine ecosystems. Climate change is reshaping marine environments by altering ocean temperatures, salinity, and other abiotic conditions, which affect the distribution and behaviour of these pelagic fish.

In light of the challenges posed by a changing environment, this research examines how climate change, according to Shared Socioeconomic Pathways (SSPs) scenarios, impacts the habitats of three commercially significant pelagic species in the North Sea: Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), and European seabass (*Dicentrarchus labrax*). Mechanistic niche models were developed using temperature and salinity data from BioOracle and validated using 655,389 species occurrence records from EMODnet.

Model validation, conducted through Root Mean Square Error (RMSE) and visual inspection of predicted versus observed distributions, demonstrated good alignment between observed presence and predicted suitable habitats, supporting the models' reliability despite some regional mismatches due to uneven data distribution. The analysis estimated Habitat Suitability Index (HSI) values and observed distribution patterns, focusing on how optimal suitability shifted over time, independent of longitudinal variations. The HSI was classified on a scale where values were considered optimal ( $HSI \geq 0.75$ ), suboptimal ( $0.5 < HSI < 0.75$ ), and poor ( $HSI \leq 0.5$ ). The impact of climate change on habitat suitability was examined under six SSP scenarios (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP4-6.0, SSP5-8.5).

In the North Sea, the projected impacts of climate change on the distribution of suitable habitats for Atlantic herring, Atlantic mackerel, and European seabass show notable trends under the SSP5-8.5 scenario. For Atlantic herring, habitat suitability is projected to decrease from an HSI of 1.00 in 2010 to 0.82 by 2100 due to changes in temperature. Similarly, Atlantic mackerel exhibits a

decline in suitability from optimal habitat (HSI = 0.78) in 2010 to suboptimal (HSI = 0.56) by 2100. In contrast, European seabass maintains an HSI of 1.00 across all time periods. These results suggest a general resilience of European seabass to projected climate change impacts in the North Sea, whereas Atlantic herring and Atlantic mackerel may encounter more variable habitat conditions over the century.

The findings align with previous research showing latitudinal shifts in marine species due to warming temperatures, with significant implications for ecosystems and fisheries, particularly in the northern and southern regions of Europe. This underscores the necessity of adapting fisheries management to account for climate-induced shifts in pelagic fish distributions. As European fleets face new challenges posed by changing environmental conditions, this research provides crucial insights into future habitat suitability trends, aiding in the sustainable exploitation and conservation of these vital marine resources. Ultimately, this study highlights the importance of understanding shifts in fish habitat suitability to determine whether pelagic fisheries represent the future of the North Sea.