



## Climate-smart or not? Evaluating MSP zoning scenarios against projected climate change in Italian waters

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As ocean conditions change rapidly under climate forcing, anticipating future states is becoming essential for effective Marine Spatial Planning (MSP). A climate-smart approach integrates projected changes into planning decisions, prioritising the protection of stable areas (climate refugia) and reducing pressures in areas experiencing intense climate stress (hotspot of change). Despite increasing recognition of climate-smart principles, it remains unclear to what extent existing or proposed MSP strategies effectively account for future climate dynamics.

This study aims to evaluate how effectively alternative MSP scenarios incorporate climate-smart principles under projected future conditions. We assessed three stakeholder-developed scenarios differing in objectives and spatial zoning (*Business As Usual*, *Nature@Work*, *Blue Development*) across three Mediterranean case study areas: the Northern Adriatic, Northern Tyrrhenian, and Strait of Sicily. We applied an analogue-based 3D climate velocity approach derived from temperature-based bioclimatic variables, comparing present (2006-2030) and future (2031-2055) conditions across four vertical biozones (euphotic, mesophotic, mesopelagic, bathyabyssopelagic). Climate-smartness was evaluated through indicators quantifying the extent to which conservation measures protect climate refugia and whether ecosystem-dependent uses are allocated away from climate hotspots.

Results indicated high climate exposure across all regions, with the Northern Adriatic exhibiting the fastest rates of change. None of the scenarios fully safeguarded areas of future climatic stability or consistently avoided allocating climate-sensitive uses within hotspots, highlighting a misalignment between current planning strategies and projected climate trajectories. Among the scenarios, *Nature@Work* showed the strongest potential to enhance long-term biodiversity resilience.

These findings underscore the need to embed climate foresight into MSP processes, supporting more adaptive and forward-looking ocean governance in a rapidly changing marine environment.