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Seascape management: study identifies key sites for eelgrass conservation in northwest Sweden

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Using eelgrass *(Zostera marina)* as a case study, researchers in Sweden have presented a new approach to help target conservation efforts for optimal effect. Combining insights from biophysical modelling and genetic analysis, they depict populations as an interconnected network and identify which parts of this network are most important to the survival of the regional population (and should be prioritised for protection). This approach could inform seascape management and designation of marine protected areas (MPAs) across Europe.

A marine plant that grows to 10 metres underwater, eelgrass forms meadows that act as an important habitat and provide ecosystem services such as nutrient sequestration. However, eelgrass habitats have drastically declined in the last century, notably suffering large losses in the 1930s due to eelgrass wasting disease, which caused the disappearance of 90% of the eelgrass along the European and North American Atlantic coasts. Zostera beds are now on the OSPAR List of Threatened and/or Declining Species and Habitats.

Sweden has initiated a national action plan to protect and restore eelgrass. This study focuses on the country's north-west coast, which has lost 60% of its eelgrass meadows since the 1980s due to eutrophication and overfishing (which increase the prevalence of microalgae that block light needed for eelgrass survival). The researchers aimed to better understand how eelgrass disperses, which is important but difficult to assess due to the variability of ocean currents. They assessed 377 meadows in two fjord areas: Gullmarsfjord and Marstrand. Distribution data from 1980 and 2015 indicated that Gullmarsfjord's meadows were relatively stable over this period, while 111 out of 237 meadows disappeared in Martstrand.

The researchers collected 40 eelgrass shoots from 22 locations for genetic analysis; they identified high levels of genetic diversity, and a low number of clones shared among meadows — suggesting that eelgrass chiefly spreads by seeds among sites, with meadows serving as nodes and stepping-stones for genetic dispersal. Using an oceanographic model and informed by observations of drifting shoots releasing seeds they then modelled physical eelgrass dispersal. Viewing extant and lost meadows as an eelgrass exchange network, the researchers applied a mathematical method for identifying key points in a system that undergoes disturbance. Using this method, they ranked the importance of each site to the regional population, based on the probable dispersal of each meadow's propagules (reproductive material).

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Seascape management: study identifies key sites for eelgrass conservation in northwest Sweden (continued)

Finally, they used the gathered data to simulate eelgrass demographics — population structure, size, and dynamics — over tens of thousands of generations, from past to future. This highlighted the effect of the 1930s' 'bottleneck" (a crash in numbers and genetic diversity, which can be detrimental for successful evolution) and enabled the researchers to predict which meadows are particularly vulnerable to extinction. Demographic modelling is a valuable new approach in conservation, they say, for forecasting changes and identifying valuable and vulnerable meadows.

Combining their insights, the researchers identify subpopulations that could be treated as management units in each region (four in Gullmarsfjord and three in Marstrand). The genetic clusters reflected dispersal barriers such as physical isolation from other meadows, validating the findings from each approach. Interestingly, these units overlapped well with existing waterbodies used for management under the EU Water Framework Directive.

While both regions had good levels of genetic diversity, their networks were very different. Marstrand was considerably more interconnected than the linear-shaped Gullmarsfjord. Marstrand nodes had up to eight links each; Gullmarsfjord only one or two. The relatively low connectivity of Gullmarsfjord eelgrass could therefore impact its ability to evolve and adapt to environmental change.

Identifying nodes that contribute most to the growth of the overall population is crucial for prioritising conservation efforts, say the researchers. In Gullmarsfjord, most high-ranked meadows were in the inner fjords, while in Marstrand they were mostly further away from the mainland, and, in southern Marstrand, surviving meadows were isolated.

For designation of marine protected areas, where human activities are restricted for conservation purposes, the researchers propose that more spatial protection would be useful around the islands in Sälöfjord and on the west side of Hakefjord, in the Marstrand area, and at two sites in Brofjord in Gullmarsfjord.

The study also identifies seven lost meadows whose restoration would best enhance population growth. Four of these, in the Sälöfjord water body, historically harboured very large meadows of 40 to 240 hectares in size. The high rate of potential dispersal in Marstrand indicated that population recovery was possible (assuming intervention to address levels of sediment and algae, which prevent eelgrass growth).

Despite some limitations (such as detailed genetic sampling not always being possible), this suite of tools offers a roadmap for studies in conservation management, say the researchers, both for eelgrass and other important habitats such as coral reefs and forests. These findings could be particularly important for assessing the efficiency of the EU's network of Marine Protected Areas, which, the European Environment Agency is suggesting, should be extended to sustain ecosystem resilience.[1] For example, if the method is applied to a marine species or habitat, policymakers can ask: are the most highly-rated populations and threatened networks protected? The EEA also notes the importance of improving understanding of the interconnectivity of marine systems for planning MPAs. This toolkit could be used to reveal genetic networks in the marine environment and how they are affected by other ecological factors.

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1. https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/assessments/marine-protected-areas