Popular science summary of the PhD thesis

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Title of the PhD thesis	Population Dynamics of Blue Mussels in Subtidal Areas, Longevity, Recruitment, and Productivity, Under Multiple Stressors
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Science summary

Blue mussels (*Mytilus edulis*) play an important role in coastal ecosystems. They create hard structures on soft seabeds that provide habitat for many marine species, improve water clarity through filtration, and contribute to nutrient cycling. Some mussel beds develop into biogenic reefs, which are ecologically important and can qualify for protection, for example within Natura 2000 sites. Mussels are also recognised as a sustainable and nutritious food source, contributing both to ecosystem health and future food security. Despite this importance, wild mussel populations and mussel aquaculture production have declined markedly across Europe and the North Atlantic in recent decades. Wild beds are affected by overfishing, nutrient enrichment, and climate change, while aquaculture faces challenges such as shortages of seed mussels, adverse weather, and increased predation. Subtidal beds, which remain permanently underwater, are particularly difficult to study. The Limfjorden in Denmark provides a unique opportunity to investigate these dynamics. This shallow, nutrient-rich fjord supports extensive subtidal mussel beds and has a long history of both wild fisheries and aquaculture. It experiences nutrient enrichment, seasonal oxygen depletion, and complex spatial management, making it an ideal natural laboratory for studying how environmental and human pressures influence mussel populations. Long-term stock assessment data and GPS-based vessel tracking provide detailed information on environmental conditions, population trends, and fishing activity.

This thesis examines the population dynamics of subtidal blue mussels in the Limfjorden, focusing on factors affecting mussel bed longevity, recruitment, and productivity. Data from both wild and on-bottom cultivated beds were analysed to evaluate ecological, management, and economic dimensions of mussel sustainability. Results show that approximately half of the newly formed subtidal beds disappear within the first year. Bed longevity decreased with starfish predation, fishing, increasing summer temperature fluctuations, and oxygen depletion, while it increased with higher initial biomass, multiple size groups (cohorts), and greater water depth. Recruitment was identified as the main driver of population structure, more so than fishing pressure. Over time, declining recruitment has altered cohort composition, while shell material was found to promote settlement, suggesting potential for use in restoration. The study also compared different cultivation methods. In on-bottom it is possible to harvest around half of the initial relayed biomass in the Limfjorden. Maintaining access to seed and suitable grow-out sites is essential for sustaining mussel farming in the Limfjorden. Economic analyses indicate that on-bottom cultivation is generally viable when using wild seed and can become profitable with aquaculture seed under higher growth rates, offering potential for both economic and ecological gains.

Overall, the findings show that subtidal mussel populations are shaped by a combination of environmental pressures, biological interactions, and human activities. Newly settled beds are especially vulnerable, while older, multi-cohort beds are more stable. On-bottom cultivation both depends on and supports wild populations, contributing to local biomass and ecosystem productivity. Learnings from wild populations can guide cultivation strategies and support nature restoration. Integrating ecological, economic, and management perspectives is essential for sustaining wild mussel stocks and aquaculture production under changing environmental conditions.