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To what degree can coastal waters be protected by local efforts?

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Coastal ecosystems are hotspots of marine biodiversity, marine pollution, and multiple human interests. A large share of responsibilities of managing and protecting the coastal ecosystems - often rich in diversity and amenity values - is typically mandated to municipalities, communities and institutions sharing the coastline and catchment area. On the other hand, the quality of water – and hence the state of the coastal ecosystems – is also dependent on the level of water pollution in the neighboring regions. The objective of this paper is to assess the leverage and effectiveness of local pollution mitigation efforts in improving the water quality of nearby coastal waters. For this end, we employ a systems approach and develop a modelling framework to describe human-nature-human interactions to conduct what-if analyses for alternative societal developments and levels of policy effort in nutrient abatement. Our case study area is Archipelago Sea in the Baltic Sea. We demonstrate that there is room and opportunity for clear improvement towards the Good Environmental State (GES) in most parts of the Archipelago Sea. However, GES is far from reachable in any Archipelago Sea area, coastal region or inner bay through unilateral local action conducted in the catchment draining to the Archipelago Sea only. Local water protection efforts are necessary but not adequate measure to render the Archipelago Sea to a good environmental state. GES can be achieved for most areas within Archipelago Sea through well-coordinated and carefully adjusted load reductions and joint action between regions and countries that share the Baltic Sea catchment, except for inner archipelago, river mouths and the inner bays. In these areas – which also occur to be amongst the hotspot areas for various human interests – GES could be achieved only through extremely expensive local mitigation effort in the catchment area. To reach GES also on inner archipelago would require major transitions, investment in R&D and subsequent technological advancements in the energy sector, wastewater treatment, agriculture, and control of nutrients stored in the sediments of coastal seas. Moreover, this result calls for consideration on the relevance of current threshold values and targets for GES in different coastal zones. There is need for either more detailed classification that better accounts for geomorphological qualities of the coastal zone, or a new set of indicators that reflect the provision of ecosystem services rather than biological production. Our simulations also imply that the phenology of phytoplankton biomass occurrence is altered by increased nutrient loads. The shifts in the timing and relative abundance of spring and summer blooms are worth considering when planning the mitigation measures and the optimal timing/targeting of them.