THE FINNISH NATURE PANEL

MARINE BIODIVERSITY LOSS IN COASTAL AREAS OF FINLAND

Summary and recommendations of the Finnish Nature Panel to support nature policy planning and decision-making

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REPORT SUMMARY

The Finnish Nature Panel is an independent scientific advisory panel that supports nature and biodiversity policy planning and decision-making. The Nature Panel's reports are based on scientific evidence and multidisciplinary expertise.

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Marine Biodiversity Loss in Coastal Areas of Finland

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INTRODUCTION

Biodiversity loss is a global threat[1,2,3] that is also unfolding faster in seas and oceans than ever before in human history[4]. Biodiversity loss refers to the decline in wildlife on Earth as a result of human activity – the degradation of ecosystems, the loss of species and the reduction in population sizes. Long before species become extinct, the numbers of individuals in their populations decline, which has led to species becoming threatened in Finland and elsewhere in the world[1,5]. Humans are part of nature and need it in order to survive. Success in halting biodiversity loss is therefore also a matter of life or death for humanity[6].

Biodiversity loss is also visible in the Baltic Sea and on the Finnish coast. In this summary for decision-makers, the Finnish Nature Panel presents an overview of the changes in Finland's underwater coastal nature and the pressures caused by human activity that lie behind these changes. The summary is based on the Finnish Nature Panel's report 'Vedenalaisen luonnon köyhtyminen Suomen rannikkoalueilla' ('Marine Biodiversity Loss in Coastal Areas of Finland')[7]. The key objective of the report is to increase understanding of what biodiversity loss in our coastal waters means in practice, and how this degradation of nature manifests itself in different groups of organisms, habitats and marine areas. The report provides evidence-based recommendations to support decision-making. The recommendations focus in particular on protecting biodiversity in coastal and marine areas and reducing pressures from human activity. The Finnish Nature Panel's report shows that biodiversity loss on our coastlines is comprehensive, and the degradation of underwater coastal biodiversity is occurring in all Finnish marine areas. The biodiversity loss spans almost all underwater habitats and groups of organisms. Biodiversity loss is caused by a number of pressures from human activity, the most significant of which is nutrient loading and the eutrophication it causes.

Finland's coastal and marine areas are unique. Finland has a vast coastline of around 46,000 kilometres – the tenth longest of any country in the world[8]. The shallow coastal zone is rich in and important for biodiversity. Due to the low salinity, shallowness and shoreline fragmentation, Finland's coastal waters support unique underwater habitats and their diversity of species. Coastal waters and their biodiversity also provide ecosystem services that are important for humans, such as carbon and nutrient sequestration, oxygen production and viable and productive fish stocks that can support sustainable fishing[9,10,11]. Diverse and functional coastal ecosystems mitigate eutrophication, sequester carbon[12,13] and are essential for nature-based recreation and tourism.

Coastal waters are affected by many pressures. Eutrophication, mechanical disturbances of the seabed, land use, construction in water and coastal areas, unsustainable use of natural resources, climate change, invasive species introduced by human activity, and other local and global pressures caused by human activity are having a powerful impact on the resilience of the Baltic Sea and its ecosystems. Coastal areas are particularly vulnerable to these impacts[14]. Coastal underwater ecosystems absorb nutrient loads from both land and the open sea, filtering and recycling nutrients between different areas. Under pressure from human activity, the natural values of coastal waters are deteriorating, species diversity is diminishing, and the services provided by ecosystems are being compromised. Despite some signs of recovery, the situation in the Baltic Sea's coastal areas is poor, with no clear improvements[15,16,17,18,19].

National and international commitments guide coastal operations. Finland's previous and current governments have been and are committed to improving the state of nature and halting biodiversity loss[20,21]. Finland is also committed to achieving EU and UN biodiversity targets by 2030. Both the EU Biodiversity Strategy[22] and the targets of the UN's Kunming-Montreal Global Biodiversity Framework[23] focus primarily on increasing the scope of protected areas and restoring natural areas degraded by human activity. The targets of the Kunming-Montreal Global Biodiversity Framework require at least 30% of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, to be effectively protected and managed and at least 30% of areas of degraded terrestrial, inland water, and marine and coastal ecosystems to be restored. The EU's proposed Nature Restoration Law[24], published in November 2023, outlines that EU countries must restore at least 30% of habitat groups or habitats listed in the Habitats Directive in poor condition by 2030, 60% by 2040, and 90% by 2050 to good ecological condition. This provision applies to habitats both inside and outside protected areas, in terrestrial and aquatic ecosystems. In addition to this, the law will oblige member states to extend restoration measures to habitats of threatened species listed as such in regional marine conventions, such as the Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention') and the Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention), even if they are not listed in the annexes of the EU Habitats Directive[25] . The Habitats Directive requires the protection of certain important underwater habitats and species along the Finnish coast. Additionally, the EU Marine Strategy Framework Directive[26] and Water Framework Directive[27] oblige Finland to monitor and assess the status of the sea and coastal waters and take the necessary measures to achieve good status.

In the Baltic Sea, work to halt biodiversity loss is based on the Helsinki Convention [28] and in particular the associated Baltic Sea Action Plan[29] of the Baltic Marine Environment Protection Commission (HELCOM). Whether underwater species and habitats in Finnish marine areas are considered threatened is assessed in national assessments of threatened species in Finland[5,16]. The Marine Strategy Framework Directive and the Water Framework Directive provide the basis for national water and marine management plans[30,31]. Protecting marine biodiversity and halting biodiversity loss are also included in the draft national Biodiversity Strategy[32], the Maritime Spatial Plan[33] under the Land Use and Building Act[64], and the soon-to-be updated Coastal Strategy[34]. These policy commitments and targets are extremely important in the work to halt biodiversity loss, but achieving change requires more ambitious implementation and ensuring adequate resources.

What is meant by underwater coastal biodiversity loss?

Biodiversity describes the diversity of life on Earth. It consists of several different components, such as diversity within and between species, ecosystem diversity, functional diversity and genetic diversity[1]. The Finnish Nature Panel's report[7] defines biodiversity loss as negative changes in biodiversity over time and applies the broad definition of biodiversity used by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The report examines changes in the underwater nature of coastal areas over different time scales (5–250 years). The observed change is determined based on the difference between the status or value of biodiversity in the starting year and the ending year of the comparison in each dataset. Biodiversity loss can manifest in the disappearance and decline of species or populations, a reduction in the number of individuals or biomass of populations and biotic communities, a reduction in species' distribution range, a decline in ecological functions (e.g. a reduction in primary production), a decline in the health or growth of individuals at population level, and structural or functional changes in ecosystems or biotic communities.

The Finnish Nature Panel has compiled the first comprehensive report on changes in the underwater littoral zone. Rapid and cost-effective research-based action is needed to reverse the negative trajectory of coastal nature. Comprehensive assessments of changes in biodiversity and how these changes occur in shallow littoral areas have not previously informed decision-making on marine nature and its protection. The Finnish Nature Panel's report[7] contributes to filling this gap. The underwater biodiversity loss in Finland's coastal areas has been examined on the basis of scientific literature and other key assessments of marine nature. These include marine and water management status assessments, national assessments of threatened species and habitats, national reporting on species and habitats protected under the EU Habitats Directive, and the HELCOM Biodiversity Assessment. A systematic literature search rendered altogether 3,513 results, of which 90 articles were screened out as relevant for biodiversity changes in the shallow coastal waters in Finland and are assessed in the Finnish Nature Panel's report[7]. The main results and messages from the report is presented and discussed in this report summary. The Finnish Nature Panel's report provides an overview of what is known about changes in Finland's underwater coastal nature and the pressures from human activity that are causing these changes.

The report examines the underwater environments of shallow coastal waters in the Finnish marine area and the aquatic organisms[1] and the communities and ecosystems they form. The underwater shallow coastal areas mainly cover the upper swash zone (hydrolittoral zone) and the following lower permanently submerged zone (infralittoral zone). These zones are also used in EU legislation[35] and are defined in the European Nature Information System's (EUNIS) habitat types classification[36,37]. Based on these definitions, the report looks at underwater nature at depths of 0–10 metres, the so-called 'photic zone', where sunlight reaches.

BIODIVERSITY LOSS OCCURS IN ALL FINNISH MARINE COASTAL AREAS

Around 5% of the underwater species and just under a quarter of the habitats along the Finnish coast are assessed as threatened, and around a quarter of all underwater habitats along the coast are assessed as still declining[5,16]. In addition to threatened species, the decline of important keystone species such as bladder wrack, eelgrass and the blue mussel is a cause for concern. Keystone species provide habitats for many other organisms and are essential for maintaining coastal biodiversity and ecosystem services. The diversity of invertebrate benthic animals that underpin the food webs of Finland's coastal waters is relatively low by nature, making the ecosystem particularly vulnerable. If one species disappears locally, its important role and function in the ecosystem will also disappear if there are few or no substitute species. This feature distinguishes the Baltic Sea from many of the world's seas and oceans.

According to the Assessment of the Status of the Marine Environment set out in Finland's Marine Strategy, Finland's marine areas are not in good condition. None of the biodiversity indicators, with the exception of the grey seal population, are in good condition in all marine areas. Nor is any single marine area in good condition according to all indicators[17]. According to the water management assessment, only 13% of the surface area of coastal waters achieved good ecological status, and no water management district achieved excellent ecological status for coastal waters[38].

The Finnish Nature Panel's report[7] shows that the status of Finland's coastal waters is generally poor and that underwater biodiversity loss in shallow marine areas is progressing. Degradation of biodiversity is occurring in all coastal marine areas and in almost all underwater habitats and groups of organisms in the littoral zone (Table 1).

[1] The biota to be included in the survey is limited to aquatic organisms in the littoral zone, with no waterfowl, mammals or reptiles included. The following groups of organisms are included in principle: microbes, microalgae, macroalgae, aquatic vegetation (vascular plants, aquatic mosses and charophyte algae), zooplankton, soft bottom dwelling animals (infauna), hard bottom dwelling animals (epifauna) and fish.

Table 1. Summary of the prevalence of biodiversity loss and the strength of the knowledge base in the literature on underwater nature in shallow coastal areas. The results are broken down by organism group, habitat and marine area. The table shows the strength of the knowledge base of the research literature reviewed in the Finnish Nature Panel's report and how prevalent biodiversity loss was found to be in the datasets of the research literature. In total, 774 observations were found in the datasets examined that involved investigation of biodiversity loss. The prevalence of biodiversity loss is defined as the relative proportion of observation showing biodiversity loss of all the included datasets for each group under consideration, and the prevalence is classified as low (green, less than 33% of datasets showing biodiversity loss), moderate (yellow, 33–67%) or high (red, more than 67% of datasets showing biodiversity loss). The knowledge base refers to the number of datasets from scientific articles on biodiversity change and is classified as sparse (less than 10% of the total number of datasets), moderate (10–24%) or abundant (more than 24% of the total number of data sets).

	Prevalence of habitat loss in the dataset			Knowledge base in the datasets		
	Low	Moderate	High	Sparse	Moderate	Abundant
Organism groups						
Microalgae		■		X		
Macroalgae		■				X
Aquatic plants		■			X	
Zooplankton			■	X		
Hard bottom dwelling animals			■	X		
Soft bottom dwelling animals		■			X	
Fish		■				X
Multiple groups and ecosystems			■	X		
Habitats						
Soft bottoms in the swash zone	■			X		
Soft bottoms in the permanently submerged littoral zone		■				X
Hard bottoms in the permanently submerged littoral zone			■			X
Littoral waterbody	■			X		
Multiple environments*		■				X
Sea areas						
Bothnian Bay		■		X		
The Quark		■		X		
Bothnian Sea		■		X		
Åland Islands		■				X
Archipelago Sea		■			X	
Gulf of Finland		■				X
Multiple sea areas		■		X		

* Not all the datasets could be appropriately linked to a specific environment, and such datasets were therefore classified as belonging to the 'Multiple environments' group.

The literature review shows that biodiversity loss in coastal waters is very prevalent and manifests itself in many different ways – in total, the report lists 45 different forms of biodiversity loss. Most commonly, biodiversity loss manifests as a decrease in species presence and local disappearance of species, as well as a decrease in population abundance (number of individuals and/or biomass) (Figure 1). Biodiversity loss often occurs in multiple ways in groups of organisms, habitats or marine areas, and these can take place simultaneously, for example, through changes in species populations and individual characteristics, in the composition of biotic communities, and in ecosystem structure and function. Data on fish is relatively abundant and based on the datasets, biodiversity loss among fish is occurring in more than 20 different ways. For marine areas, more data is available for the more southerly marine areas of Finland than for those to the north. Based on the datasets, all marine areas are experiencing biodiversity loss, but fewer forms of biodiversity loss have been found in the Bothnian Bay and the Kvarken area than in the marine area around Åland, the Archipelago Sea and the Gulf of Finland, where more than 20 different forms of biodiversity loss have been identified in each area.

Where it does occur, biodiversity loss is clearly visible and the negative changes in nature have almost invariably been significant in magnitude. The magnitude of the change can be illustrated by calculating an effect size for the observed changes, which takes a value between 0 and 1, where 1 is the maximum possible change. The average magnitude of change across all datasets was 0.66, meaning that the changes caused by biodiversity loss were generally large. The magnitude of the change was not dependent on how long term the change observation was, and instead a significant deterioration in the state of nature was observed in both short and long term studies. Negative changes in biodiversity are most evident in aquatic plants and macroalgae, in southern marine areas, and in species occurrence and number of organisms.

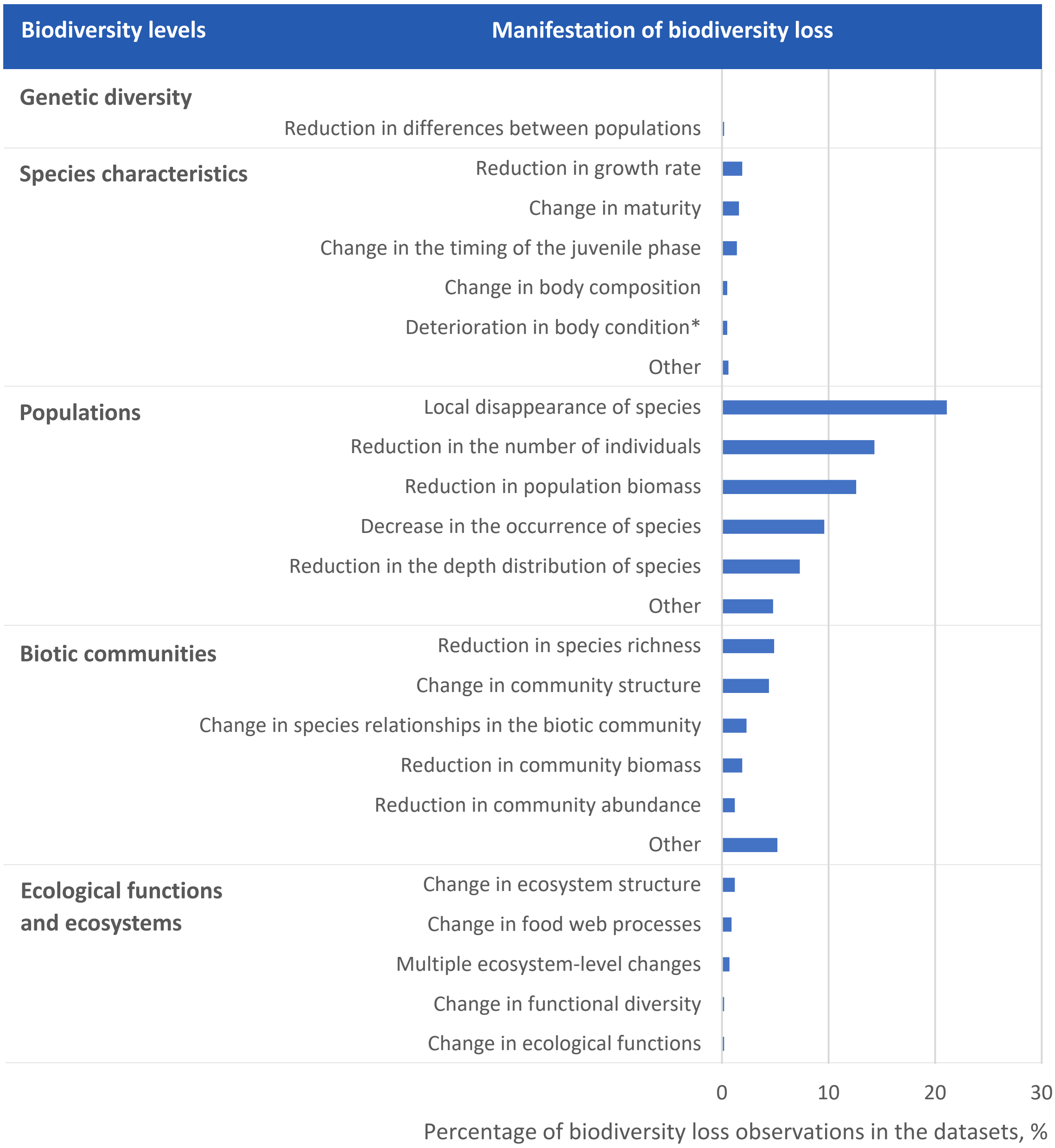

Figure 1. The most common expression forms of biodiversity loss in shallow coastal areas based on research literature. The manifestations of biodiversity loss are categorised according to five different levels of biodiversity. For each level, the most prevalent ways in which biodiversity loss is occurring are shown. The remaining forms of biodiversity loss are included in the 'other' category. A total of 45 different types of biodiversity loss were identified in the observations showing evidence of biodiversity loss (n = 427). The five most prevalent manifestations of biodiversity loss were: local disappearance of the species (21%), reduction in population numbers (14%), reduction in population biomass (13%), reduction in species occurrence (10%) and reduction in depth distribution of species (7%). Together, these accounted for 65% of the biodiversity loss datasets. *Condition refers to the changes in length and weight in fish.

EUTROPHICATION IS THE MAIN DRIVER OF BIODIVERSITY LOSS IN COASTAL WATERS

Eutrophication is by far the most common cause of biodiversity loss and is associated with most of the forms in which biodiversity loss is occurring in the Baltic Sea and shallow coastal waters according to the literature (Figure 2). Eutrophication refers to the increase in the primary production of algae and aquatic plants, i.e. the increase in photosynthesis and consequent growth, due to increased availability of nutrients, especially nitrogen and phosphorus. The increase in primary production causes water turbidity, siltation of the bottoms and the deoxygenation of the near-bottom water due to excessive organic loading. Eutrophication of coastal waters leads to multiple changes in the structure and function of biotic communities and ecosystems. For example, keystone species important in algae and aquatic plant communities, such as eelgrass and bladder wrack, are declining as species that prefer lower light and nutrient availability, such as filamentous algae, become more abundant.

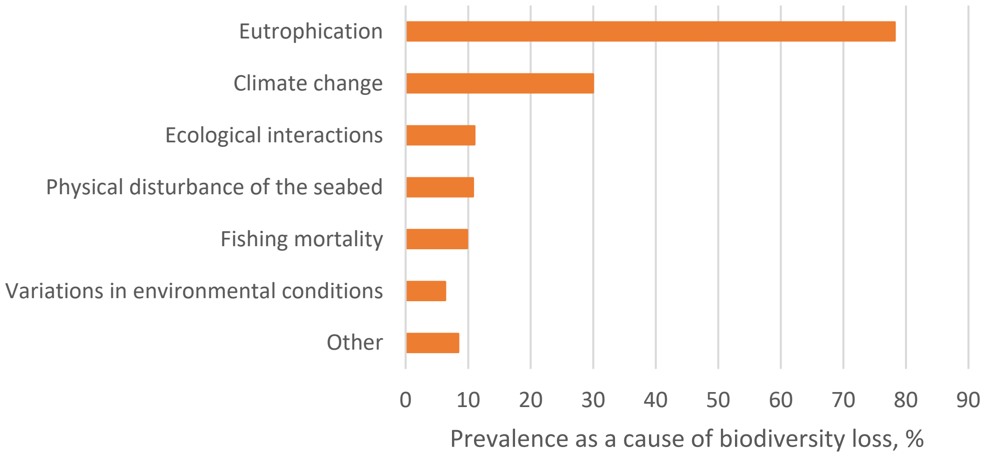

Figure 2. Different drivers of biodiversity loss in Finnish coastal areas as the prevalence in the research literature datasets. There were 427 observations showing evidence of biodiversity loss in the research literature. The figure shows the prevalence of each driver or cause of biodiversity loss in the dataset. One or more drivers of biodiversity loss have been attributed to each observation of biodiversity loss. The 'other' group includes the following drivers: nutrient depletion, habitat loss or degradation, invasive species, water acidification, artificial warming of the water, species stocking of fish, and harmful substances.

Nutrients are released as diffuse loading, especially from agriculture and forestry and from point sources such as emissions from urban settlements, fish farming and industry. In addition to this, eutrophication is sustained by the high internal loading of the Baltic Sea, when phosphorus that has been bound to the bottom sediments for decades under anoxic conditions begins to leach back into the water[39]. The adverse effects of eutrophication are visible in all underwater organism groups along the coast and in all Finnish marine areas, but most of in the southern marine areas and least of all in the Bothnian Bay and Kvarken. Long-term eutrophication of the Baltic Sea is the most significant cause of endangerment for almost all coastal underwater habitats assessed[16], and according to the overall status assessment, none of Finland's coastal waters are in good condition with respect to eutrophication[17].

Other causes of underwater biodiversity loss include climate change, mechanical disturbance of the seabed and overfishing. Fishing causes direct mortality and, if too intense, can lead to changes in the size and age distribution of the species fished, as seen for example in the pikeperch in the Archipelago Sea[40] and concerning the whitefish in the Bothnian Bay[41]. In addition to eutrophication, the main causes of underwater habitats becoming threatened are near-shore and underwater construction and boat trafic[16], and 30% of the seabeds along the Finnish coast have been assessed as disturbed[17]. Human activity that puts pressure on underwater coastal nature will continue and increase[42,43], and understanding the combined effects of these pressures is increasingly important when designing measures.

CLIMATE CHANGE IS ADVANCING – THE BALTIC SEA IS ONE OF THE FASTEST CHANGING SEAS IN THE WORLD

Climate change, combined with other environmental pressures, has made the Baltic Sea one of the fastest changing seas in the world[44]. The effects of climate change, including warming of seawater, are known to maintain and exacerbate eutrophication of the Baltic Sea, but a better understanding of local pressures and the combined effects of climate change is needed to assess the overall impacts[45]. Mitigating climate change and halting biodiversity loss are mutually reinforcing goals[46], and resolute climate policy will also contribute to slowing the continued deterioration of marine nature.

It is predicted that climate change will increase sea water temperatures and reduce ice cover in the Baltic Sea[45]. Climate change is altering living conditions in the coastal zone, with has multiple impacts on species, biotic communities and on ecosystem structure and functioning, such as the cycling of carbon, oxygen and other chemicals[47,48].

Many organisms in the Baltic Sea are living at the limits of their physiological tolerance, where even small changes in critical environmental factors such as salinity and temperature can have significant consequences. The low genetic diversity of many species and rapid environmental changes reduce their capacity to adapt[49] and thus the resilience and buffer capacity of the whole ecosystem to climate change[50].

KNOWLEDGE GAPS IN COASTAL WATERS SHOULD BE ADDRESSED

The Finnish Nature Panel's report shows that there are clear gaps in research and knowledge on biodiversity changes in shallow coastal areas, by marine area, habitat and organism group. There is less research data from the more northerly sea areas – the Bothnian Bay, Kvarken and the Bothnian Sea – than from the more southern marine areas of Åland, the Archipelago Sea and the Gulf of Finland. In particular, little information is available on the habitats of the shallowest swash zone, mainly only on the soft mud bottoms of the swash zone, but even this information is limited (Table 1). The report's literature review also found that, for example, datasets on zooplankton in shallow coastal waters are very scarce overall, and that no research data on changes in aquatic plants are available in four of the six marine areas. No data was found on microbes smaller than planktonic organisms. Filling these knowledge gaps is essential for halting the loss of biodiversity. For example, the aquatic plants of shallow, soft bottoms maintain biodiversity by providing habitats and breeding sites for many species of fish and invertebrates. Coastal zooplankton, on the other hand, is an important source of food for economically important species such as herring, perch and pikeperch during their juvenile stages.

There are also gaps in national monitoring and evaluation. Despite the large amount of data produced by the Finnish Inventory Programme for Underwater Marine Diversity, VELMU, for up to a third of the underwater habitats in the Baltic Sea the threat status cannot be assessed properly due to insufficient data, and there is no formal monitoring of coastal underwater habitats in Finland[16]. There are also regional and organism group specific gaps in the marine management monitoring programme. For example, coastal fish stock monitoring is not spatially comprehensive[51].

The genetic diversity of coastal underwater organisms is poorly understood and there is very limited research data on changes in genetic diversity over time. This prevents, for example, the assessment of the combined effects of climate change and local drivers of biodiversity loss on organisms. An understanding of the importance of genetic variation in keystone species is essential, for example in seabed habitat restoration projects[50,52].

Data on the status and changes in ecosystem functions is particularly scarce. Marine ecosystem functions include oxygen production, carbon sequestration, and biomass production and decomposition. Changes in species occurrence and abundance cause changes in ecosystems, their functioning and the services they provide. These changes can be unexpected and shake the stability and resilience of ecosystems. There are also gaps in our knowledge on the drivers of change, especially on the cumulative interactions of climate change and local pressures on different organism groups and at different ecosystem levels along the Finnish coast.

In Finland, there is limited experience and scientific evidence of success and effectiveness in coastal underwater restoration of nature (e.g. experimental restocking of eelgrass and charophytes), and experimental projects have so far been short-lived and small-scale[53,54,55].

THERE IS A SUFFICIENT KNOWLEDGE BASE TO IMPLEMENT MEASURES

Despite the knowledge needs, there is enough data to state with certainty that the coastal underwater nature is in poor condition. We also know the main pressures on nature and the human activities that cause them[17]. Furthermore, it has been possible to assess many underwater coastal species and habitats as threatened[5,16]. Existing knowledge can be used to identify specific needs for improving the state of the sea and to take the necessary measures[42]. To halt biodiversity loss in coastal waters, measures must be comprehensive and holistic, ranging from land-based measures to measures in marine areas.

The possible measures needed consists firstly of addressing human activities and the pressures that cause biodiversity loss, secondly of conservation and protection measures, and thirdly of restoration actions. The measures chosen should be carefully considered and cost-effective. Addressing the sources and activities that cause nutrient loading is a priority. The prospects for success of conservation or restoration measures will be poor if the pressures that have caused biodiversity loss in the first place cannot be reduced or eliminated and the degradation continues. Furthermore, the territorial coverage of the measures should be sufficiently wide.

RECOMMENDATIONS FROM THE FINNISH NATURE PANEL TO IMPROVE THE BIODIVERSITY STATUS OF COASTAL WATERS

Emissions sources of nutrient loading should be addressed throughout the Baltic Sea catchment area

Long-term conservation work in the Baltic Sea has been valuable and has probably slowed down the rate of biodiversity loss. However, action to support biodiversity in coastal waters has so far been insufficient. The Finnish Nature Panel's report shows that eutrophication is the main driver of biodiversity loss in Finland's coastal waters and has not been curbed despite targets. The Programme of Prime Minister Petteri Orpo's Government[21] commits to promoting the better ecological status of inland water bodies and marine areas. Reducing eutrophication is key to achieving this objective.

The Finnish Nature Panel’s recommendations:

- **Water protection measures should be improved for land use that causes diffuse loading.** Measures to reduce diffuse loading from agriculture often also bring carbon sequestration benefits at the same time. To reduce diffuse loading from forestry, water protection measures for reforestation and ditch network maintenance should be improved. Improvements could be made through updates to the Forest Act or the Water Act.
- **Support for agriculture and forestry should be linked to measures to improve the status of the environment and reduce loading.** The national support scheme should be modified where this is a matter decided on nationally. The EU's Common Agricultural Policy should be influenced to include more mechanisms to protect the environment.
- **Nutrient cycling in agriculture should be supported. The** recycling of agricultural nutrients should become more efficient, for example by using manure, biowaste and slurry to produce fertiliser or as biogas. A closed nutrient cycle prevents nutrient run-off into water bodies. Improving the nutrient

cycle is also an objective of the Programme of Prime Minister Petteri Orpo's Government[21] as part of the Archipelago Sea Programme for Agriculture.

- **Point source loading should be reduced.** Support schemes and legislation should address the most significant sources of point source loading, such as urban wastewater and nutrient discharges from fish farms. The conditions should be created for fish farms to become fully closed-loop facilities.

Consideration of marine nature should be promoted in planning and permitting

Halting biodiversity loss requires, as a starting point, avoiding damage to nature and optimising how synergies are taken into account as part of all planning and permit activities. The weighting of marine nature in the environmental impact assessment (EIA) process and in permit applications should be strengthened.

The Finnish Nature Panel’s recommendations:

- **Underwater marine nature should be taken into account more comprehensively in permit and assessment processes.** It should be required that the effects of a project on marine nature, alone and in combination with other activities, are taken into account more comprehensively in the EIA process and in the permit and notification processes under the Environmental Protection Act and the Water Act58. The legal weight of water management and marine management objectives should also be reinforced in permit assessments[56,57].
- **Compliance with the mitigation hierarchy should be required in permit applications.** According to the mitigation hierarchy, damage to nature should primarily be avoided and mitigated, and the remaining damage to nature compensated for. Applications for permits should include a compensation plan for damage to nature.
- **Marine spatial planning should be developed**. Marine spatial planning should become more binding in, for example, directing offshore wind and other projects that threaten coastal nature away from the most sensitive and ecologically significant areas, and in reducing adverse synergies[56,57,58].

The protection of marine areas should be developed and made more effective

The targets of the Kunming-Montreal Global Biodiversity Framework call for at least 30% of marine areas to be protected by 2030. One third of the surface area of this 30%, or 10% of the total surface area of the marine areas, must be strictly protected. The Programme of Prime Minister Petteri Orpo's Government[21] commits to launching a voluntary conservation programme for marine nature as well. In addition to protection, marine environments that have already been degraded must be restored and rehabilitated in line with international targets.

The Finnish Nature Panel’s recommendations:

- **The number of nature reserves under the Nature Conservation Act should be increased and valuable underwater areas safeguarded.** The protection of already-identified ecologically significant underwater areas should be improved and adequate connectivity of protected areas should be ensured [60,61]. Guidelines should be prepared on the use of restrictions under the Water Traffic Act to protect the occurrence of habitats protected under the Nature Conservation Act and other threatened habitats [56,63], as well as other valuable marine areas.
- **The protection of aquatic habitats should be supplemented by adding key habitats important for underwater biodiversity to the Nature Conservation Act.** These habitats include, for example, pondweed and water milfoil beds, bladder wrack beds and blue mussel beds[58].

- **Legislation should be used to prevent the deterioration of important spawning and nursery areas for fish.** In addition to preventing eutrophication, this would require an instrument similar to the protection of places where habitats or species occur in the Nature Conservation Act[9,56].
- **Overfishing should be prevented and fishing managed to ensure the diverse and healthy fish stocks.** Commercial and recreational fishing of coastal fish stocks should be steered on the basis of scientific recommendations, where necessary more effectively, by regulating catch levels, equipment and times, and fish catch sizes.
- **Mechanical disturbance to seabed habitats should be reduced.** Dredging and dumping should become subject to permits or the Water Act and notification process improved so that best practices are always applied, and the overall cumulative impact of dredging activities in coastal areas should be reduced [42,56].
- **The most effective measures for marine nature rehabilitation should be identified and the targets associated with international commitments in this area implemented.** At the same time, knowledge on the rehabilitation of shallow underwater areas should be developed and rehabilitation measures suitable for shallow coastal areas with degraded natural values piloted.

Knowledge gaps on biodiversity in shallow coastal areas should be addressed

Monitoring and research on underwater coastal habitats is needed to target water protection and rehabilitation measures and to monitor the achievement of their objectives. Adequate resourcing of these must be ensured.

The Finnish Nature Panel's recommendations:

- **Long-term funding should be secured for a biodiversity monitoring programme for shallow coastal waters.** The existing marine management monitoring programme should be implemented and biodiversity monitoring increased in shallow coastal areas to cover all Finnish marine areas and their key habitats.
- **Understanding of the cumulative impacts of climate change and local pressures on coastal nature should be increased.** The coastal environment is changing rapidly and understanding of the adaptive capacity of organisms is essential. Modelling of climate change impacts should be developed to better take into account shallow and diverse archipelago and coastal areas. The cumulative effects of climate change when combined with other local pressures should always be considered when planning and implementing coastal water use, management, protection and rehabilitation measures.
- **More research should be done on the significance of internal loading in relation to the total phosphorus load.** Agricultural loading in the Archipelago Sea catchment area is the most significant source of loading for the overall loading of the Finnish coastline of the Baltic Sea, a so-called HELCOM hot spot.
- **Even greater geographical coverage of marine and coastal research should be sought. The** VELMU programme is unique internationally and its broad geographical knowledge base is well placed to achieve this. There is less research data on our northernmost marine areas than on our southernmost ones, but we also need more research to understand the loss of biodiversity in the southern marine areas and its causes.
- **The continuity of basic experimental research on coastal species, biotic communities and ecological functions should be ensured with adequate funding.** For this purpose, the existing FINMARI research infrastructure for Finnish marine research provides a solid scientific platform. FINMARI brings together the Finnish marine research infrastructure and develops it through national and international cooperation.

Halting biodiversity loss requires prioritisation of nature in policy-making and ensuring long-term funding

Halting biodiversity loss will require a society-wide sustainability transformation that puts nature and its protection at the heart of all aspects of society and decision-making. Taking biodiversity into account, safeguarding natural values and improving the state of nature must be reflected in policy-making if Finland is to meet the objectives of the Government Programme and international commitments to halting biodiversity loss. We need to ensure that the targets and commitments already set are met and accelerate the implementation of the measures. Further decisions may also be needed to expand the targets if biodiversity loss continues.

The Finnish Nature Panel’s recommendations:

- **Funding should be increased for tangible measures to improve the status of marine and coastal waters and halt biodiversity loss.** Petteri Orpo's government has already committed21 to strengthening overall coordination between administrative sectors and research and to improving the effectiveness of targeting conservation measures in the Baltic Sea, especially in the Archipelago Sea. Adequate funding is needed to implement these actions.
- **Knowledge of marine, archipelago and coastal nature at different levels of education and among key stakeholders should be strengthened.** The Programme of Prime Minister Petteri Orpo's Government21 aims to increase the impact of Baltic Sea information. Achieving this objective requires good planning. Education and information transfer are key to enabling the sustainability transition.
- **An idependent group of researchers should be set up to develop an evidence-based long-term plan to tackle biodiversity loss.** The objectives of the long-term plan should be operational, quantified and time-bound, so that the ecological, social and economic impacts of the plan can be anticipated and the achievement of the objectives monitored. The plan would cover all habitats in Finland and would also provide essential support for underwater biodiversity.

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