Impact assessment of the proposal for amended marine spatial plans for the Gulf of Bothnia, the Baltic Sea and Skagerrak/Kattegat

Espoo consultation document (ref. no. 03746-2022)

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International consultation on proposals for amended marine spatial plans

Marine spatial planning is one of our most important tools for achieving a long-term sustainable development of our seas. From November 2023 to February 2024, proposals on amended marine spatial plans for the Gulf of Bothnia, the Baltic Sea and Skagerrak/Kattegat with the associated impact assessment are being circulated for international consultation.

The Swedish Agency for Marine and Water Management (SwAM) has prepared the consultation proposal within the scope of a Government assignment on new or changed areas for energy extraction in the marine spatial plans. The objective of the assignment is to enable another 90 terawatt hours of yearly electricity production at sea, in addition to the planned capacity in the current marine spatial plans (M2022/00276). The aggregated strategic objective then amounts to 120 terawatt hours yearly energy production. The use energy extraction refers to offshore wind energy.

In accordance with the assignment, offshore wind energy is the main focus of the proposal. The starting point for the planning for offshore wind energy has mainly been the report from the first step of the assignment presenting potential new or changed areas for energy extraction in the marine spatial plans (Swedish Energy Agency, 2023a).

In addition to proposals for energy extraction areas, we also present a number of alternative areas. Proposed areas and alternative areas are marked differently in the plan maps. During the consultation, the alternative areas shall be seen as possible replacements or complements to proposed areas. To achieve the mission’s objectives, we estimate that several of the areas that are now presented as alternatives need to be included in the final proposal. During the consultation, we therefore wish to receive comments both on proposed areas and the alternative areas. The goal is to arrive at the most suitable use of the marine area from a holistic perspective based on the assignment’s strategic objective.

This document, the *Impact assessment of proposal on amended marine spatial plans for the Gulf of Bothnia, the Baltic Sea and Skagerrak/Kattegat,* presents the identified potential environmental, economic and social impacts of the proposed plan. A summary of the potential impacts is included in the plan proposal. This impact assessment covers the environmental impact assessment requirements of strategic environmental assessment according to Chapter 6, Sections 1-19 of the Swedish Environmental Code.

Summary

This impact assessment with included Strategic Environmental Assessment is input to the international consultation on the proposal for amended marine spatial plans to be held November 2023 to February 2024.

Sand extraction

Sand extraction at Svalans and Falkens grund in the Bothnian Bay and Utklippan, Sandhammaren and Sandflyttan in the Baltic Sea are considered to be able to entail large effects locally on seabed environments and partly also water quality. Extraction operations and transportation to and from the coast can lead to higher airborne emissions, and are deemed to result in a small deterioration of air quality, mainly locally. The effect on human health and on the climate is considered to be insignificant considering other emission sources.

Shipping

In the South Bothnian Sea, the marine spatial plan's guidance entails an extension of travel distance for shipping. This will contribute to an increase in air emissions, including greenhouse gases with some effect on climate. A marginal deterioration of air quality is considered to take place locally, but without an effect on human health. The marine spatial plan for the Baltic Sea contains investigation areas for shipping, including Hoburgs bank, the Midsea banks and Salvorev. The investigation alternative is described in the approved marine spatial plan of 2022 with an environmental impact assessment and sustainability assessment, and includes a rerouting of shipping away from sensitive natural areas to protect birds and marine mammals. Also in this case, an increased travel distance for shipping is considered to give rise to some negative effect on climate. The rerouting is at the same time considered to be able to benefit the marine environment through reduced noise disturbance and reduced emissions of pollutants at sea. This potential positive effect is especially important for birds and marine mammals that are present in the offshore bank area, such as the long-tailed duck and the Baltic Sea harbour porpoise.

Energy

Birds

The marine spatial plan's guidance on energy extraction is considered to entail a risk of negative effects on migratory birds and breeding, resting and wintering birds in several places. The risk of significant negative effects is the largest where energy areas are placed in the middle of narrow passages across the sea, so-called bottlenecks, which are found in all three marine spatial planning areas. Energy areas along the broad bird migration path across the Baltic Sea also entail a risk of negative effects. Wind power establishment on or next to offshore banks, and close to the coast in turn entails varying risks of impact on breeding, resting and wintering birds, and on species that migrate along the coast. Possible barrier effects need to be investigated,

especially upon establishment in several areas simultaneously and with consideration to planned wind power projects in the neighbouring countries.

Benthic habitats

Impact on the seabed occurs in the expansion of offshore wind energy, with permanent changes in the form of an artificial substrate in the areas that are relevant for bottom-fixed foundations. In some settings, the introduction of a new artificial substrate can have positive effects for the marine environment. However, the effects, positive and negative, need to be investigated specifically for each location to, among other things, avoid damage to protected benthic habitats. In areas at a greater depth where floating wind power foundations are relevant, the impact on the seabed is generally lower.

Marine mammals

Disturbance of marine mammals is considered to be able to occur mainly in connection with the construction phase of offshore wind energy establishment. The risk is especially big in the Baltic Sea harbour porpoise's range in the South-eastern and Central Baltic Sea, given the population's status as critically endangered. The small population of harbour seals in Kalmarsund is classified as endangered. Other populations of marine mammals in Swedish waters are given the status "least concern" in the Swedish Red List. In most cases, negative impact on marine mammals should be possible to minimise to acceptable levels using noise-reducing measures and by avoiding disturbance during sensitive reproduction periods. The long-term effects during the operating phase are insufficiently studied, which can motivate caution in the pace of establishment and avoidance of a large number of wind power projects in areas that are important to the species.

Fish and fish spawning

According to current knowledge, establishment of offshore wind energy is not considered to constitute a threat to fish species or fish populations, provided that adequate consideration measures are introduced and adapted to local conditions. In particular, the impact on fish spawning and nursery grounds needs to be considered. Construction and decommissioning of wind power stations causes some sediment dispersion that can affect fish larvae, and thereby fish spawning, negatively. The risk is present in several of the energy areas that are located in or next to known fish spawning areas. However, the risk is generally considered possible to minimise to acceptable levels through adaptation of the construction and decommissioning phases to the spawning periods for the species spawning in the areas in question.

If fishing is limited within wind farms, the fishing pressure will decrease in energy extraction areas, which can be beneficial to the fish resource, benthic environments and marine mammals. Several such areas are located in Skagerrak and Kattegat, where energy establishment has the potential of contributing to green infrastructure as links between protected areas. Today however, it is not possible to determine the scope of this positive effect for the environment.

Air and climate

Emissions of airborne pollutants and greenhouse gases can increase as a result of shipping traffic for construction, maintenance and decommissioning of wind farms. Based on current

knowledge, the magnitude of the effect is, however, not possible to estimate. At the same time, positive effects for the climate are considered to be able to arise through expanded production of fossil-free electricity. In the marine spatial plan proposals, the production potential in proposed energy areas is estimated to correspond to around two-fifths of the potential in alternative energy areas.

Wind power establishment according to the plan proposal's guidance on energy extraction is considered to entail a risk of impact on other interests. A brief review of effects on shipping, commercial fishing, cultural environments, landscapes and recreation is found below.

Electricity production potential

Proposed energy areas have the potential to contribute 101 TWh and the alternative energy areas 279 TWh of fossil-free electricity in accordance with Sweden's climate and energy policy objectives. The introduction of safety distances to shipping will entail a decrease in actual production potential of the energy areas.

Shipping

The marine spatial plans do not provide guidance on specific safety distances to shipping. Distances will be required for all energy areas. The need for location-specific adaptations to promote coexistence with shipping needs to be assessed for each energy area and decided in the permit process. Should safety distances not be applied, it would present a safety risk to shipping with potential consequences for the environment and human health. The energy areas are presented differently in relation to the use shipping in the plan maps. The presentation should be more consistent in the continued planning.

In the Gulf of Bothnia, the impact on winter navigation constitutes another potential risk that needs to be worked out in order for accessibility and maritime safety to be sustained.

Commercial fishing

For commercial fishing, the estimated loss in landing value in all three marine spatial planning areas amounts to around SEK 23 million annually, corresponding to around 3% of the annual landing value of Swedish fishing. The loss in the proposed energy areas is estimated to be around one third of this amount. The fishery in Skagerrak and Kattegat account for around 60% of the loss. In the Gulf of Bothnia and the Baltic Sea, it is mainly the pelagic trawl fishery that is affected, while in Skagerrak and Kattegat, it is mainly bottom trawl fishing targeting shrimp, crayfish and fish where the biggest losses are considered to occur. In all three marine spatial planning areas, the consequences for the local food supply from the sea, fish ports and coastal communities can be significant and should be taken into consideration in the review of wind power projects.

Cultural environment, landscape and recreation

Negative effects on cultural environments, landscapes and recreation are considered to be able to arise as a result of, among other things, visual impact from offshore wind farms. The effect is considered to be greatest upon establishment in energy extraction areas closest to the coast, and affects several areas from Haparanda archipelago in the Bothnian Bay, North Kvarken and the

South Bothnian Sea coast in the Gulf of Bothnia; areas on Gotland and Öland, and south of Skåne in the Baltic Sea marine spatial planning area; to larger parts of the Skagerrak and Kattegat coast, with a focus on the areas off of and north of Halmstad and up to Kungälv. The distance to land and the size of the energy areas, especially in parallel with the coast, are crucial to the magnitude of the effect. The impact and need for adaptation to promote coexistence need to be assessed from a regional and local perspective.

Recreation areas at sea exist in some places and accessibility upon the establishment of offshore wind energy needs to be ensured. Knowledge of the effects of wind power on cultural environment and recreation, and its social and economic effects on the tourism industry from a local and regional perspective, for example, is today inadequate and needs to be supplemented.

Particular consideration of high nature values

The spatial extent of areas with particular consideration of high nature values has been expanded in all three marine spatial planning areas. Focus is especially on the need for strengthened protection of birds, especially migratory birds, but also sea birds in foraging and wintering areas. The proposed expansion of areas with particular consideration of high nature values with a focus on sea birds can provide some protection in the form of requirements on precautionary measures in the review of licensed activities in these areas, including offshore wind energy.

In the Baltic Sea and Skagerrak and Kattegat, some new consideration areas refer to stronger protection of the Baltic Sea harbour porpoise and nature types worthy of protection. Together with other consideration areas and areas with the use nature in the marine spatial plans, the new consideration areas point to the need for special protection in the planning and regulation of human activities and are considered to be able to contribute to a sustainable use and strengthened green infrastructure in the marine spatial planning areas.

Cross-border effects

Birds, fish and marine mammals

The majority of identified environmental effects are considered to be cross-border and affect Sweden’s neighbouring countries to a varying extent. The bird, fish and mammal species that are considered to be able to be affected by uses that the marine spatial plans have influence over are in many cases part of cross-border populations. The bird migration routes across Swedish waters and offshore banks in all three marine spatial planning areas are used by populations that migrate far beyond Scandinavia, and are thereby of global significance.

Shipping and commercial fishing

The effects on shipping and fishing also impact foreign vessels and fishermen and accessibility to shipping lanes and ports in neighbouring countries. Most of the shipping traffic to and from the Baltic Sea passes through Skagerrak and Kattegat, and this marine spatial planning area is of global significance to all trade with the Baltic Sea region. In terms of fishing, the potential effects on foreign fleets are considered to be at least as large as those on Swedish fishing.

Cultural environment and recreation

The effects on cultural environment and recreation in the North Bothnian Bay, Hanö Bay, Öresund region and most of Skagerrak and Kattegat are also considered to be able to affect the corresponding values in Finland, Denmark and Norway.

Energy

Wind power's potential positive effects in the form of expanded production of fossil-free electricity can benefit not only the countries that Sweden has electricity trading with, but also other countries considering potential benefits to the climate.

Cumulative effects

In Sweden's and its neighbouring countries' territorial waters and exclusive economic zones, human use is continuously increasing. Planned offshore wind energy accounts for a strong increase in the short and medium term, not only in Sweden, but also in its neighbouring countries. Consideration must therefore be given to the risk of cumulative effects in the continued planning and permit review of mainly offshore wind energy, but also other activities. The risk can be especially large in areas with a large concentration of energy areas and where there are high nature values of international significance. Cross-border collaboration on the assessment of these kinds of cumulative effects is desirable.

Contributions to achieving Sweden's environmental quality objectives

Reduced climate impact – positive effect by creating better conditions for a greatly expanded establishment of offshore wind energy in Swedish territorial waters and the Swedish exclusive economic zone.

Clean air – small or marginal risk of negative effect through harmful air pollution.

A non-toxic environment – marginally elevated risk of environmental toxins being released from the sediment in sand extraction activities.

A balanced marine environment, flourishing coastal areas and archipelagos – both negative and positive effects through development of sand extraction activities in a few valuable areas and guidance on particular consideration of high nature values in significantly more and larger areas.

A rich diversity of plant and animal life – both negative and positive effects through offshore wind energy and sand extraction activities, which entail risks to biodiversity of significance from the local to the international level, and guidance on protection for specific valuable areas and a need to adapt maritime activities with the aim of preserving biodiversity and the integrity of the ecosystems.

Contents

1. Introduction

1.1. Marine spatial planning and the planning objectives

The marine spatial plans should show the most suitable use of the sea. In marine spatial plans, this involves providing spatial conditions for different types of activities or protection in the sea from a holistic perspective. Marine spatial planning is the process in which the marine spatial plans are prepared. In this process, current and future activities are organised in the marine areas so that environmental, economic and social objectives are achieved. Approved marine spatial plans provide guidance for other planning, management and reviews of projects. Marine spatial planning is one of several tools for the state to guide and influence activities and the environmental status of the sea.

In July 2014, the EU adopted the Framework Directive on Maritime Spatial Planning (2014/89/EU). The Directive requires marine spatial planning to support the sustainable development of offshore energy, maritime transport, fisheries, aquaculture and the preservation, protection and improvement of the environment. The ecosystem approach should be applied in planning so that the maritime activities' pressure on the environment is consistent with good environmental status according to the EU Marine Strategy Framework Directive, implemented in Sweden through the Marine Strategy Framework Ordinance.

The EU Framework Directive on Maritime Spatial Planning was incorporated into Sweden's national legislation in September 2014 through a provision in the Environmental Code (Chapter 4, Section 10) on national marine spatial planning in Sweden, and in 2015 through the Marine Spatial Planning Ordinance (2015:400), which regulates the implementation of the marine spatial planning. The Environmental Code states that the objective of the marine spatial plans shall be to contribute to a long-term sustainable development.

The Marine Spatial Planning Ordinance clarifies that the marine spatial plans' design shall contribute to a good environmental status and that the ocean's resources shall be used sustainably so that maritime industries can develop. One explicit objective is that various activities should be able to exist together. The integration of economic policy objectives, social objectives and environmental objectives aims to provide a holistic perspective in the planning. Based on this aspect, 10 planning objectives were prepared during the previous planning process (Figure 1). The overarching objective for marine spatial planning is *Healthy marine environment and sustainable growth*, which is supported by the other nine planning objectives. The planning objectives also take into account various international objectives, political focus, legislation and environmental objectives.

New objectives in the planning process that began in 2022 mainly concern increased ambitions regarding areas for offshore energy extraction. In addition to these, the marine spatial plans have been updated based on new conditions for spatial protection and other interests.

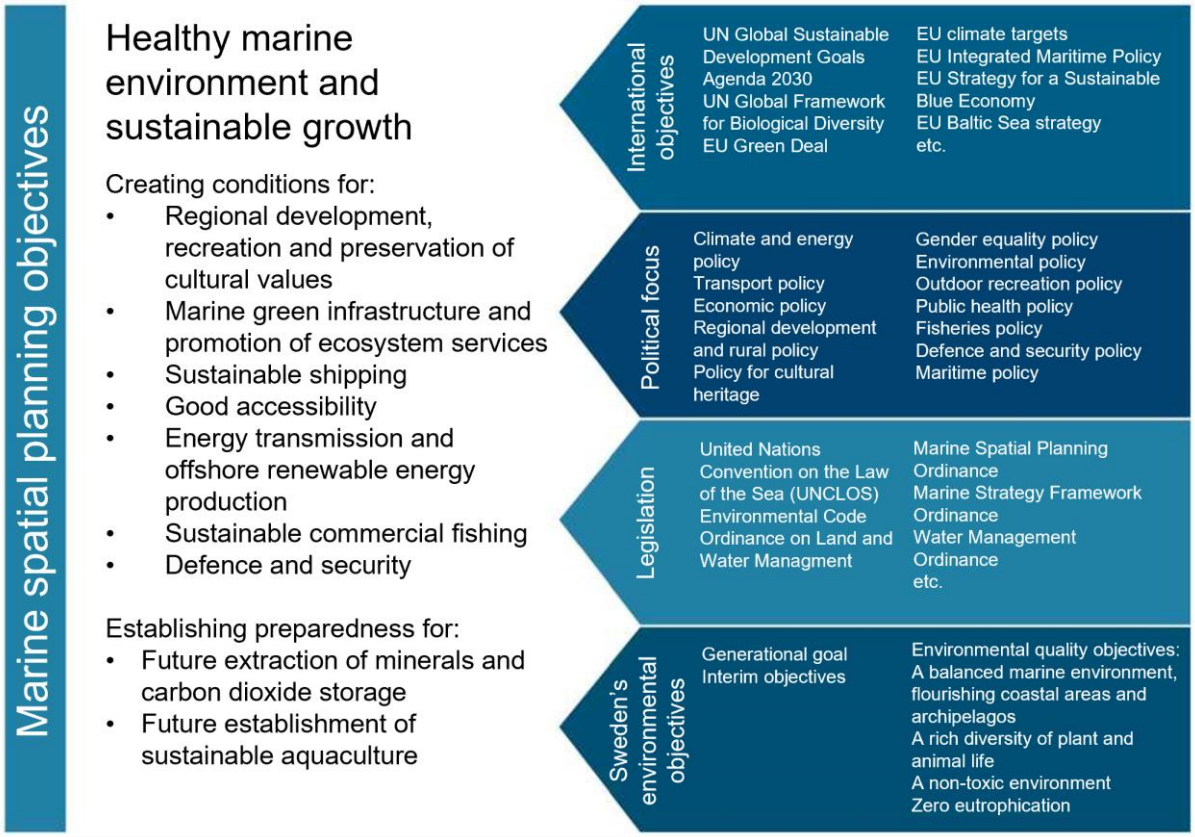


Figure 1. The planning objectives and some of the overall objectives and conditions that have been points of departure in the formulation of the planning objectives (SwAM, 2023a).

1.2. Strategic environmental assessment of marine spatial plans

1.2.1. Formal requirements for strategic environmental assessment of marine spatial plans

According to the Environmental Assessment Ordinance, marine spatial plans are assumed to entail such a significant environmental impact as is referred to in Chapter 6, Section 3 of the Environmental Code. There are therefore requirements on the performance of strategic environmental assessment according to Chapter 6, Sections 1-19 of the Environmental Code. The work on strategic environmental assessment shall be documented in an environmental impact assessment.

The requirements on the environmental assessment of marine spatial plans are also based on the Environmental Code's portal clause according to which the Code shall be applied so that:

1. human health and the environment are protected against damage and inconveniences regardless of whether they are caused by pollution or other impact;

2. valuable natural and cultural environments are protected and cared for;

3. biodiversity is preserved,

4. land, water and the physical environment otherwise are used so that management that is good in the long term from an ecological, social, cultural and socio-economic perspective is safeguarded; and

5. re-use and recycling, as well as other management of materials, raw materials and energy is promoted so that a cycle is achieved.

The requirements mean that social and economic aspects also need to be included in a broad assessment of effects. This document has therefore been given the title of impact assessment at the same time as the requirements regarding the strategic environmental assessment have been guiding in the work, and consideration has been taken to the requirements for the environmental impact assessment. The impact assessment takes the form of a document that covers all three marine spatial plans, the effects of which are presented both separately and together.

Pursuant to Chapter 6, Section 10 of the Environmental Code, the authority that prepares or amends a plan shall consult on the scope and degree of detail of the impact assessment. A delimitation consultation was held from 8 July to 10 October 2022.

Both the Espoo Convention with associated protocols and the Strategic Environmental Assessment Directive (2001/42/EC) regulate consultation regarding significant cross-border environmental impact. These have been implemented in Swedish law through incorporation into Chapter 6 of the Environmental Code and the Environmental Assessment Ordinance (2017:966). The general requirements are to notify affected countries of current planning and conduct consultations when the plan proposal and environmental impact assessment are prepared.

As the responsibility for consultation with other countries today lies with the Swedish Environmental Protection Agency, SwAM has informed the Swedish Environmental Protection Agency that the marine spatial planning is considered to be able to give rise to significant cross-border impact. The neighbouring countries Norway, Denmark, Germany, Poland, Lithuania, Latvia, Estonia, Finland and Åland have therefore been informed through a consultation process that took place between 1 December 2022 and 28 February 2023.

1.3. The marine spatial plans' relation to other plans and programmes

An environmental impact assessment shall, pursuant to Chapter 6, Section 11 of the Environmental Code contain a summary of the plan's main purpose and its relation to other relevant plans and programmes. The marine spatial plans should aim for a sustainable development and planning should be based on objectives and strategies at the local, regional, national and international level. The selection of plans, programmes and other processes presented in the section mainly takes place based on their relevance to the on-going marine spatial planning, which has a focus on identifying new areas for offshore energy extraction.

National interests, policy documents and spatial planning

1.3.1.1. National interests

National interests are geographic areas that have been pointed out as nationally significant. The marine spatial plan proposal should be consistent with provisions for the management of land and water areas and with defined national interests as follows:

1.3.1.

National interests according to Chapter 3 of the Environmental Code (reported by national interest authorities)

- These include national interests for commercial fishing, nature conservation and outdoor recreation, cultural environment conservation, facilities for energy production and electricity distribution, facilities for communications, and national defence facilities. National interests and the respective authority are set out in Section 2 of the Ordinance on Land and Water Management.

National interests according to Chapter 4 of the Environmental Code (listed directly in the Act)

- These concern bigger areas with large natural and cultural values and values for outdoor recreation that are of national significance. This includes coastal areas and Natura 2000 areas (listed in a specific order).

The marine spatial plans should be guiding for uses of the sea, based on identified national interests and trade-offs between them.

1.3.1.2. Connection to the transmission network

Svenska Kraftnät is currently working on developing the process for actors who want to connect offshore wind energy to the transmission grid on land. To handle the connection requests, they work with so-called marine capacity zones. In these zones, Svenska Kraftnät will prepare one or more connection points, the positioning and capacity of which are subsequently announced to all stakeholders. An offer of connection is given to the operator or operators that first receive the necessary permits regarding the construction and operation of a wind farm in the respective zone (Svenska Kraftnät, 2023).

1.3.1.3. Strategy for sustainable development, a Swedish maritime strategy, and EU strategies

According to the Marine Spatial Planning Ordinance, the marine spatial plan proposal shall be designed so that the plan integrates economic policy objectives, social objectives and environmental objectives. In the *National Strategy for Regional Sustainable Development throughout the Country 2021–2030*, a number of strategic areas and priorities are set regarding economic, social and environmental policy objectives. The national strategy is a guide for the direction of the regional development strategies (see section 1.3.1.4) and a governing document for state funding for regional development work. The major societal challenges that permeate the national strategy for sustainable regional development are: environmental problems and climate change, demographic changes, and increased inequalities nationally and within the EU. The strategic area that is deemed to be the most relevant for the marine spatial planning is *Equal opportunities for housing, work and welfare in the entire country*, which includes “good urban

planning". Urban planning shall promote a societal structure that contributes to sustainable living environments, reduced climate impact, and the preservation of biological diversity and ecosystem services in a changing climate. An additional strategic area of relevance to the marine spatial planning is *Accessibility throughout the country through digital communication and the transport system* (Government of Sweden, 2021).

In 2015, the Government decided on a national maritime strategy for Sweden. The strategy aims to achieve the Government's vision of "Competitive, innovative and sustainable maritime industries that can contribute to increased employment, reduced environmental pressure and an attractive living environment". This vision is based on three equally important perspectives: A balanced marine environment, Competitive maritime industries and Attractive coastal areas. The strategy concerns several policy areas with connections to the sea, regional development, industry and the environment, and thereby contributes to the implementation of an integrated Swedish maritime policy. In the strategy, the marine spatial plans are highlighted as an important instrument to guide development in Swedish waters. By indicating the most suitable use for various marine areas, the marine spatial plans and the environmental assessment promote, for example, safety at sea in line with the strategy, so that risks to people and animal and plant life in connection with accidents are minimised.

In the Swedish maritime strategy, the significance of the EU's strategies to the various marine basins is also highlighted. For Sweden, the EU's strategy for the Baltic Sea region is relevant, which aims to strengthen cooperation to jointly handle challenges and opportunities. The strategy's three main objectives are: Saving the sea, Connecting the region, and Increasing prosperity. The strategy includes an action plan, which comprises the policy areas of spatial planning and marine spatial planning (PA Planning), and energy (PA Energy). The Baltic Sea Strategy contributes to the implementation of Agenda 2030, but also the EU's so-called Green Deal. The Green Deal aims for a transition to a modern, resource-efficient and competitive economy, and together with other desired aims, includes an industrial transition for a climate-neutral EU by 2050. According to the Baltic Sea Strategy, adaptation to the Green Deal requires climate measures and the promotion of sustainable development to be integrated into all of the strategy's policy areas. Swedish marine spatial planning is closely integrated with the neighbouring countries' work in the area and their measures according to the action plan.

At the EU level, there are also a number of sector-specific strategies of relevance to marine spatial planning in the policy areas of climate and energy, transport, fishing, outdoor recreation, and security and defence. Both the EU's strategy for blue economy and the strategy for offshore renewable energy work for the implementation of the EU's Green Deal (European Commission, 2021; European Parliament, 2022). In addition, there is a proposed plan called REPowerEU, which aims to speed up the transition in the energy sector for a reduced import dependency and an increased investment in renewable energy and hydrogen. The plan includes, among other things, a proposal to amend the directive (2018/2001) regarding the promotion of the use of energy from renewable energy sources. The amendment proposal includes systems for pointing out land and marine areas for energy production (including environmental assessment), and that facilities for the production of renewable energy shall be considered to be of overriding public interest. If the proposal is realised, it can affect both the marine spatial planning and environmental assessment processes.

1.3.1.4. Regional development strategies

According to the Ordinance (2017:583) on Regional Growth Work, each region must prepare so-called regional development strategies (RUS). These strategies contain visions, objectives and long-term priorities for development in the respective counties, and provide an overview of the region's perspectives on sustainable development. With regard to sector-specific claims and assets, these strategies are of relevance to marine spatial planning. The EU's strategy for the Baltic Sea region, the national strategy for sustainable development, the marine and fisheries programme and the municipal comprehensive plans should guide the direction of the regional development strategies. Regional development strategies should be well established locally and regionally, and be prepared in collaboration with affected municipalities, regions, county administrative boards and other relevant national authorities.

1.3.1.5. Municipal and regional comprehensive planning

According to the Planning and Building Act (2010:900), each municipality shall have a current comprehensive plan that covers the entire municipality, including the marine area (internal waters and territorial waters) that is within the municipality's boundaries. Through the Marine Spatial Planning Ordinance, the municipalities and the state have a geographically overlapping planning responsibility in most of the territorial sea. This means that differences between municipal and national planning interests in the overlapping zone can arise, which is a challenge for national and municipal planning to handle through collaboration and dialogue. Through strong collaboration, future goal conflicts between the planning levels can be minimised. The national marine spatial plans can also contribute to developing and strengthening the municipalities' planning of the coastal zone and territorial sea.

A municipality can also control the supply, distribution and use of energy. According to the Municipal Energy Planning Act (1977:439), each municipality must have a current plan for the supply, distribution and use of energy in the municipality. In its planning, the municipality must promote sound management of energy and work for a safe and adequate energy supply (Swedish Energy Agency, 2022).

For the management of cross-border issues, such as infrastructure, climate and housing supply, spatial planning also takes place at the regional level. A regional plan should provide the outlines for the use of land and water areas, and should aim to facilitate municipal and other planning. The regional plan is not binding, but should be a guide for comprehensive and detailed development plans and area regulations. According to the Planning and Building Act, regional planning is to be carried out in Stockholm and Skåne counties; in the rest of the counties, it is optional. The regional plan is relevant to marine spatial planning based on its spatial planning and the connection between land and sea, such as that concerning infrastructure and climate.

1.3.2

Environmental and climate objectives

1.3.2.1. National environmental objectives

Sweden's environmental objective system includes a generation goal, 16 environmental quality objectives, and six interim objectives. The generation goal is overarching for Swedish environmental policy, which in turn should be a guide for the environmental work at all levels in society. Under the generation goal, there are a number of so-called indents that clarify the

meaning of the goal and what environmental policy should focus on. The indents that are especially relevant to marine spatial planning are:

- The ecosystems have recovered, or are on their way to recovering, and their ability to generate ecosystem services in the long term is secured.
- Biodiversity and the natural and cultural environment are to be preserved, promoted and used sustainably.
- Human health is exposed to a minimal negative environmental impact at the same time as the environment's positive impact on human health is promoted.
- The share of renewable energy is increasing and energy use is efficient with a minimal impact on the environment.

Out of the 16 Swedish environmental quality objectives, the following are most central to the marine spatial planning: A balanced marine environment, flourishing coastal areas and archipelagos, Reduced climate impact, A non-toxic environment, Zero eutrophication, A rich diversity of plant and animal life, and A good built environment. The environmental quality objectives are described by a number of specifications, some of which are especially relevant to the marine spatial planning. This applies, for example, to ecosystem services, favourable conservation status, endangered species, green infrastructure, protection of outdoor recreation and preservation of cultural and nature values. Specifications of good environmental status according to the Marine Strategy Framework Ordinance (2010:1341) and good chemical and ecological status according to the Water Management Ordinance (2004:660) are of significance to marine spatial planning.

1.3.2.2. Climate policy nationally and within the EU

In 2017, Sweden adopted a climate policy framework consisting of a Climate Act (2017:720), climate objectives and a climate policy council. The Climate Act requires the Government to conduct a policy that is based on the climate objectives and to report regularly on the development. Sweden has a long-term climate target of zero net emissions of greenhouse gases by 2045, to then achieve negative emissions. This target means that the emissions of greenhouse gases from Swedish territory shall be at least 85 per cent lower in 2045 than the emissions in 1990. The remaining emissions (down to zero) are achieved through so-called complementary measures. To achieve the target, the capture and storage of carbon dioxide of fossil origin is also counted as a measure where there is no reasonable alternative (Swedish EPA, etc.). The climate adaptation work relates to the marine spatial planning through the work for increased preparedness and risk and vulnerability analyses according to the Ordinance on Climate Adaptation Efforts by Public Authorities (2018:1428), but also based on the national climate adaptation strategy (Government bill 2017/18:163) with the priority of biological and ecological effects.

The EU's goal of climate neutrality by 2050 works in line with international commitments under the Paris Agreement. Through a regulation on a European climate law, the political ambition to achieve the climate objectives by 2050 shall become a legal obligation for the EU and through its adoption, Member States undertake to reduce the net emissions of greenhouse gases by 55 per cent by 2030 (European Council, 2021a). The EU's strategy to achieve these objectives is the Green Deal (see section 1.3.1.3) and this is expected to be put into practice through the so-called 55-per-cent package. The package includes a set of proposals for revision of climate, energy and

transport-related legislation and new legislative initiatives to adapt Union law to the EU's climate objectives. The EU Strategy on Adaptation to Climate Change (European Council, 2021b) and its measures, such as the collection and exchange of data and knowledge, and the objective of promoting nature-based solutions to strengthen climate resilience and ecosystems is also of relevance to marine spatial planning.

1.3.2.3. EU directives for the marine and aquatic environment

The EU Marine Strategy Framework Directive (2008/56/EC) aims to achieve a good environmental status in the EU's marine area and is implemented in Swedish legislation through the Marine Strategy Framework Ordinance (2010:1341). As regards Sweden's marine areas, SwAM has, through Regulation HVMFS 2012:18, determined the characteristics of good environmental status and established environmental quality standards and indicators. The agency has also established an environmental monitoring programme and an action programme. Marine spatial planning supports the implementation of marine environment management mainly through spatial planning that benefits good environmental status. The work in marine management also takes place through regional agreements such as Helcom (the Helsinki Convention) with an action plan for the Baltic Sea, and its equivalent in the North-East Atlantic, OSPAR (Convention for the Protection of the Marine Environment in the North-East Atlantic).

The EU Water Framework Directive (2000/60/EC) also has some connection to marine spatial planning based on land-based activities, water resources and potential indirect impact factors from source to sea. The directive is implemented in Sweden through the Water Management Ordinance (2004:660) and has corresponding objectives for environmental status in fresh water and the coastal area. Sweden's five water authorities decide on management plans, environmental quality standards and action programmes.

1.3.2.4. Work for biodiversity

The Swedish work to strengthen biodiversity, counteract climate change and work for sustainable use comprises several tools. Some of these are marine spatial protection, regional action plans for green infrastructure, counteracting physical impact on the aquatic environment, restoration, measures for endangered species, counteracting invasive species, and regulations in fishing. The national work is mainly based on the implementation of the EU Birds and Habitats Directives (2006/147/EC and 92/43/EEC, respectively), the EU Biodiversity Strategy 2030 and the EU's common fisheries and agricultural policy. The role of marine spatial planning is about spatial guidance and trade-offs regarding e.g. commercial fishing and protection of nature values.

The EU Biodiversity Strategy (European Commission, 2020) includes a long-term plan for the protection and restoration of nature and ecosystems, which among other things entails an objective of protecting at least 30 per cent of the marine area by 2030. Of these 30 per cent, 10 percentage points should be strictly protected. The strategy also includes measures for invasive species and endangered species, and requirements for the Member States to prepare national commitments for protection and restoration. As part of the strategy work, the European Commission presented a proposal for a regulation on the restoration of nature in June 2022, which among other things means that 20 per cent of the sea is to be restored by 2030.

In addition, according to the strategy, the Member States must ensure that at least 30 per cent of all species and habitats that currently do not have a favourable status reach that category or

show a strong positive development. The Commission will also request that the Member States, by 2030, ensure that there is no deterioration in conservation trends and conservation status for any of the habitats and species that are protected according to the Birds and Habitats Directives (including EUNIS for marine environments). Marine spatial planning supports the implementation of these directives and strategies through the spatial guidance that the marine spatial plans provide on the use of the sea.

1.4. Terminology and definitions

Use is a term for the types of activities or interests that are categorised in the marine spatial plans: electricity transmission, energy extraction, investigation area for energy extraction, defence, general use, culture, nature, recreation, sand extraction, investigation area for sand extraction, shipping, investigation area for shipping and commercial fishing.

Pressure is the change in physical conditions that the plan's implementation entails (e.g. that an area is claimed, water clouding, noise).

Effect or **impact** is the change in the environment that the pressure entails on an ecosystem component (ecosystems or individual flora and fauna). Effects can be direct or indirect, cumulative, positive or negative, long or short term and give rise to consequences (see below).

The **ecosystem approach** is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It aims to give consideration to environmental, social and economic aspects and a more integrated approach to management. The approach includes a number of guiding principles (the Malawi Principles), including the principle of ensuring that the use of the ecosystems remains within their limits (Convention on biological diversity, 2007).

Ecosystem components in Symphony are living environments, species or groups of animals and plants that constitute a part of the marine ecosystems.

Ecosystem services are the products and services from nature's ecosystem that contribute to human prosperity and well-being. The concept helps to systematise the connection between ecology and society and highlight that well-functioning ecosystems are important to society, health and welfare.

Climate neutrality means that emissions of greenhouse gases are net zero.

Consequence is the significance of the effects/impacts from an environmental and societal perspective.

Environmental aspects are the aspects described in Chapter 6 of the Environmental Code, with regard to which the environmental assessment is done.

The **environmental impact assessment** is the written report that among other things shall identify, describe and assess the significant environmental impact that the implementation of the plan, the programme or the change can be assumed to entail.

Strategic environmental assessment of plans and programmes is the process behind the environmental impact assessment. It contains certain steps that public authorities and municipalities must carry out when establishing or amending certain plans or programmes whose implementation is likely to have significant environmental effects (Chapter 6 of the Environmental Code).

1.5. Reading instructions

This impact assessment is divided into eight chapters. After this introductory chapter, there are three chapters with a description of the expected environmental effects of the marine spatial plans for the Gulf of Bothnia, the Baltic Sea and Skagerrak and Kattegat. In Chapter 5, the assessments are compiled for each marine spatial plan in relation to assessment grounds according to the Marine Strategy Framework Directive and the Water Framework Directive. The chapter also contains analyses of the marine spatial plans' contribution to achieving Sweden's environmental quality objectives and objectives in other policies, plans and strategies. The following chapter contains proposals of measures to forestall, prevent, counteract or remedy the significant negative environmental effects identified in the impact assessment. The chapter also includes an analysis of measures for follow-up and monitoring of these environmental effects. Chapter 7 describes the management of alternatives in the impact assessment and the present situation regarding environmental and socio-economic conditions. The last chapter presents the method used in the impact assessment.

2. Impact assessment of the marine spatial plan for the Gulf of Bothnia

2.1. Assessment of environmental effects

Effects on protected animal and plant species and biodiversity

2.1.1.1. Birds

2.1.1. The bird population's variations have several causes that are often different in the species' different living environments. It is therefore usually very difficult to point out the factor that is of the greatest significance to the development of a certain population. Among the uses that the marine spatial plan provides guidance on, it is mainly recreation, fishing, shipping and energy extraction that risk affecting bird populations negatively. Out of these, it is only the guidance on energy extraction, in the form of offshore wind energy, that can entail significant changes in how the Gulf of Bothnia marine spatial planning area is used compared with the zero alternative.

Fact-based documentation on mortality, barrier effect or displacement effect caused by offshore wind energy in Swedish waters is not currently available. Studies in other countries and regions – of which the majority so far are modelling studies from the North Sea region – indicate that offshore wind energy can have significant negative effects for some species that forage or breed in the ocean, or move across the ocean. At the same time, there are other species that are not affected at all, and even some that are attracted to and can benefit from offshore wind energy (Leemans & Collier, 2022; Bergström et al., 2021; Rydell et al., 2017). The fact-based documentation on not only the effects of wind power, but also in many cases on population status and other impact factors is deficient, making assessments of effects uncertain. Even if the probability of negative effects is generally greater in areas where there are known accumulation or migration routes, the risk of impact in other areas cannot be entirely ruled out. For this reason and with regard to the precautionary principle, the effect categories "no effect" and "marginal effect" were merged with the effect category "small effect".

In the Gulf of Bothnia marine spatial planning area, the largest risks for large and medium-sized negative effects on birds are concentrated in the South Bothnian Sea, especially the areas around Finngrunden. The proposed energy areas B149, B152, B156, B158 and to a lesser extent B146, B164, B142 and B148 are considered to entail the greatest risk mainly to migratory birds, but also to wintering birds. The area is of major regional significance for resting and wintering sea birds, of which several are known to be highly sensitive to disturbance.

When it comes to migratory birds, the autumn migration past Finngrunden and the South Bothnian Sea is especially extensive, with over 100 species and one million individuals of large birds. In comparison, studies show that the spring migration comprises just under 70 species. Several migratory bird species are red-listed. In addition to the passage of large birds, a presumed very large number of perching birds area also migrating. For species such as goose, swan, large loon and small loon, a significant share of the populations is considered to pass the area, from breeding areas in North-eastern Scandinavia and North-western Russia. For the

subspecies taiga bean goose, the central migration route for the collective world population is over this area.

Along the coast, there are very important breeding areas, resting and wintering areas for sea birds, which are at risk of being negatively impacted by wind power expansion in the proposed energy areas B146, B152 and B156. Sand guillemots, lesser black-backed gulls and Caspian terns, and a high density of sea eagles are some of the known breeding species in the area, which also use shallow areas at Finngrunden for foraging. Especially important areas are Lövstabukten and Björn's archipelago and the Gräsö Eastern Archipelago nature reserve. The archipelago area west of B146 has a rich bird fauna and along the coast, there is a migration route for sea birds. Several bird species worthy of protection breed in the area. Of these, large loon, Slavonian grebe and osprey are sensitive to human disturbance.

The energy areas in North Kvarken are located just north of the migratory bird route that extends in a north-western-south-easterly direction between Umeå-Holmön and the Vaasa region in Ostrobothnia, Finland, where the passage over the sea is the shortest. The migration route is used by several disturbance-sensitive species of predatory birds as well as crane, goose, wader, swan and other mountain and taiga species. The limits of the route corridor vary with the weather and wind conditions, which is why all six proposed and alternative energy areas – B107, B108, B135, B137, B138 and B139 – are considered to entail a risk of a moderate negative impact.

At the coast, there are to some extent breeding sea birds and birds that migrate along the coast, and there is a risk of some negative impact from wind power establishment in the proposed energy areas B139, B137, B107, B108 and B138, albeit small. With regard to the latter area, the proximity to Holmöarna is also deemed to pose some risk to the species that breed there.

In the far north of the Bothnian Bay, the coastal section that borders Haparanda Archipelago national park is very sensitive. Several of the islands are bird protection areas, and several areas are pointed out partly due to them being relatively unaffected by humans. The area close to the coast is very important for migratory, resting and breeding birds, of which several are sensitive to anthropogenic pressures. The bird migration is considered to take place broadly along the coast and partly over the open sea, and there is some risk that they would be negatively affected by wind power establishment. The risk is greater closer to the coast, which is why the potential negative impact is deemed to be medium in the alternative energy area B117, and small in the proposed energy areas B110 and B111. The risk is lower in the alternative energy area B113.

On the Finnish side of the Bothnian Bay, several wind farms are planned, which increases the risk of cumulative effects in connection with wind power establishment on the Swedish side (see Figure 2). This risk should be taken into account in future reviews of wind power projects on both sides of the border. A somewhat lower risk of cumulative impact exists in the other parts of the Gulf of Bothnia, as the location of the planned Finnish wind power areas is somewhat sparser.

Below, Figure 3 and Figure 4 use colour coding to show the size of the estimated effect of the proposed energy extraction areas on migratory birds and wintering birds in the Gulf of Bothnia marine spatial planning area.

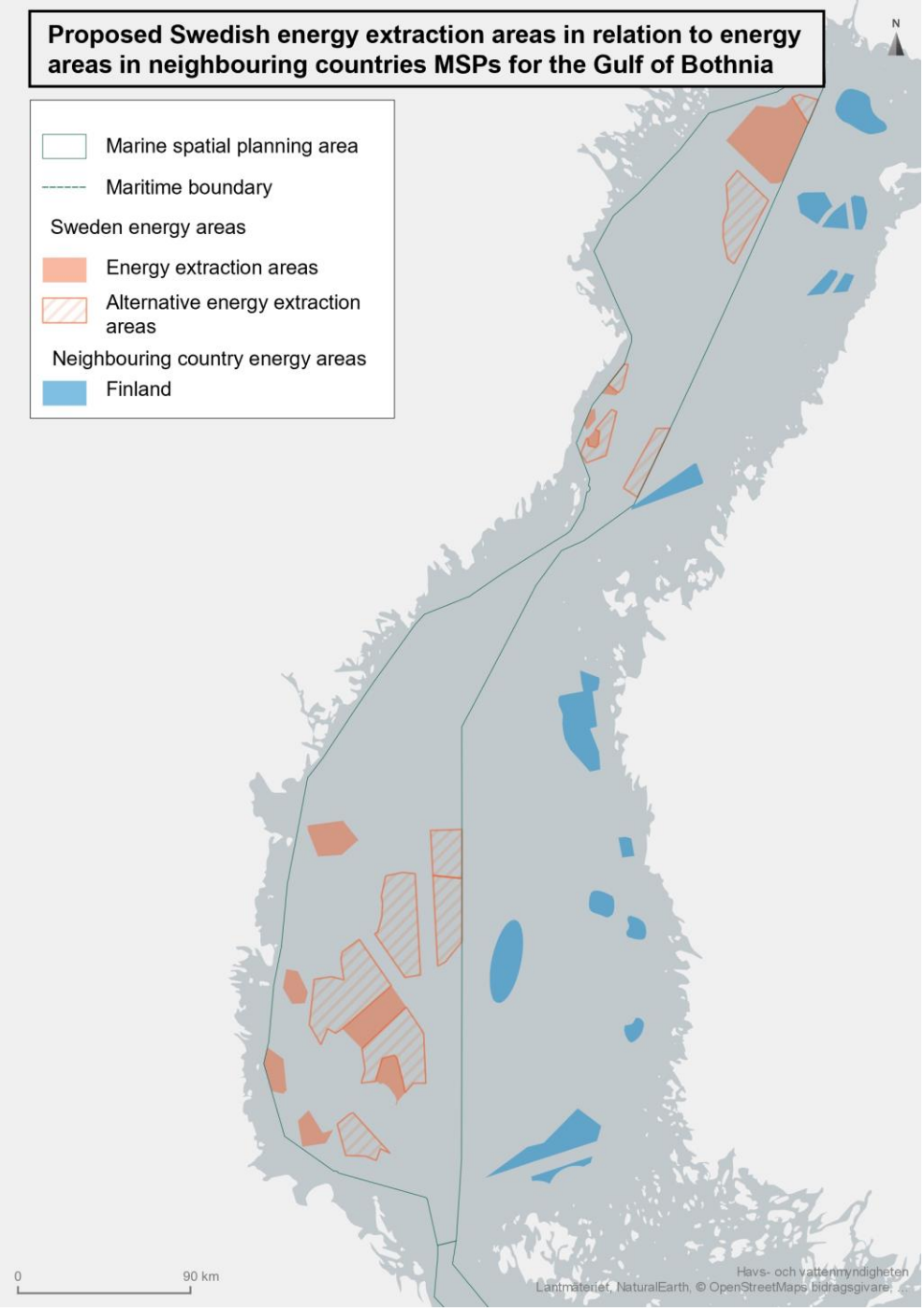


Figure 2. Map of planned or proposed energy extraction areas in Finland and Sweden in the Gulf of Bothnia.

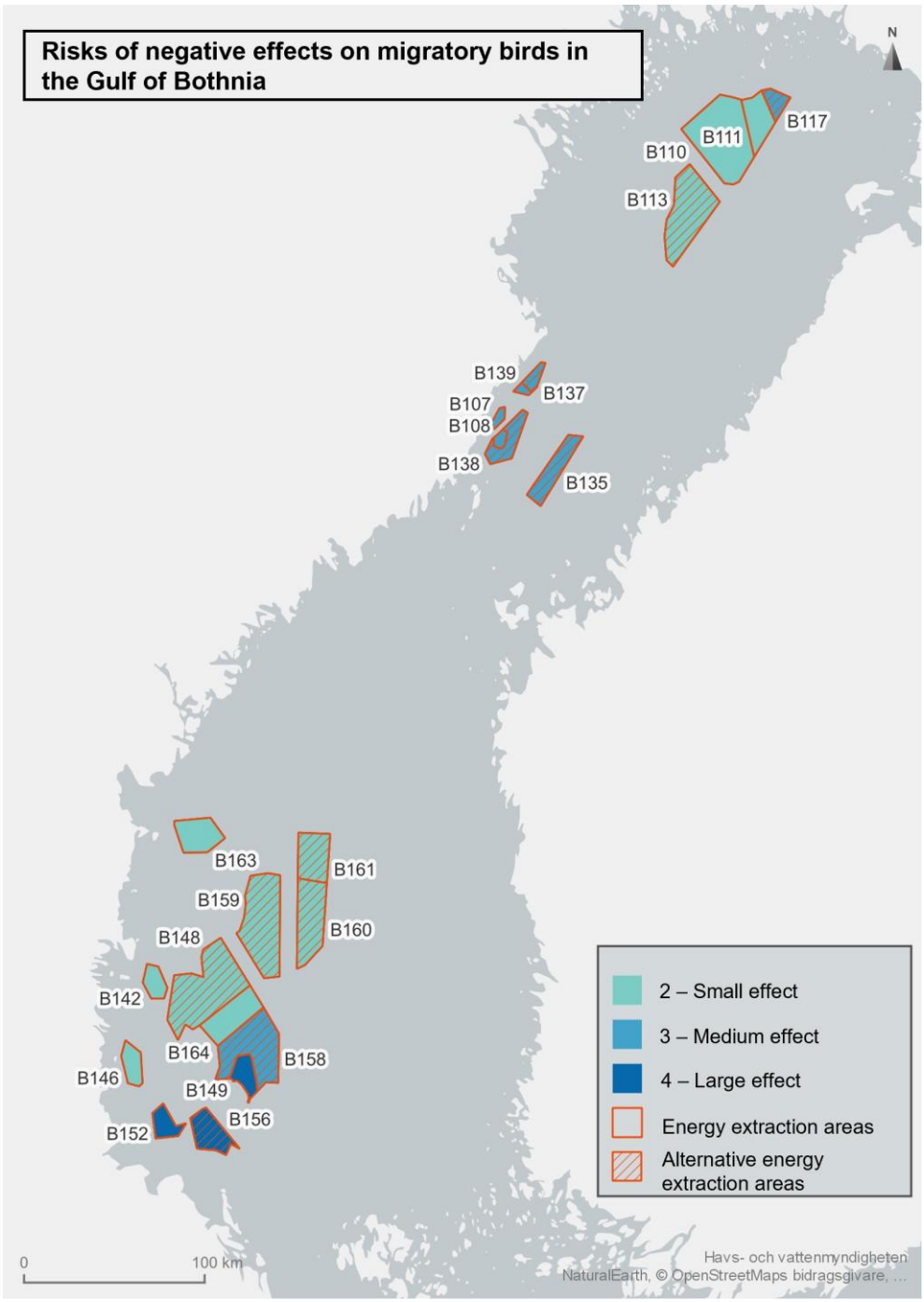


Figure 3. Risks of negative effects on migratory birds in the Gulf of Bothnia. Dark colour shows a large effect and light colour shows a small effect.

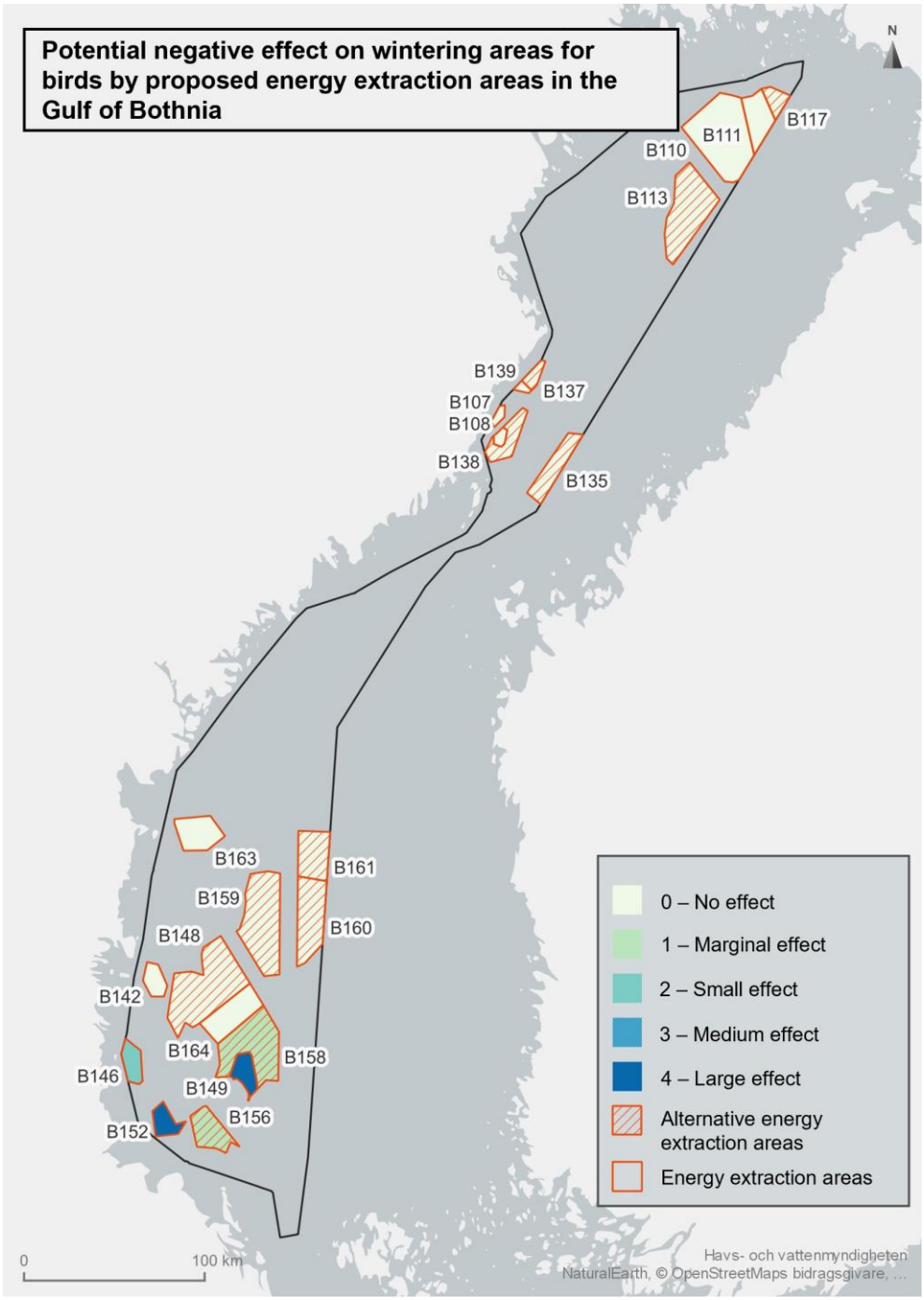


Figure 4. Potential negative effect on wintering areas for birds by proposed energy extraction areas in the Gulf of Bothnia. Dark colour shows a large effect and light colour shows a small effect.

2.1.1.2. Marine mammals

The impact on marine mammals mainly arises through the spread of impulsive underwater noise and sediment dispersion during the construction phase for offshore wind energy, but the

operating phase can also give rise to negative effects through continuous underwater noise, for example. In the Gulf of Bothnia, the marine mammals present are ringed seal and grey seal.

Ringed seal

The ringed seal mainly occurs in the Bothnian Bay with their population concentration furthest north in the bay. It is considered to be of “least concern” according to the red list for 2020 (Swedish Species Information Centre, n.d.).

Sensitive periods during the ringed seal’s life cycle are February-May when mating, birthing, suckling and fur change takes place. Establishment during this period should therefore be avoided. There is a lack of knowledge about how the areas with offshore wind energy can affect the conditions for ringed seals e.g. through an impact on the occurrence of sea ice. The proposed energy areas B110 and B111 and the alternative area B117 are considered to have the largest potential negative effect on ringed seal due to the overlap with their most important range. The proposed and alternative areas (B107, B108, B135, B137, B139, B138) at North Kvarken are deemed to have a limited risk of affecting ringed seal while the other energy areas in the Bothnian Sea are not considered to be at risk of affecting them.

Grey seal

The grey seal occurs in the Gulf of Bothnia mainly at North Kvarken and in the South Bothnian Sea. It is considered to be of “least concern” according to the red list for 2020 (Swedish Species Information Centre, n.d.).

The grey seal is considered to be sensitive to disturbance between February and June and has a larger occurrence in coastal areas than in the open sea. The more coastal energy areas B142 and B146 are considered to have the largest potential negative effect on grey seal. However, effects from the construction phase are considered possible to minimise to negligible levels if measures corresponding to double bubble curtains are used in piling.

2.1.1.3. Benthic habitats

The seabed impact in energy areas is dependent on a number of factors. What type of facility is used e.g. bottom-fixed or floating foundations as well as the degree of bottom trawling in the area.

In the majority of the energy areas in the Gulf of Bothnia, the degree of seabed impact will mainly depend on the type of foundation that is of interest. In the Gulf of Bothnia, it is mainly the following energy areas where all or parts are deeper than 70 metres and can therefore be of interest for floating installations: B110, B113, B135, B163, B160 and B161. In these cases, the seabed impact is considered to be marginal.

The benthic environments in areas off of the coast and offshore banks in the Gulf of Bothnia are comprised of soft bottoms with clay, but also especially in the South Bothnian Sea a great deal of stone and boulders. In the areas with a soft sediment, bottom-fixed foundations entail an introduction of a new hard substrate. Here, so-called reef effects can arise that contribute to biodiversity and a positive effect, but also some risk of spread of unwanted invasive species. If consideration to seabed conditions is taken in the design and construction, negative effects on

existing benthic environments are considered to be avoidable for both bottom-fixed and floating facilities.

In the Gulf of Bothnia, bottom trawling is conducted to a very limited extent. It is only for energy areas in the South Bothnian Sea, mainly B156 and B152 where a positive effect can be assumed to arise from reduced bottom trawling as a result of energy extraction.

2.1.1.4. Fish and spawning areas

In the current proposal for the amended marine spatial plan for the Gulf of Bothnia, the guidance on energy extraction entails the largest change compared with the approved marine spatial plan. The conclusions on the effect of guidance on other uses in the environmental impact assessment of the approved marine spatial plan are therefore considered to apply to this proposal (SwAM, 2019a).

In terms of effects on fish and fish spawning, the guidance on sand extraction at Svalans and Falkens grund in the Bothnian Bay is considered to possibly entail a small negative effect locally on fish, especially spawning herring and vendace. The proposed extraction area partly coincides with shallower spawning areas in the open sea, although not with the species' most important spawning areas. Since there are several spawning areas in the Gulf of Bothnia, the most important of which are in the coastal zone, the negative effect is considered to be marginal in relation to the entire marine spatial planning area. It is important to adapt the extraction activities to important reproduction periods for the fish species in the area.

The environmental impact assessment of the approved marine spatial plan also raises the risk of marginally elevated pressure through underwater noise and operational emissions from shipping in connection with the marine spatial plan's guidance on somewhat longer shipping lanes after adaptation to proposed energy areas in the South Bothnian Sea. Considering that the change in shipping traffic is relatively small and that the fish move in a very large area, the effect on fish is considered to be marginal.

In terms of the marine spatial plan's guidance on energy extraction, it can entail a risk of negative impact on fish, especially where energy areas coincide with spawning and nursery areas. According to the latest synthesis of effects of offshore wind energy on fish, the collective scientific evidence indicates that the introduction of wind power turbines at sea does not pose a threat to fish species or fish populations (Öhman, 2023). However, this conclusion only applies if certain precautions are introduced to minimise the most acute pressures from offshore wind energy, especially impulsive underwater noise and sediment dispersion. Like other studies, however, the synthesis highlights that the effects can differ significantly between different areas and that important knowledge gaps remain (see also Hogan et al., 2023). For these reasons, wind power establishment should always be preceded by a local assessment of how fish are affected.

In the Gulf of Bothnia, there are several proposed and alternative energy areas that coincide with known spawning areas for herring. The exact range of the spawning areas is not always known, which is why more detailed assessments need to be done prior to possible future wind power establishment. It is mainly the energy areas that are located close to the coast or in shallower areas that have a greater risk of affecting herring spawning areas. In the South Bothnian Sea, the proposed energy areas are B142, B146, B152 and B164, and parts of the alternative energy areas B158, B159, B160 and B161. In North Kvarken, all proposed and alternative energy areas

are at risk of affecting spawning areas, especially the areas closest to the coast: B107, B108, B137 and B139, and to a lesser extent B138. Of the areas in the Bothnian Bay, it is mainly the alternative energy area B117 and partly the proposed energy area B111 that coincides with spawning areas for herring, and where possible future wind power establishment is considered to need to be adapted. In Figure 5 and Figure 6, modelled spawning areas for vendace and herring in the Gulf of Bothnia are shown.

The decrease in fishing activities that can occur as a result of establishment of offshore wind power in the proposed energy areas can lead to a reduced fishing pressure on the fish resource and benefit its recovery. Since it is not known how fishing will be affected by and adapted to possible wind power establishment, it is not possible to estimate how large such a positive effect could be.

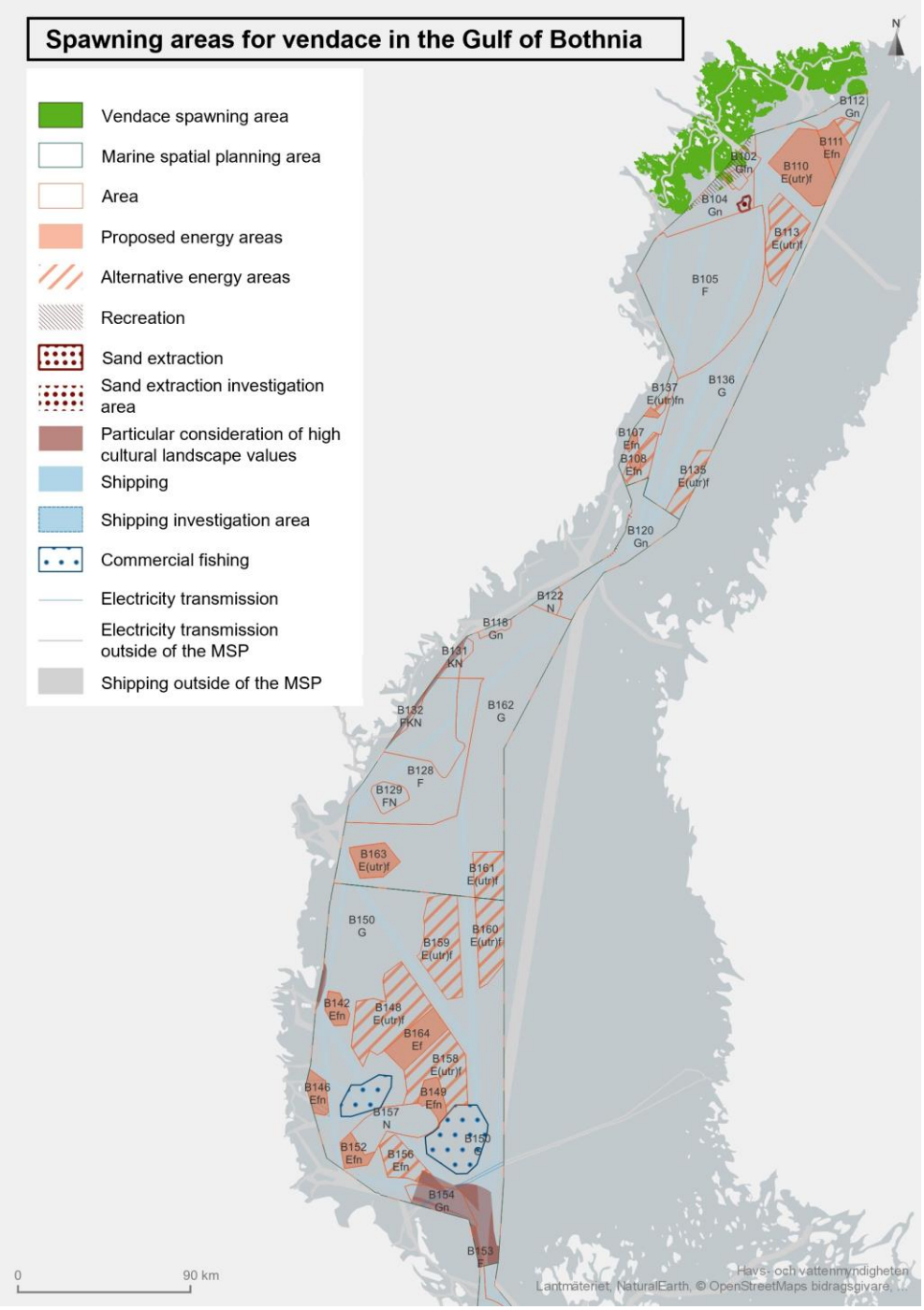
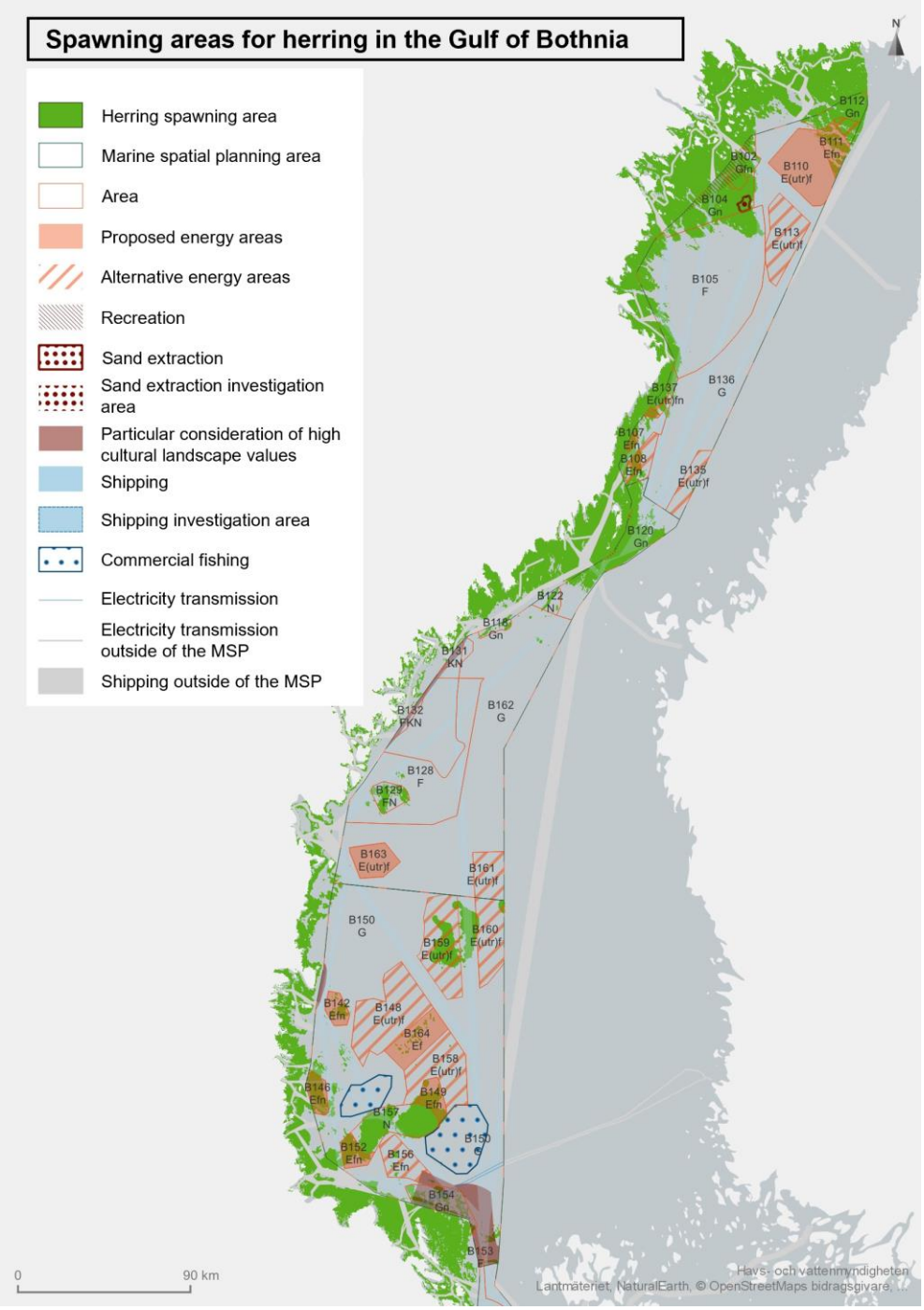


Figure 5. Spawning areas for vendace in the Gulf of Bothnia. Spawning areas are shown in green. (Source: SLU Aqua).



2.1.2.

Figure 6. Spawning areas for herring in the Gulf of Bothnia. Spawning areas are shown in green. (Source: SLU Aqua).

Effects on water and air

Effects on water as a living environment refer to changes in water's physical and chemical conditions as a result of the marine spatial plan's guidance on the various uses. In the Gulf of Bothnia, it is the guidance on sand extraction and energy extraction that is considered to be relevant from this perspective.

In terms of sand extraction, the proposed extraction activities at Svalans and Falkens grund are considered to possibly entail a negative effect on water quality locally, as a result of increased turbidity in the vicinity of the extraction. The effect is considered to be short-term, and thereby insignificant in terms of the marine spatial plan as a whole, in line with the conclusion in the environmental impact assessment of the approved marine spatial plan (SwAM, 2019a).

Modelling studies have shown that the establishment of offshore wind energy can affect hydrographic conditions not only in the vicinity of a wind farm, but also at a larger regional level (Arneborg et al., 2023). Preliminary results from modelling of the effects from reduced wind power behind existing wind farms in the Baltic Sea and Skagerrak and Kattegat indicate relatively small changes in salinity and temperature, as well as layering. The modelling, however, does not take into account the wind turbines' effects underwater, where foundations are considered to be able to slow down water currents and create greater turbulence and thereby a larger mix of water masses. The extent to which these effects cancel each other out is not known at present. The preliminary results indicate that larger wind power areas have larger effects. It is therefore especially important to further investigate the cumulative hydrographic effects of the large proposed and alternative contiguous energy areas in the Gulf of Bothnia.

In terms of effects on air, the assessment refers to changes in emissions of airborne pollutants as a result of the marine spatial plan's guidance. The uses that are relevant in this context are shipping, fishing, sand extraction and offshore wind energy due to construction and service boat traffic in connection with construction, operation and decomissioning of wind farms. In terms of shipping, the marine spatial plan for the Gulf of Bothnia proposes an approximately five per cent longer shipping lane through the South Bothnian Sea as a result of the energy areas B149, B148, B158 and B164. According to the environmental impact assessment of the approved marine spatial plans (SwAM, 2019a), the consequences of the extended route are marginally higher emissions from shipping and thereby marginally reduced air quality locally.

Establishment of wind power in the proposed energy areas can entail longer travel distances for fishing vessels as well. At present, however, it is not possible to predict the extent to which this may happen, which is why it is also not possible to estimate possible changes in air emissions from fishing vessels as a result of the marine spatial plan's guidance on offshore wind energy.

The guidance on energy extraction is considered to be able to lead to an extensive wind power establishment with associated strong increase in transports for construction and service of the wind power stations. The scope of the transport increase cannot be assessed without more detailed knowledge of the wind farms' activities, and thereby also how large a negative effect on air quality they can cause.

As for shipping, the marine spatial plan's guidance regarding sand extraction does not differ from that in the approved marine spatial plan. The conclusions in the environmental impact assessment from 2019 therefore apply to this proposal. According to this assessment, the proposed sand extraction at Svalans and Falkens grund in the Bothnian Bay may lead to an increase in air emissions from maritime transport in sand extraction and between extraction and port. This is considered to be able to have a marginal negative impact on air quality locally.

Effects on climate

Effects linked to climate are considered to be positive considering guidance on energy areas for offshore wind energy for the Gulf of Bothnia marine spatial plan. Wind power as a renewable energy source during operation does not contribute to emissions of greenhouse gases and has low emissions of carbon dioxide from a life cycle perspective (Swedish Energy Agency, 2023a).

2.1.3. The potential for extraction of fossil-free energy in the Gulf of Bothnia's proposed energy areas is estimated to be an annual production of 55.1 TWh. Including alternative energy areas, the potential is estimated to be a total of 165.2 TWh (also see section 2.2.1.2). The actual effect on the climate also depends, however, on if and which energy sources are replaced or constitute an alternative energy base, and whether or not these are fossil-based.

The proposed marine spatial plan's guidance on energy extraction can impact other uses with a potential effect regarding emissions of greenhouse gases. This applies, for example, to possible changes in the distances travelled for shipping and commercial fishing. For the South Bothnian Sea, proposed energy areas B148, B149, B158 and B164 located along the shipping lane entail an extended distance travelled for shipping. The impact in terms of emissions of greenhouse gases is, however, difficult to estimate, but the number of passages affected is considered to be a limited. The extended travel distance has been estimated at a maximum of around 15 km based on the plan map and AIS data, which is considered to be of minor significance (SwAM, 2019b). Note that the route of the shipping lane in this marine spatial plan does not differ from the approved marine spatial plan, where the shipping lane is moved and goes north-east of the proposed energy areas.

In total, the plan is considered to contribute to national and international climate objectives, the transition to a fossil-free energy sector and the transition to a fossil-free industrial and transport sector (Swedish Energy Agency, 2023b).

2.1.4.

Effects of proposals on the new areas with particular consideration of high nature values

The plan includes a number of proposals for new areas with particular consideration of high nature values (so-called lower-case n-regions). These have been prepared in a process together with coastal county administrative boards and the Swedish Environmental Protection Agency. SwAM is responsible for the final drafts presented in the consultation.

The planning area of the Gulf of Bothnia is generally characterised by a lower share of protected areas as well as fewer areas with particular consideration of high nature values than both the Baltic Sea and Skagerrak and Kattegat. However, the plan proposal includes a number of proposals for complementary areas with particular consideration of high nature values. This partly concerns the proposed area B152 west of western Finngrunden and the alternative area B156 south of Finngrunden. Both of these areas are proposed with particular consideration of migratory birds and wintering birds.

In addition, a larger expansion of the areas with particular consideration of high nature values B106, B107, B120, B137, B138 and B139 has been proposed at and north of North Kvarken. It also confirms the Ecologically or Biologically Significant Marine Area (EBSA) that is over North Kvarken in the cross-border Swedish-Finnish waters. The area B118 has also been expanded to the south-west.

The proposals for complementary areas with particular consideration of high nature values are considered to contribute to strengthened consideration mainly of birds in the use of these areas, both for areas with proposed use energy extraction and other uses. Together with areas with particular consideration of high nature values in the approved marine spatial plan, these are considered to provide a good complement to the spatial protection, contribute to green infrastructure and ecosystem services and a sustainable use in the Gulf of Bothnia. The areas with the use nature and particular consideration of high nature values within the Gulf of Bothnia marine spatial planning area are shown in Figure 7.

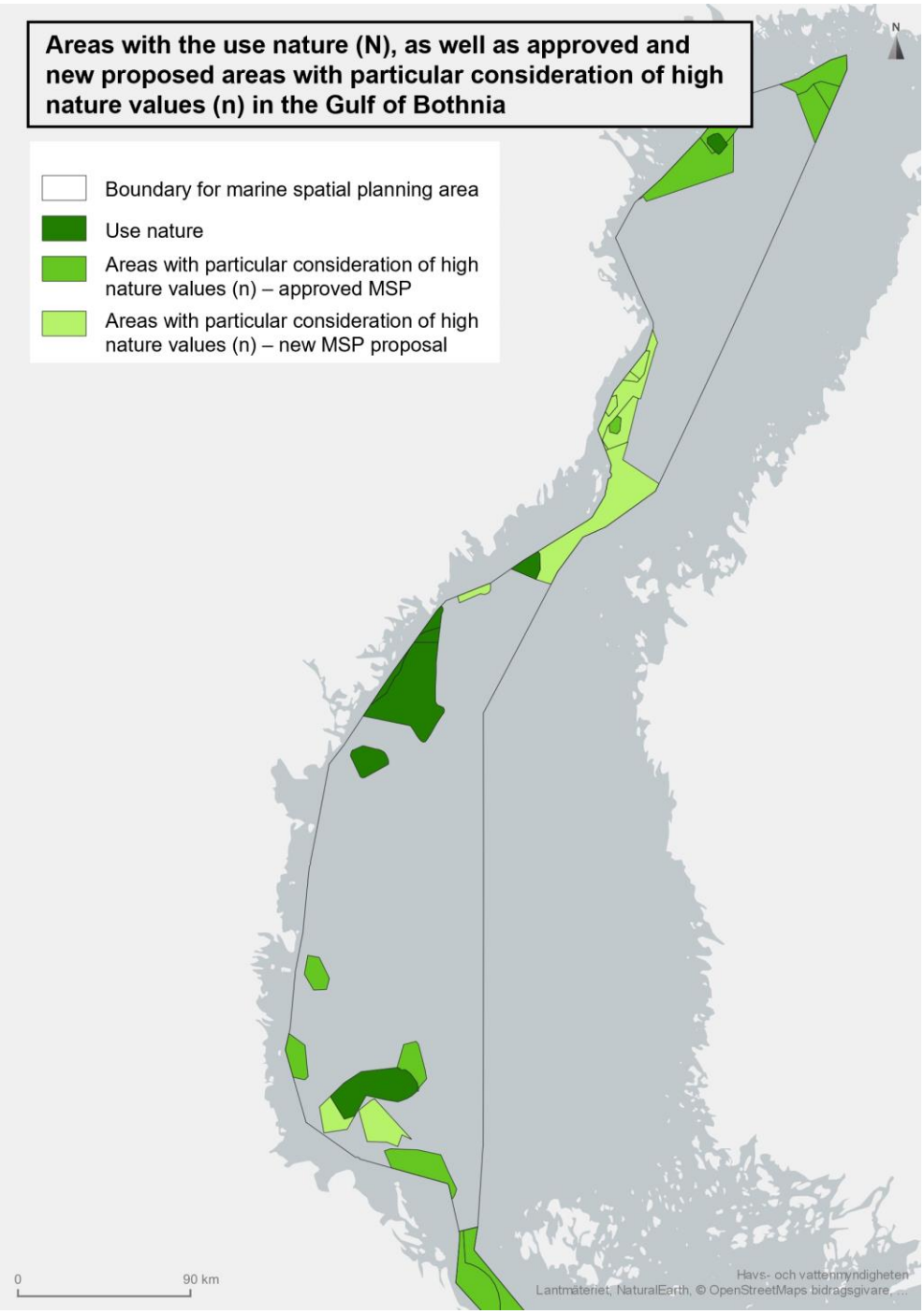


Figure 7. Areas with the use nature (N), as well as approved and new proposed areas with particular consideration of high nature values (n) in the Gulf of Bothnia.

2.2. Assessment of economic effects

Effects on sectors

2.2.1.1. Commercial fishing

The impact on commercial fishing's operating and profitability in the Gulf of Bothnia comes mainly from the marine spatial plan's guidance on new or revised energy extraction areas. Of a total of
2.2.1 22 energy extraction areas that are indicated in the plan proposal, half of them have the potential to negatively affect commercial fishing. Out of these, five are alternative energy extraction areas.

The estimated total annual loss of landing value in the Gulf of Bothnia amounts to just over SEK 1 million as a result of wind power establishment in the 11 proposed and alternative energy areas, which corresponds to around 0.16 per cent of the annual landing value for Swedish commercial fishing in Swedish waters (Table 1). The largest potential losses are in the pelagic trawl fishery in the alternative energy area B158, followed by the bottom trawl fishery targeting mainly herring in the alternative energy area B156, which is located north and south of Finngrunden in Gävlebukten. No other fisheries are considered to be affected by the proposed wind power establishment in the Gulf of Bothnia. The economically very valuable whitefish fishing in the Bothnian Bay is conducted very close to the coast, outside the marine spatial planning area.

	Plan alternative 1: proposed energy areas	**Plan alternative 2: proposed and alternative energy areas**
Loss of annual landing value (SEK)	142,858	1,020,261
Share of the annual landing value (percentage)	0.02	0.16

Table 1. Estimated loss of landing value in commercial fishing as a result of proposed energy extraction in the Gulf of Bothnia.

In addition to Swedish fishing, extensive Finnish fishing is taking place throughout the Gulf of Bothnia, which is at least as large as the Swedish fishery. Assuming that Finnish fishing is conducted in the same areas as the Swedish fishing, the total loss to the commercial fishing in the Gulf of Bothnia can be twice as large as indicated in Table 1.

Figure 8 uses colour coding to show the size of the estimated effect of the proposed energy extraction areas on the landing value from Swedish fishing in the Gulf of Bothnia. Appendix A shows maps of estimated landing values and loss in landing value within proposed and alternative energy areas in the marine spatial planning areas.

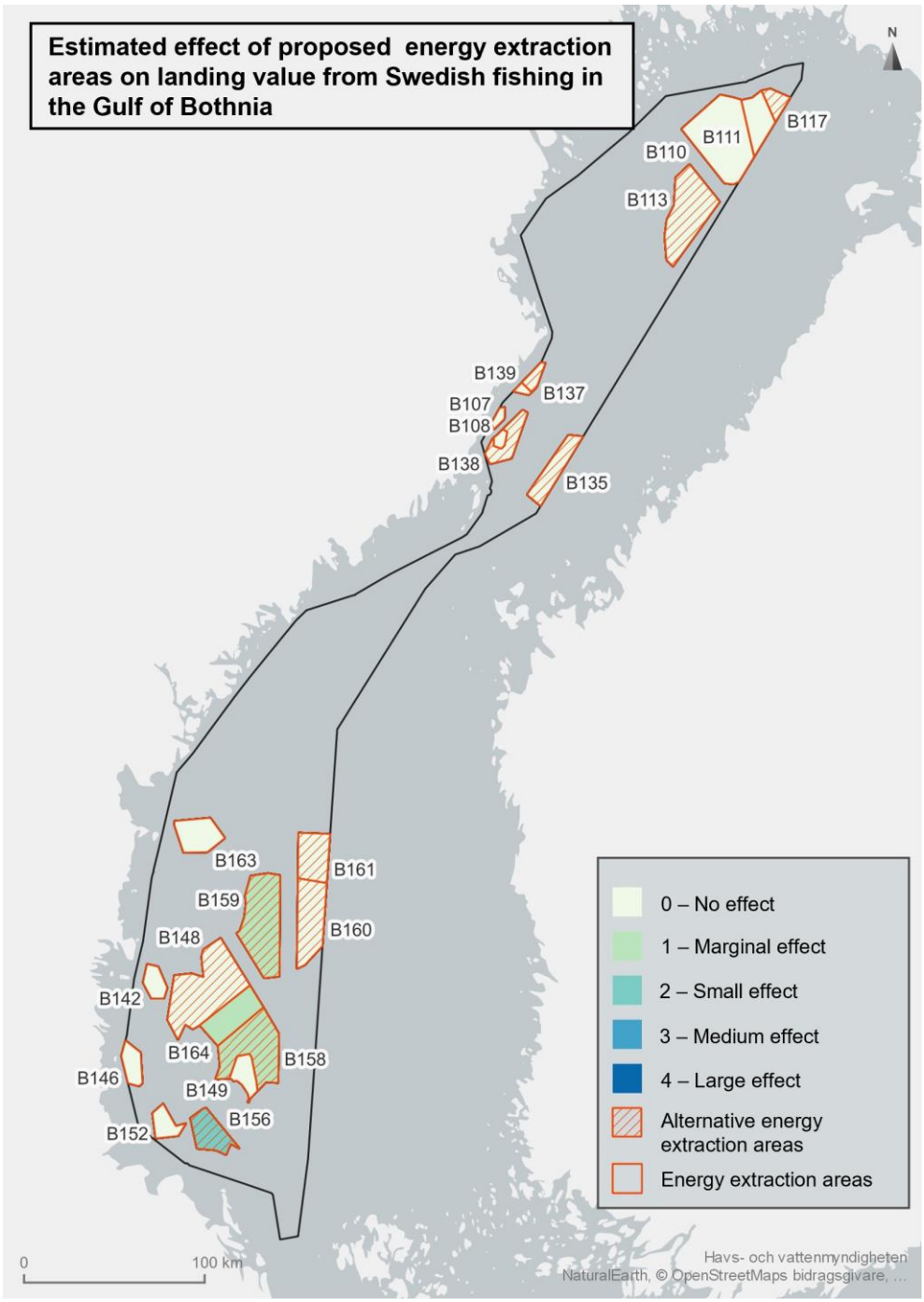


Figure 8. Estimated effect of planned energy extraction areas on landing value from Swedish fishing in the Gulf of Bothnia. Dark colour shows a large effect and light colour shows a small effect.

2.2.1.2. Energy extraction

The Gulf of Bothnia has on average somewhat lower wind speeds than the other two marine spatial planning areas, but short distances to the mainland and relatively low water depth in large areas, which means that several areas nonetheless show medium economic potential based on the chosen assessment method. Among these are three of the marine spatial planning area's four

largest areas in terms of area and production potential – B148, B158 and B159. None of these areas are close to the mainland.

The lowest potential is in areas B113 in the Bothnian Bay, B135 in North Kvarken and B163 in the South Bothnian Sea. According to the assessment method, the result for the first two areas is mainly due to the wind farm design not having come far, at the same time that they are not very large in terms of area and thereby do not have very large production potential.

Table 2 compares the collective area and estimated annual electricity production from the energy extraction areas included in plan alternatives 1 and 2. Figure 9 uses colour coding to show the size of the estimated relative economic potential of the proposed energy extraction areas in the Gulf of Bothnia.

	Plan alternative 1: proposed energy areas	**Plan alternative 2: proposed and alternative energy areas**
Surface area (km^2)	2,757	8,260
Estimated annual production (GWh)	55,148	165,191

Table 2. Surface area and estimated annual electricity production in plan alternatives 1 and 2 in the Gulf of Bothnia marine spatial plan.

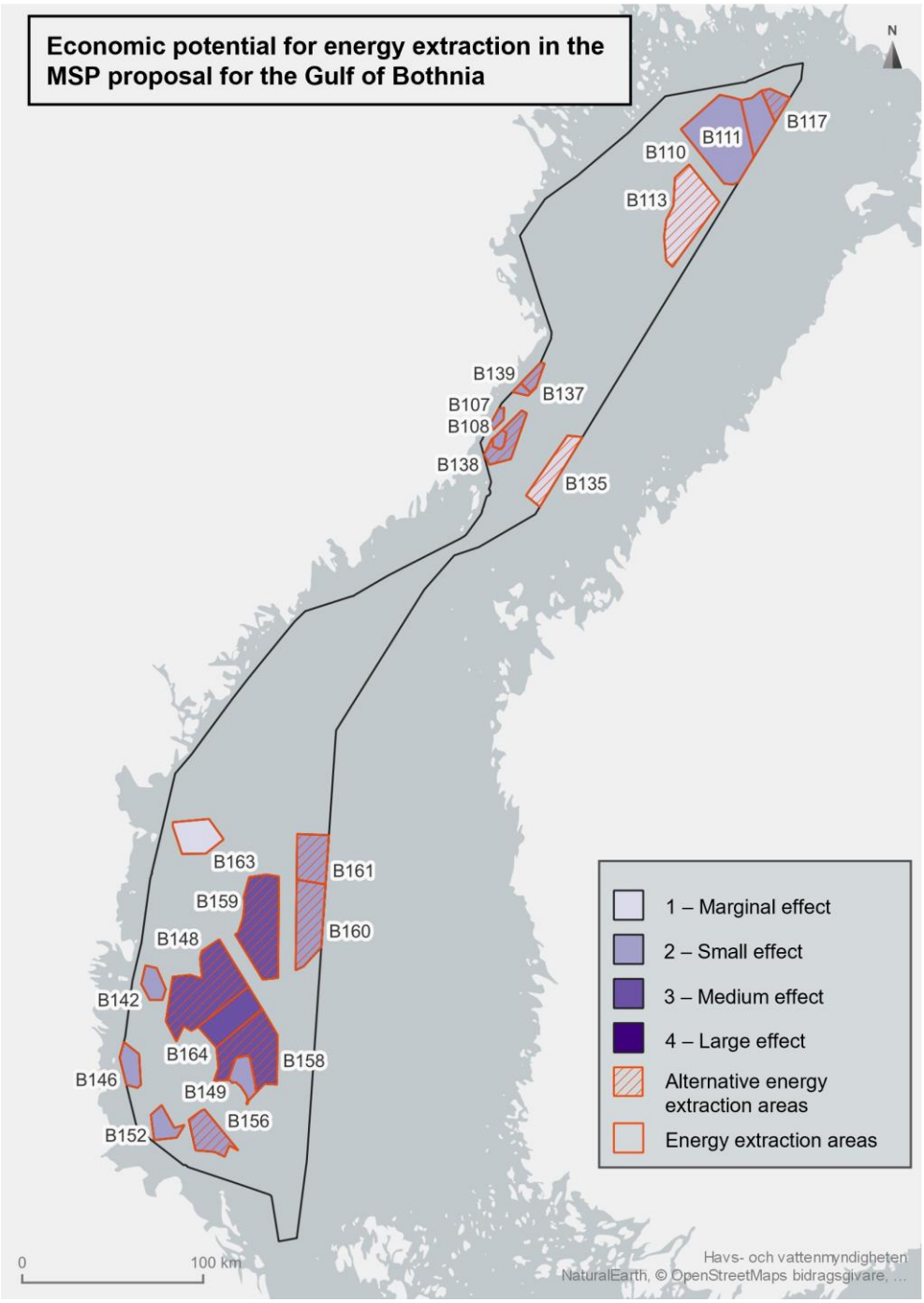


Figure 9. Economic potential for energy extraction in the marine spatial plan proposal for the Gulf of Bothnia. Dark colour shows large potential and light colour shows small potential.

2.2.1.3. Shipping

Shipping is considered to be able to coexist with energy extraction at sea provided that the right conditions are provided and that the safety of shipping is taken into account. This means that consideration must be given to safety distances so that maritime safety and national and international rules at sea can be complied with.

The marine spatial plan is a guide on the most suitable use. Establishment of operations at sea, such as wind power, requires review and decisions including specification of consideration and safety distances to enable coexistence with shipping. The conditions for shipping in the planning area are an important component in terms of passenger and freight transports, accessibility to and from ports in Sweden, neighbouring countries and internationally. A need for further investigation regarding the impact on winter navigation from wind power establishment in the planning area is indicated in the marine spatial plan proposal for the Gulf of Bothnia.

In the marine spatial plan proposal for the Gulf of Bothnia, there are a total of 11 proposed energy areas, and an additional 11 alternative energy areas. Safety zones for the respective energy areas are included to a varying degree. However, the marine spatial plan indicates that the safety zone needs to be taken into account based on the conditions of the respective energy area. The proposed energy areas in the Bothnian Bay B110, B111, B113 and B117 include a certain safety distance from national shipping lanes, although not to neighbouring countries. The energy areas are also located between several shipping lanes between Luleå, Haparanda and Finland, which means that multidimensional consideration is required.

In North Kvarken at the shipping lane between Umeå, Skellefteå and further north, a number of energy areas (B107, B108, B135, B138, B139, B139) are proposed. Out of these, all need to be adapted so that the plan map consistently presents the energy use next to the use shipping.

In the south, adjacent to shipping lanes between Gävle and Sundsvall, the marine spatial plan provides guidance on a number of energy areas. The application of safety zones for the various energy areas varies and here as well, and the safety distances need to be adapted to local conditions. Shipping is proposed to follow the line indicated in existing marine spatial plans in the route that goes across the South Bothnian Sea up to Sundsvall and Härnösand. This route differs from the national interest of shipping and entails making a slight detour, considering the energy areas (B148, B149, B158, B164). The impact of the detour and the extended travel distance is difficult to estimate, but a limited number of passages are nonetheless considered to be affected. Based on the plan map and AIS data, the extended travel distance is estimated to be no more than around 15 km, which is considered to be of minor significance based on the frequency of passages and distance (SwAM, 2019).

Figure 10 uses colour coding to show the potential negative effect that energy areas can have on shipping in the Gulf of Bothnia marine spatial planning area. Dark colour shows a large effect and light colour indicates a small effect.

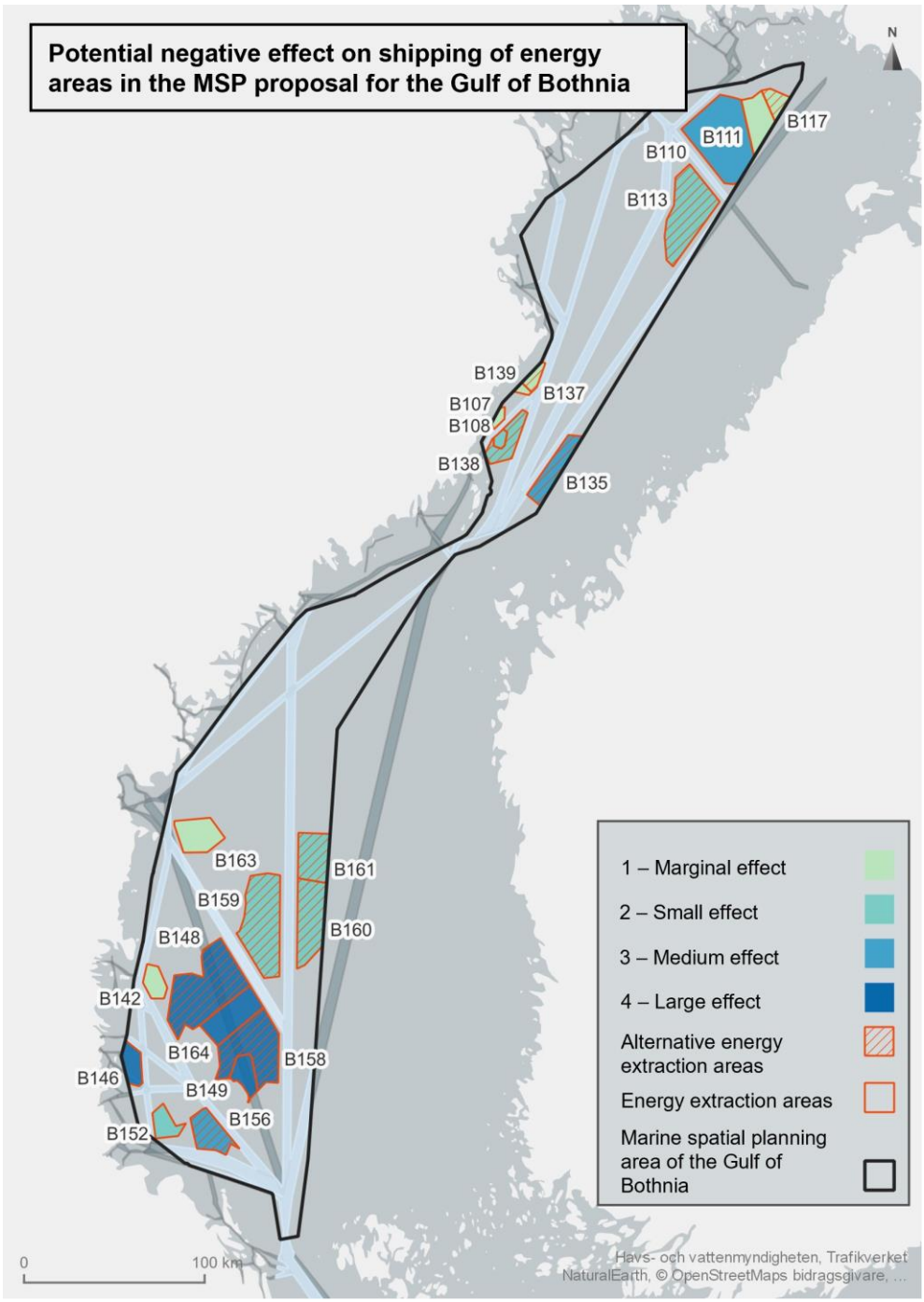


Figure 10. Potential negative effect on shipping of energy areas in the marine spatial plan proposal for the Gulf of Bothnia. Dark colour shows a large effect and light colour shows a small effect.

2.3. Assessment of social effects

Population and health

Knowledge of the effects of offshore wind energy on people's health is extremely limited. The health effects of wind power on land have been studied to a greater extent, and some conclusions can also be relevant to offshore wind energy, although they are rarely directly applicable.

2.3.1.

Vindval's latest synthesis report on the impact of wind power on people's interests includes a review of studies of effects on health (Bolin et al., 2021). The synthesis highlights noise, shadows and warning lights as the main possible impact factors. In terms of noise, the authors refer to several studies on reported noise disturbances within a few kilometres of wind power stations[1], however, no scientifically confirmed results on noise levels from wind power that exceed Sweden's guideline values outside of housing, nor evidence of sleep disturbances or other negative health effects from exposure to noise caused by wind power. According to the authors, some studies show that there may be a positive correlation between reported noise disturbance and other forms of perceived disturbance from wind power, namely visual impact.

Environmental impact assessments of Swedish offshore wind farms generally contain an assessment of effects of airborne noise. In Sweden, the guideline value for wind power noise is 40 dBA at housing, and 35 dBA in areas where the noise situation is especially important and natural noise is dominant. For example, modelling that is included in the applications for the parks at Gretas klackar in the South Bothnian Sea and Kattegatt Syd, Kattegatt Offshore and Galatea Galene in Kattegat show that the collective noise level decreases to 35 dBA within a maximum of five kilometres from the park's outer boundary. The impact from airborne noise at the coast is considered to be negligible.

In the Gulf of Bothnia, there is no proposed energy extraction area that is closer than 5 km to settlements on the coast. Based on the existing knowledge of land-based wind power's health effects and results from modelling studies for Swedish offshore wind energy projects, the risk of health effects from wind power establishment in proposed energy areas is considered to be negligible.

In terms of shadows, the Swedish National Board of Housing, Building and Planning (2009) indicates that it is difficult to determine the limit for which distance shadows from wind power stations are noticeable. At the same time, experience shows that no shadow effect is perceived at a distance of three kilometres. In a study for the UK Department of Energy and Climate Change, a distance of ten rotor diameters is mentioned as the boundary beyond which shading is not perceived as problematic (Brinckerhoff, 2011). For modern turbines with a total height of 350 m and rotor diameter of 320-330 m, this means a boundary distance of 3.2 to 3.3 km. In the marine spatial plan for the Gulf of Bothnia, there is no proposed energy area that is closer than five kilometres to the mainland, which is why shadows and associated health risks for people on the coast are considered to be insignificant.

[1] The authors used hub height and not distance in metres as an inclusion criterion. Distances of 20 to 40 hub heights that are used in the underlying study correspond to around 1,200 - 2,400 m for wind power stations with a total height of no more than 100 m according to the study.

When it comes to health effects from warning lights that wind power stations are equipped with, Bolin et al. (2021) refer to a literature review that shows correlations between disturbance from direct visual impact, shading and warning lights from wind power stations and an increased risk of sleeping problems. However, it is unclear exactly what effect exposure to the warning light has and how this effect is impacted by the distance to the light source. Considering the proposed energy areas' relatively large distance to the mainland in the Gulf of Bothnia, the risk of negative health effects on the population on the coast is considered to be negligible.

Other health effects that can be traced to the marine spatial plan's guidance on other uses in the Gulf of Bothnia are presented in the sustainability assessment of the approved marine spatial plans from 2019 (SwAM, 2019b). There, it is concluded that neither the proposed sand extraction in the Bothnian Bay nor the guidance on shipping entailed any health risks. The guidance on these two uses in this marine spatial plan proposal for the Gulf of Bothnia is no different from that decided upon in the approved marine spatial plan, which is why the same conclusions are considered to continue to apply.

The assessment of the proposed energy areas' effects on shipping indicates a decreased navigational safety due to a large number of permanent installations in the vicinity of shipping lanes, which in some cases coincide with safety distances in a marine area exposed to ice formation in winter (see section 2.2.1.3). This entails an elevated risk of shipping accidents, which indirectly entails a higher risk to human health, both for those directly involved in a possible accident and for the public in, for example, a subsequent environmental accident.

2.3.2. Effects on cultural environment

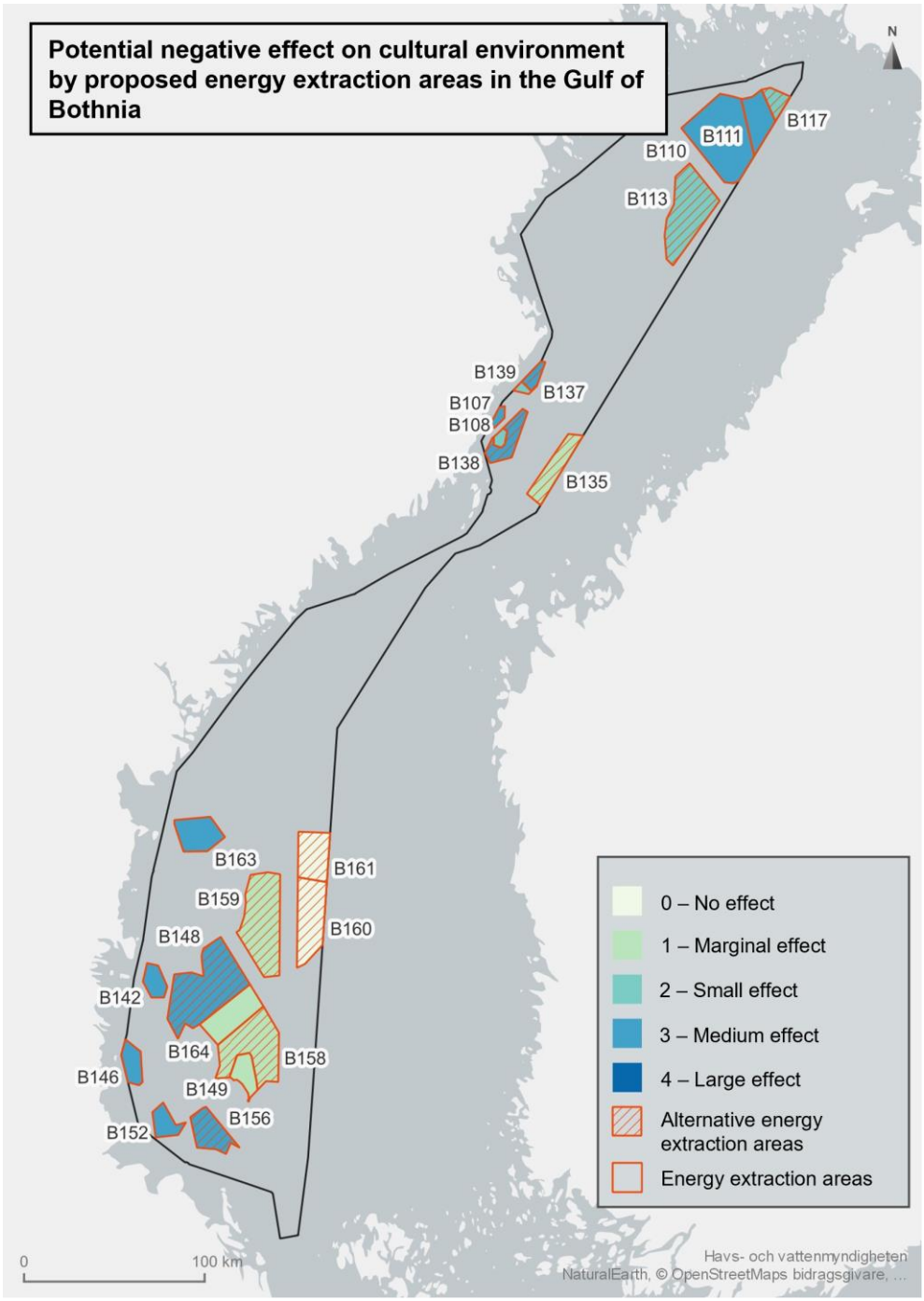
In 11 of the Gulf of Bothnia's 22 proposed and alternative energy areas, the risk of a negative effect on the cultural heritage values on the coast is considered to be medium-sized. With one exception, all of these areas are entirely or partly within the territorial sea boundary, and are thereby relatively close to the coast. The exception is the alternative energy area B148 in Gävlebukten, the relatively high effect of which depends to a greater extent on the area's large size. The area borders the territorial sea boundary in the west.

In four additional energy areas, the risk of a negative effect on the cultural environment is considered to be small. These areas are also located relatively close to or very close to the coast, which is why dominance or competition with cultural values on land is considered to be able to occur. Five other areas are considered to entail a risk of a marginal negative effect. These areas are all further away from the coast. With the exception of the alternative energy area B135 northeast of Umeå, the other four areas are located in Gävlebukten, which despite their size is far enough away from the coast so that the risk of impact is considered to be marginal. The two alternative energy extraction areas B160 and B161 at the maritime boundary to Finland are considered to have no effect on the cultural environment.

Most of the planned energy areas in the Bothnian Bay also entail a risk of impact on cultural environments in Finland, considering the proximity to the Finnish coast.

Figure 11 uses colour coding to show the estimated effect of the proposed and alternative energy areas on the cultural environment in the Gulf of Bothnia. In general, it can be concluded that the alternative energy areas on average have a lower effect on the cultural environment, mainly due

to their distance to the coast being greater. This is especially noticeable in the South Bothnian Sea, where most of the alternative areas are located far out to sea.



2.3.3.

Figure 11. Potential negative effect on cultural environments by proposed energy extraction areas in the Gulf of Bothnia. Dark colour shows a large effect and light colour shows a small effect.

Effects on recreation

The plan proposal indicates the use recreation in six areas in the Gulf of Bothnia. The proposed areas are based on existing national interests for outdoor recreation.

In the marine spatial plan proposal, there are a total of 11 proposed energy areas, and a further 11 alternative energy areas. Proposed energy areas in the northern part of the marine spatial planning area (B110, B111, alternative B117), entail a relatively large potential impact on the national interest of the outdoor recreational area of the Norrbotten coast and archipelago, which together with the Haparanda Archipelago north of the areas have large values for outdoor recreation. Alternative area B113 can also have some impact on these areas. Current recreational activities in the areas are, for example, natural and cultural experiences, swimming, boating, canoeing and kayaking, windsurfing and paragliding. Support criteria for experiences include, among other things, peace and quiet and untouched environments. The energy areas have to some extent been adapted to the Haparanda Archipelago and Malören national park, which is an especially pointed out area in the outer archipelago. The size of the energy areas means that large parts of the national interest area and the values of untouched environments and quiet can be negatively affected. Cumulative impact on the experiential values from all areas along the coast needs to be taken into account.

Figure 12 shows an approximation of the distance from proposed and alternative energy areas in North Kvarken and the Bothnian Bay to land. The figure does not take into account terrain or vegetation on the coast, which has a large effect on visual impact on various areas on land.

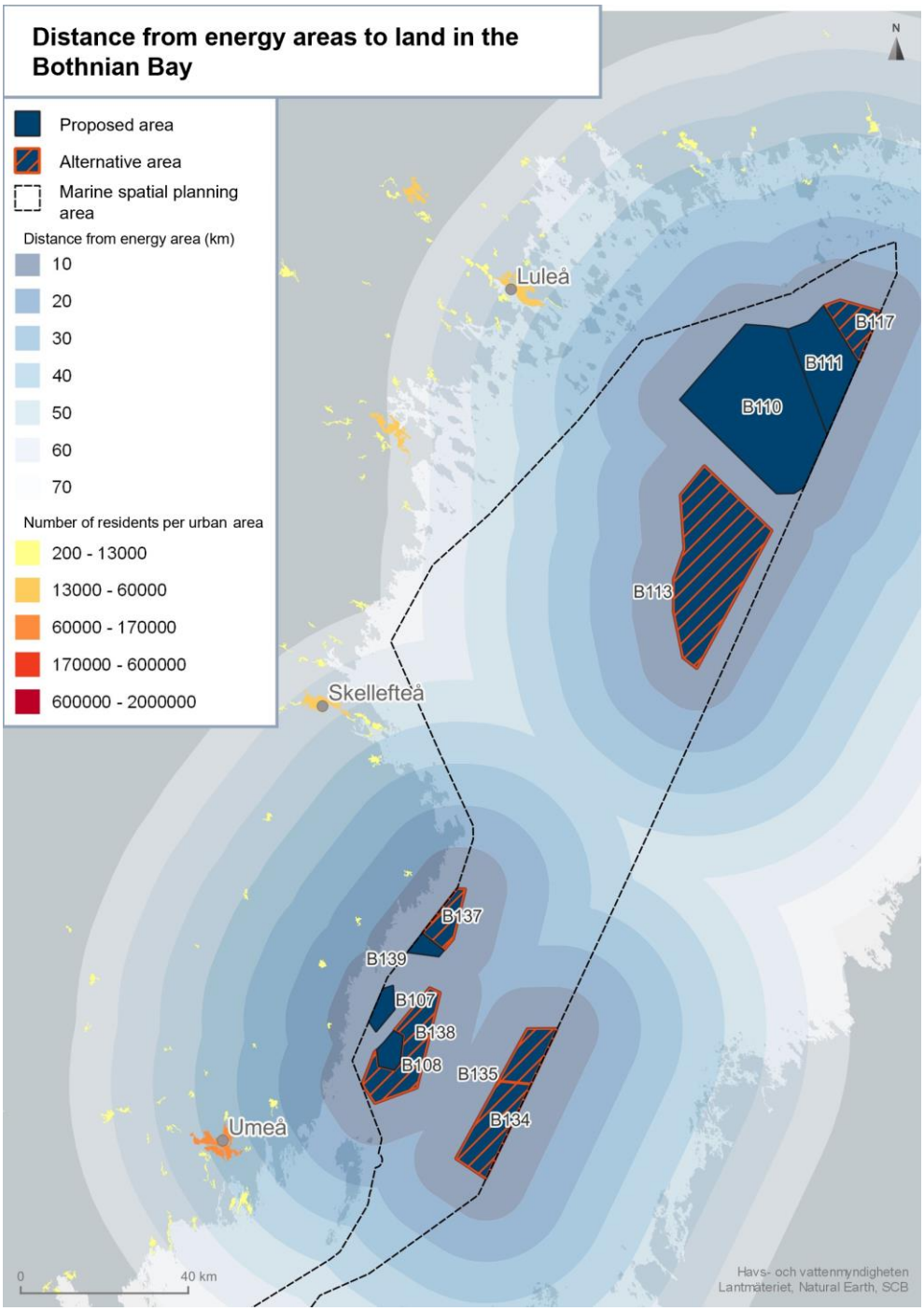


Figure 12. Map of the energy areas' distance to land and population in urban areas on land for the Bothnian Bay.

The corresponding cumulative impact also needs to be taken into account in terms of energy areas (B107, B108, B137, B138, B139 to some extent B135), which are adjacent to national interests in outdoor recreation in the areas of Holmöarna and the coast of Lövånger. Current outdoor activities include boating, angling, bird watching, paddling, skiing, skating and hiking. The Holmöarna area comprises values that can be affected by wind power, such as untouched environments, peace, quiet, low noise levels and attractive landscape appearance.

Energy area B163 is considered to have a potential negative impact within 20 km on the national interest in the outdoor recreation area Brämön-Lörudden and South-eastern Åstön. Current outdoor recreation activities include hiking, boating, bird watching, canoeing and angling.

In the South Bothnian Sea between Hudiksvall and Söderhamn, it is mainly energy area B142 that is considered to have a potential negative impact on national interests in the outdoor recreation areas Hudiksvallskusten with Hornslandet, and area B146 on the outdoor recreation area Ljusnans dalgång. However, activities for these national interests are considered to not be directly linked to the coast and sea, but according to assessment, (Swedish Energy Agency, 2023a), important values for the national interest are untouched environments, tranquillity and an attractive landscape appearance, and the value description shows that Hudiksvallskusten with Hornslandet is considered to be one of the most beautiful coastal sections in the county and at the same time one of the most valuable areas for recreation. In the Swedish Energy Agency's report, it is also noted that the area is relatively untouched and undeveloped and has a varied range of recreational activities in a culturally, geologically and biologically interesting environment and that what can damage the values are various types of facilities (such as industrial establishment) and noise generating activities (such as wind power turbines). A preparatory effort is also under way to investigate the area as a national park. The area is also pointed out in the municipality's comprehensive plan as an area for wind power. In the Swedish Energy Agency's report, an appendix also states that "if the park is rejected in an environmental review, a new assessment should be made of how the area affects the values for outdoor recreation" (Swedish Energy Agency, 2023a).

In the South Bothnian Sea at Gävle around 20 kilometres from the coast, there is the proposed energy area B152 and the alternative area B156. In the coastal area, there are national interests in outdoor recreation, the areas of the Lower Dalälven and Billudden with current activities, such as hiking and angling, and the Öregrund-Gräsö Archipelago with activities such as angling and boating. According to earlier assessments, development within or close to the area could damage the area's values, which would mainly mean that the archipelago's islands and skerries would be exposed to disturbing noise or light, changed landscape appearance or other effects that can negatively affect the perception of the area.

Figure 13 shows an approximation of the distance from proposed and alternative energy areas in the South Bothnian Sea to land. The figure does not take into account terrain or vegetation on the coast, which has a large effect on visual impact on various areas on land.

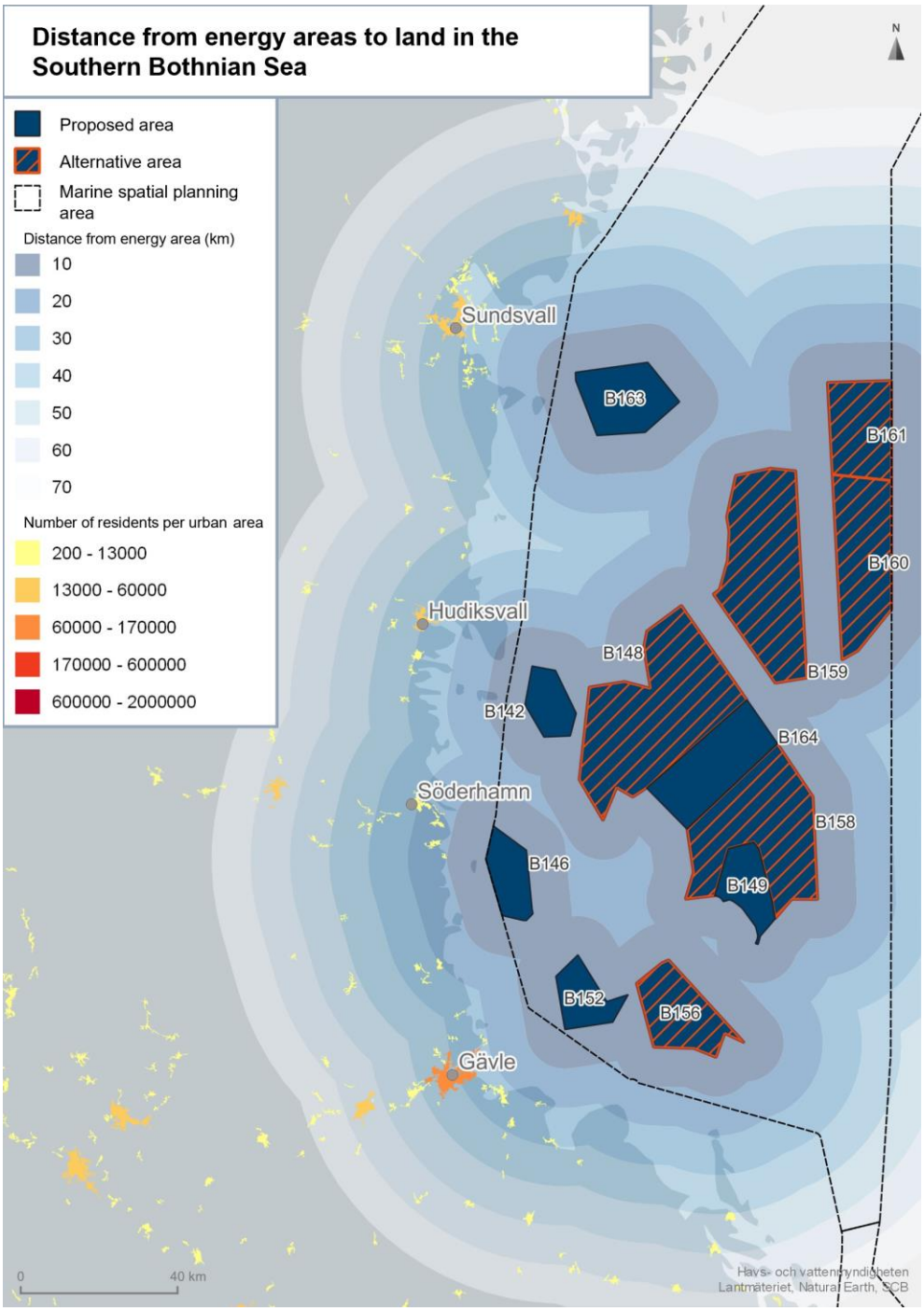


Figure 13. Map of the energy areas' distance to land and population in urban areas on land for the Bothnian Sea.

2.4. Overall assessment for the Gulf of Bothnia

In this section, the effects that the proposed amended marine spatial plan is considered to be able to give rise to for the marine spatial planning area of the Gulf of Bothnia are compiled. The starting point for the compilation is the marine spatial planning proposal's guidance on various uses.

Sand extraction at Svalans and Falkens grund is considered to possibly entail locally large effects on benthic environments and partly also water quality, but the effects are insignificant in terms of the marine spatial planning area as a whole. To avoid negative impact on spawning fish, it is important that possible future extraction activities are adapted to the spawning and nursery period for the herring that exists in the area. The extraction operations and transportation to and from the coast can lead to higher emissions of air pollution, with a small deterioration of air quality locally.

Likewise, shipping's increased travel distance in the South Bothnian Sea as a result of the marine spatial plan's guidance on energy extraction is conisdered to be able to lead to a marginal deterioration of air quality in the area, which, however, is not considered to affect human health. The effect on the climate of these increased emissions is considered to be insignificant in terms of other emission sources.

The marine spatial plan proposal's guidance on energy extraction is considered to entail a risk of negative effects on migratory birds and breeding, resting and wintering birds. The risk of effect is greatest in the Finngrunden area and in Northen Kvarken in terms of migratory birds and wintering birds and migratory birds, respectively, as well as along the coast for breeding, resting and wintering birds. Proposals on expanded areas with particular consideration of high nature values with a focus on sea birds can provide some protection in the form of requirements on precautionary measures in the permit review of wind power projects in these areas.

Wind power establishment causes changes in benthic environments, but the effect is considered to be negligible in terms of the share of seabed area that can be affected. In some environments, the introduction of a new artificial seabed substrate can have positive effects for the marine environment. However, the effects, positive and negative, need to be investigated specifically for each location, among other things to avoid damage to protected seabed environments.

Disturbance of marine mammals is considered to be able to occur mainly in connection with the construction of offshore wind energy, but the effect is considered possible minimise to acceptable levels through the introduction of precautionary measures, in particular with regard to underwater noise and avoidance of sensitive reproduction periods for ringed seal and grey seal.

Similarly, the risk of negative impact on spawning fish is considered possible to minimise by adapting the timing of construction to the spawning period for herring and vendace for wind power projects in the proposed and alternative energy areas located closest to the coast. The fish resource is considered to be able to benefit from reduced fishing in the energy extraction areas, but any possible positive effect cannot currently be quantified.

Increased shipping traffic during the various stages of the wind farms is considered to possibly entail higher emissions of airborne pollutants and greenhouse gases, but based on current knowledge, it is not possible to estimate the magnitude of the effect. At the same time, the

guidance on energy extraction is considered to possibly entail positive effects on the climate by enabling greater production of fossil-free electricity.

Wind power establishment according to the plan proposal's guidance on energy extraction is also considered to entail a risk of impact on other interests. There is a risk that navigational safety could decrease unless the safety distances to shipping lanes are respected. The marine spatial plan proposal includes safety distances for the respective energy areas to a varying degree. Safety distances to shipping lanes are missing in several energy areas in the South Bothnian Sea and in North Kvarken, and in the North Bothnian Bay and adjacent shipping lanes to Finland. The impact on winter navigation in the entire marine spatial planning area constitutes a potential risk that needs to be clarified in order for the national interest of shipping to be able to be met.

The losses for commercial fishing are very small in terms of the landing value in the entire country, and mainly affect the pelagic trawl fishery in the Finngrunden area. The effects might, however, be significant from a local and regional perspective, which also needs to be investigated more closely in possible future wind power establishment.

Negative effects on cultural environments and recreation are considered to be able to arise as a result of visual impact from offshore wind energy. The effect is considered to be the greatest in establishment in energy extraction areas closest to the coast, and a large impact is considered to mainly be able to arise in the Bothnian Bay, the outdoor recreation area of the Norrbotten coast and archipelago, the South Bothnian Sea and North Kvarken, including the area around the Holmöarna. The energy areas in the Bothnian Bay are not located as close to the coast, but occupy a relatively large part of the sight line south from the Haparanda Archipelago, which is why the visual impact might also be significant. The impact and need for adaptation to promote coexistence needs to be assessed from a regional and local perspective. Facts on the effects of wind power on the cultural environment and recreation, as well as documentation on the significance to regional development and its economic effects on the tourism industry, for example, are currently inadequate.

In the amended marine spatial plan proposal, the size of areas with particular consideration of high nature values was expanded with particular focus on birds. Together with other consideration areas and areas with the use nature in the approved marine spatial plan, these signals are considered to indicate the need for special protection in the planning and regulation of human activities and thereby contribute to a sustainable use in the Gulf of Bothnia. The marine spatial plan proposal's guidance on other uses entails no changes compared with how and where the respective activities are conducted today, and is therefore not considered to entail any specific environmental effects.

The majority of identified environmental effects are considered to be cross-border and mainly affect the neighbouring country of Finland. Bird, fish and mammal species that are considered to be able to be affected by uses that the marine spatial plan has control over are in the entire Gulf of Bothnia and are in many cases a part of cross-border populations. In terms of migratory birds, effects from activities in Swedish waters can impact populations that migrate over significantly longer distances, which is why some effects may be of global significance. The effects on shipping and fishing also affect foreign vessels and fishermen and accessibility to shipping lanes and ports in Finland. In terms of fishing, the potential effects on Finnish fishing are considered to be at least as large as the effects on Swedish fishing. The effects on the cultural environment and

recreation in the North Bothnian Bay are also considered to be able to affect values on the Finnish coast. At the same time, other countries can also benefit from the potential positive effects of wind power in the form of expanded production of fossil-free electricity.

There is no clear divide between proposed and alternative energy areas in terms of the aggregated environmental effects. The alternative areas are on average located further out to sea, which lowers the effect on the natural and cultural values on the coast. At the same time, production costs increase with distance to the coast, which can lower the cost-efficiency. An important aspect to consider in the continued planning is the risk of cumulative impact. Larger clusters of wind farms, which in the South Bothnian Sea, can entail excessively high cumulative effects that are currently very difficult to foresee. The planned wind power development in Finnish waters also needs to be taken into account, especially in the North Bothnian Bay where several wind power areas are proposed according to the Finnish marine spatial plan relatively close to energy areas in Swedish waters. The risks linked to cumulative effects can be especially high in areas with high nature values and are of regional or global significance, which is the case with the Finngrunden area in the South Bothnian Sea.

3. Impact assessment of the marine spatial plan for the Baltic Sea

3.1. Assessment of environmental effects

Effects on protected animal and plant species and biodiversity

3.1.1.1. Birds

3.1.1. Similar to the Gulf of Bothnia marine spatial planning area, it is mainly the marine spatial plan's guidance on energy extraction and investigation areas for shipping that entails a risk of a negative effect on birds. Today, sea birds and birds that migrate across the sea are affected by a number of other human activities on land and at sea. However, the marine spatial plan's guidance will not directly affect these activities in a significant way, which is why the risk profile is considered to remain unchanged.

The potential positive environmental effects of moving the shipping that currently operates through Hoburgs bank and the Midsea banks to a deep-water lane south and east of the banks were presented in the environmental impact assessment of the approved marine spatial plans (SwAM, 2019a). Based on conclusions from earlier studies and results from Symphony, it was then concluded that the relocation of shipping from the banks was the most favourable alternative for the protection of endangered species of birds and marine mammals and to reduce the cumulative environmental impact of shipping. Since the guidance on the investigation area for shipping is unchanged, the conclusions are considered to apply to this marine spatial plan proposal for the Baltic Sea.

Through large parts of the South and Central Baltic Sea, broad migratory bird paths move in a south-westerly-north-easterly direction from south of Skåne, through South Hanö Bay, past Öland and Gotland, and on towards the Gulf of Finland and South Kvarken. The migration route is used by several million individuals annually in both spring and autumn. In addition to this broad migration route, narrow passages across the sea, so-called bottlenecks, constitute especially important migration routes for land-dwelling birds and bats that try to minimise the passages over the open sea to the greatest extent possible. Known bottlenecks in the marine spatial planning area of the Baltic Sea are Öresund, the Kalmarsund-Öland-Gotland route and South Kvarken. Establishment of offshore wind energy in the proposed energy areas that are located within the broad migration route and the known bottlenecks are therefore considered to entail a risk of large or medium-sized effect on birds. There is a risk of cumulative effects with consideration to the neighbouring countries' plans for wind power establishment and this needs to be investigated in decisions on permits in Swedish waters (see Figure 14).

With the exception of the area Ö298 in Öresund, all energy areas with estimated large or medium-sized effects on birds are alternative energy areas in the marine spatial plan proposal. In terms of Ö298, the area is close to the island of Saltholm, which is an important breeding area for many bird species. East of the energy area, bird protection areas are of major significance to several bird species sensitive to disturbance. In addition to a high risk of collisions, barrier effects and displacement, there is also a risk of cumulative impact given several other impact factors in

the immediate area. The protected areas are in densely populated areas with a high collective pressure from the surroundings. An additional impact factor of wind power can therefore entail deteriorated status for protected species. Above Öresund, the density of migratory land birds and probably bats is especially high, which is why the risk of a negative effect on migratory birds is especially high.

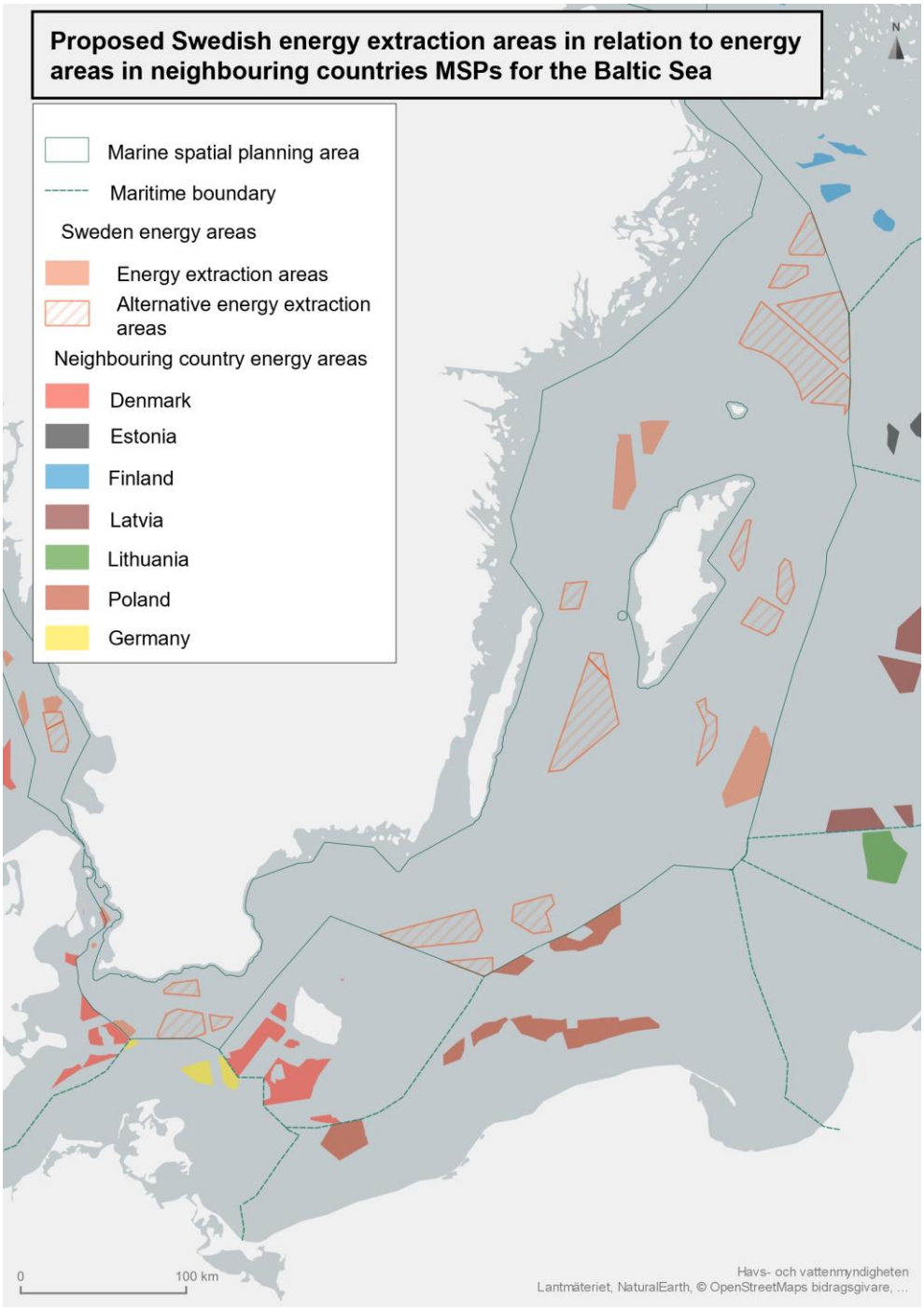


Figure 14. Map of planned or proposed energy extraction areas in Sweden and the neighbouring countries in the Baltic Sea.

Other areas with a risk of major negative impact on birds are Ö273, Ö501 and Ö277 between Öland and Gotland, Ö282 south of Skåne and Ö509 east of the northern half of Gotland. The latter two alternative energy areas are relatively close to the coast, and entail a risk of collisions, barrier effects and displacement of breeding, wintering and resting birds. The areas between Öland and Gotland are located within a core area for breeding sea birds in the Baltic Sea and in a central migration corridor for large parts of the populations of several species with breeding areas in North-western Russia and Northern Scandinavia. Many of these migrating birds rest along Öland's and Gotland's coasts, where important foraging areas are located.

Proposed energy areas with a risk of a medium negative effect on birds are located south of Skåne and Blekinge, and west and north-west of Gotland. The areas located in waterways south of Skåne, from Ö285 in the west to Ö288 in the east are considered to entail a risk that a broad area is claimed by wind power at the same time that it is used in spring and autumn by millions of migratory birds in a south-north route, including small land-dwelling birds, birds of prey and cranes. The possibility for disturbance-sensitive species to fly around all the energy areas is difficult to assess, but the risk of displacement and collisions under severe wind and light conditions is considered to be significant. It is also not clear if there can be differentiation within this broad bird range that might entail a lower risk of collisions. The risk of collisions should be able to be lowered with adapted operation of the wind farms, where, for example, the stations are shut down under certain weather conditions, or when birds are detected.

The more coastal area Ö282 entails a risk to bird species that reside or migrate along the coast. Wind power expansion in the alternative energy area Ö269 north-east of Bornholm is at risk of negatively affecting the eastern part of the broad migration movement through the Baltic Sea, especially for the birds that aim for Bornholm. The western part of the area is thus more problematic.

Within the alternative energy areas east and north-east of Gotland – Ö213 and Ö271, and Ö205 and Ö279 respectively – the bird values are not sufficiently mapped. However, it is considered likely that the migration of large numbers of birds takes place on a broad front through the areas, and can be negatively impacted by offshore wind energy. The large accumulation of alternative energy areas north-west of Gotland also entails a large risk of cumulative impact as the areas occupy a very large area along the migration corridor towards South-western Finland.

The alternative energy areas Ö255, Ö261 and Ö273 are located inside as well as next to the Natura 2000 area Hoburgs bank and Midsea banks. The offshore banks are of global significance to a number of disturbance-sensitive wintering sea birds, including the threatened long-tailed duck, as well as sand guillemots, guillemots and razorbills. None of the areas is located at a depth shallower than 30 m and therefore does not directly affect the main foraging areas for the species that forage on the seafloor. However, there is a risk of displacement of disturbance-sensitive species, especially if all or several of the proposed and alternative energy areas were to be built, which is why the effect is considered to be medium-sized. Considering the species' need for protection, further studies are considered to be necessary prior to possible establishment of wind power in these areas.

Figure 15 and Figure 16 use colour coding to show the size of the estimated effect of the proposed energy extraction areas on migratory birds and wintering birds in the Baltic Sea marine spatial planning area .

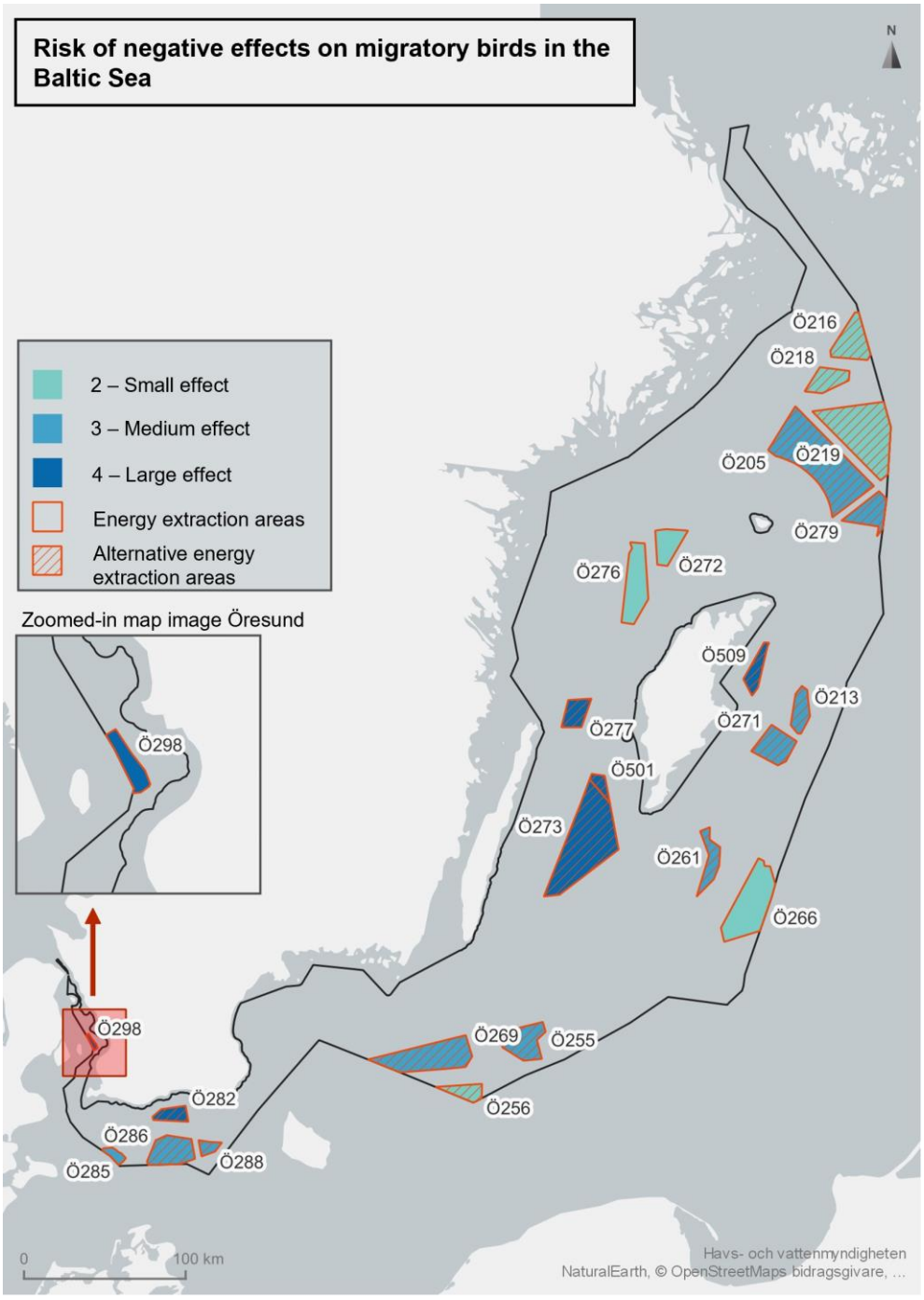


Figure 15. Risks of negative effects on migratory birds in the Baltic Sea. Dark colour shows a large effect and light colour shows a small effect.

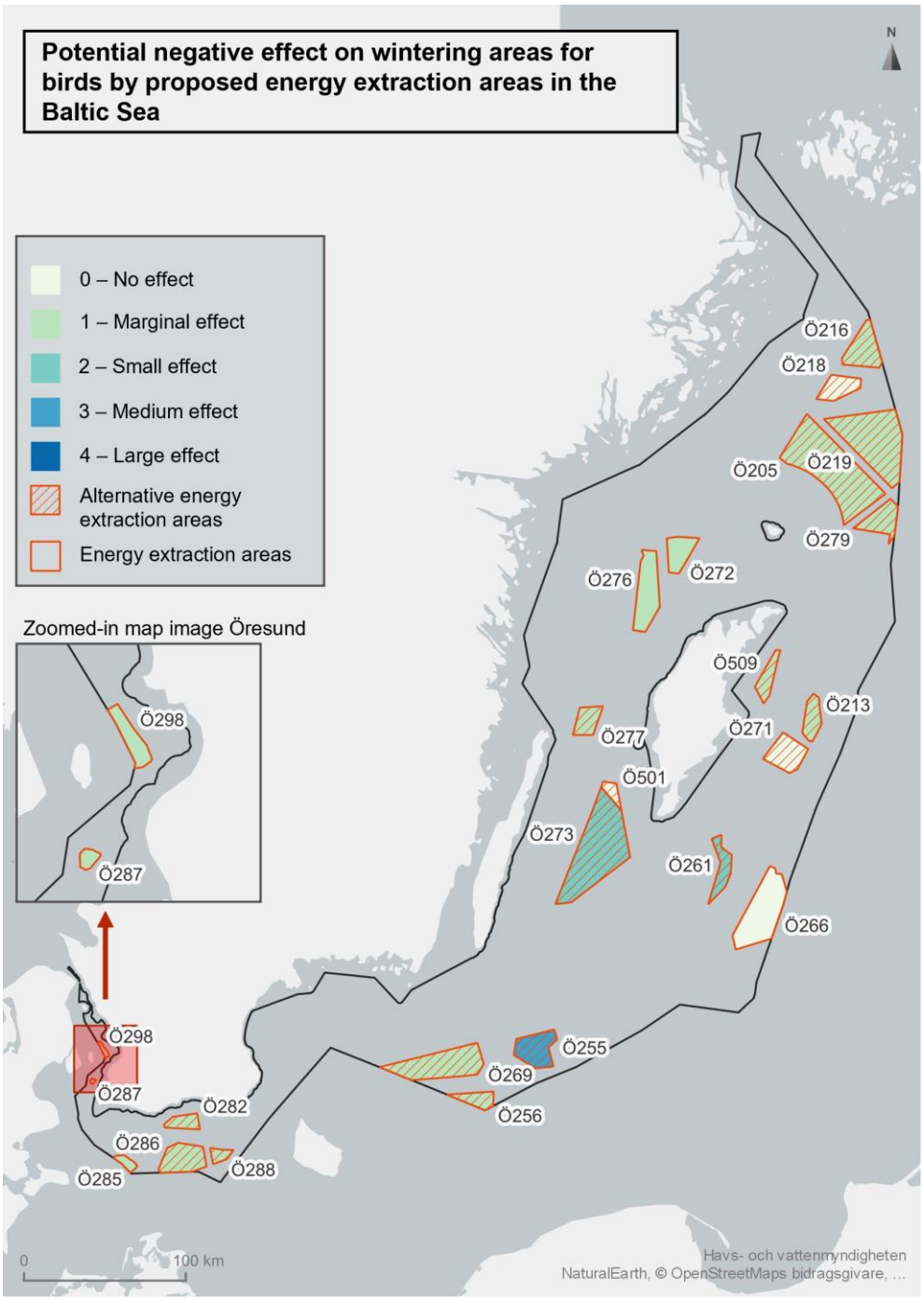


Figure 16. Potential negative effect on wintering areas for birds by proposed energy extraction areas in the Baltic Sea. Dark colour shows a large effect and light colour shows a small effect.

3.1.1.2. Marine mammals

In the Baltic Sea, there are grey seals, harbour seals and Danish Straits and Baltic Sea harbour porpoises. Grey seals and harbour seals populations have the status “least concern” according to the latest red list from SLU (Swedish Species Information Centre, n.d.).

Harbour seal

In Kalmarsund, there is also a small isolated population of harbour seals that are red listed in the vulnerable category. According to published studies (Stanley et al., 1996; Goodman, 1998), the Kalmarsund population is the most genetically abnormal among Europe's harbour seals. The population has probably been isolated from other harbour seal populations for at least 6,000 years. It is the alternative energy areas Ö269 south of Öland and Ö273 between Öland and Gotland that could affect the harbour seal population in Kalmarsund, but the potential effect is considered to be small.

Proposed energy areas Ö298 in Öresund can affect harbour seals, but even here, the effect is considered to be small.

Grey seal

The grey seal is common in the Baltic Sea. It can be disturbed and frightened away by underwater noise, but is not as sensitive to noise as the harbour porpoise. Measures implemented to reduce noise in the construction phase also contribute to the limitation of negative effects on grey seal.

Harbour porpoise

The Baltic Sea harbour porpoise is classified as critically endangered while the Danish Straits harbour porpoise has the status "least concern" (Swedish Species Information Centre, n.d.).

According to the results from the project SAMBAH, porpoises from the Baltic Sea population are gathered during the summer in the area on and between the banks in the central Baltic Sea (Hoburgs bank, Northern Midsea bank and Southern Midsea bank). The warm half-year is the time when the porpoise is most sensitive to disturbance since it calves in June-July and mates in August. The porpoise suckles its calf for up to ten months and during at least the first half-year from birth, the calf is assumed to be so dependent on the female that a possible separation can be critical. For these reasons, the area is a very important area for the Baltic Sea's acutely endangered porpoise population.

The alternative energy areas Ö255, Ö256, Ö261, Ö269, Ö273 on or adjacent to the Northern or Southern Midsea banks and Hoburgs bank are considered to have potential for a large negative effect on the Baltic Sea harbour porpoise in the construction phase. Modern noise-reducing measures, such as double bubble curtains, can help to minimise the risk of a negative effect on harbour porpoises. The season must also be taken into account.

The proposed energy area Ö266 and the alternative area Ö277 are considered to have a potential medium-sized effect on the Baltic Sea harbour porpoise.

The alternative energy areas Ö213, Ö271 and Ö509 east of Gotland are considered to have a limited negative effect on harbour porpoises if noise limiting measures are carried out in the construction phase. The same applies to the proposed energy areas Ö272 and Ö276 north-west of Gotland. The alternative energy areas Ö216, Ö218, Ö219, Ö205 and Ö279 are considered to have a small risk of negatively affecting the Baltic Sea harbour porpoise in the construction phase. The energy areas Ö282, Ö285, Ö286, Ö288, Ö298 around Skåne are considered to have

a medium potential negative effect on the Danish Straits and or Baltic Sea harbour porpoises, but the risk can be handled through noise reducing measures, such as double bubble curtains or the equivalent.

The knowledge of effects in the operating phase is limited and it is not possible to exclude negative effects even if the probability is considered to be smaller.

3.1.1.3. Benthic habitats

The seabed impact in the Baltic Sea is considered to mainly depend on the type of facility (bottom-fixed or floating), and to some extent if bottom trawling occurs in the area.

Some deeper parts of the Baltic Sea have for a long time been negatively impacted by oxygen deficit and are therefore considered to lack nature values. These energy areas overlap in whole or in part with such areas: Ö272, Ö276, Ö205, Ö219, Ö279. These areas are of interest for floating foundations whose physical structures can contribute a new hard substrate and thereby new environments for species that seek out this type of substrate. There is a risk that unwanted invasive species also benefit from an increased occurrence of hard substrates.

Natural bottom substrates in the Baltic Sea consist largely of soft sediments with clay and sand, gravel and stone. If consideration is given to the occurrence of sensitive seabed in design and construction, negative effects on existing benthic environments are considered to be avoidable for both bottom-fixed and floating facilities in the Baltic Sea.

In the Baltic Sea, bottom trawling occurs, but to a limited extent mainly in the following energy areas: Ö205, Ö255, Ö269, Ö277 and Ö288. In these areas, establishment of offshore wind energy and limitation of bottom trawling could to some extent have a positive effect on benthic environments.

3.1.1.4. Fish and spawning areas

In the current proposal for an amended marine spatial plan for the Baltic Sea, it is mainly guidance on sand extraction and energy extraction that is considered to entail a risk of impact on fish. In terms of sand extraction, the guidance in this proposal on an amended marine spatial plan is the same as in the approved marine spatial plan, which is why the conclusions in the respective environmental impact assessment are considered to apply (SwAM, 2019a).

In sand extraction at Utklippan, increased turbidity is considered to be able to occur locally. The effect is considered to be short-term since the sediment mainly consists of coarse-grained sand and gravel (SGU, 2017). Even if the area is outside the cod spawning area, cod larvae can drift into the area (SLU Aqua, 2018). The larvae are sensitive to suspended sediment at higher concentrations, which is why the extraction activities should preferably be paused during those times of the year when there are cod larvae in the water. The area is also a part of an important nursery area for the cod, and the bottom is probably used by flatfish. Based on the uncertainty regarding the operations' design and its specific effects on fish and fish habitats, and considering the precautionary principle, the effect of proposed sand extraction activities at Utklippan is considered to possibly entail moderately negative effects on fish. The effects are considered to be mostly local and reversible in the short term based on the geographic scope of the activities in relation to the marine spatial planning area and alternative spawning areas for the affected

species. Specific effects on fish and especially spawning fish should be investigated more closely in permit reviews.

The proposed sand extraction at Sandhammar bank, south of Ystad, however, is not assumed to entail any particular effects on fish. According to earlier assessments, the area has no especially valuable nature types, but it is considered to be a foraging area for flatfish (SGU, 2017). The area is characterised by great sediment mobility and the sand extraction is considered to be compensated by accumulation of sand from the upper part of the bank. High substrate dynamics and large temporal variation in bottom fauna impede the assessment of the extraction activities' specific effects on biodiversity.

Locally large negative environmental effects are considered to possibly arise in connection with the proposed sand extraction at Sandflyttan south-west of Falsterbo. Disruption of sensitive habitats for affected fish species, such as cod and flatfish, should be possible to minimise by avoiding time periods with sensitive life stages for the species, and by distributing the sand extraction so that the risk of oxygen-poor pits does not arise (SLU Aqua, 2018). Considering the high nature values in the local area, the sand extraction activities are considered to possibly entail moderate to large negative effects for fish, but specific effects need to be investigated within the scope of the Natura 2000 review. Elevated turbidity is considered to occur locally during sand extraction, but is not assumed to be long-term considering the sediment's grain size, which is why the effect is considered to be local and small in relation to the marine spatial planning area as a whole.

In terms of the marine spatial plan's guidance on energy extraction, it can entail a risk of negative impact on fish spawning areas. Despite remaining knowledge gaps, establishment of offshore wind energy is not considered to pose a threat to fish species or fish populations if adequate locally adapted precautions are taken (Öhman, 2023; Hogan et al., 2023; see section 2.1.1.4). Within the Baltic Sea marine spatial planning area, several proposed and alternative energy areas coincide with known spawning areas for cod and herring. The distribution of these spawning areas is not always known in detail, and more detailed assessments need to be done prior to possible future wind power establishment.

The risk of negative impact on spawning fish is present throughout Öresund, where the proposed energy area Ö298 is located. The waters south of Skåne and Blekinge are known spawning and nursery areas for cod, which is why possible wind power expansion in the alternative energy areas Ö286, Ö288, Ö256 and Ö269 needs to be adapted to important reproduction periods for this species. A large spawning area for flounder is believed to coincide with the cod spawning area south of Blekinge, and possible impact on this species should also be taken into consideration. The proposed energy area Ö266 is located in close proximity to a spawning area for cod south-east of Gotland, and possible impact and need for adaptation in future wind power establishment need to be investigated. On Hoburgs bank and the Midsea banks, there is some herring spawning, which is why possible impact of wind power establishment on the alternative energy area Ö255 needs to be taken into account. Modelled spawning areas for herring and cod in the Baltic Sea are shown in Figure 17 and Figure 18.

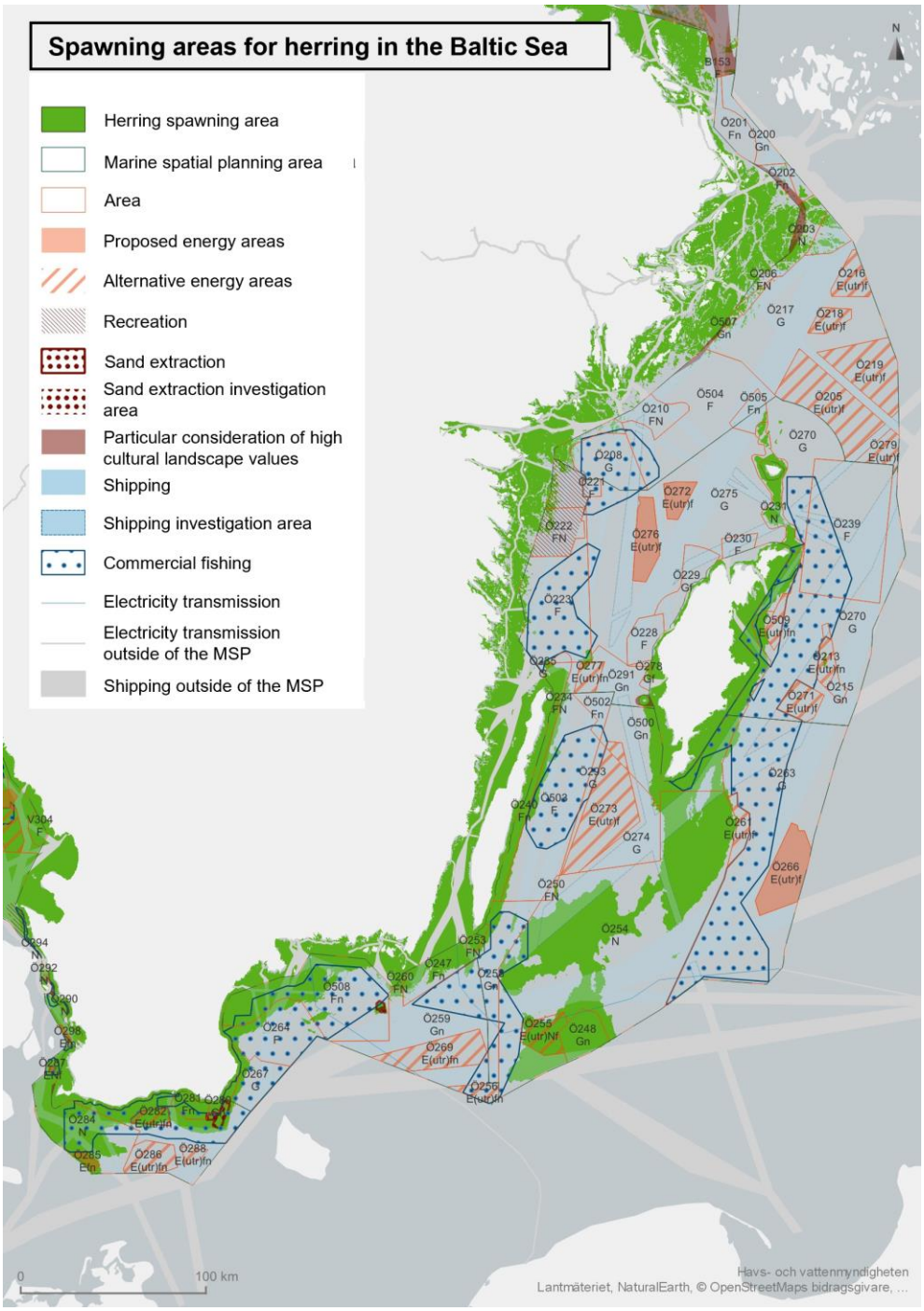


Figure 17. Spawning areas for herring in the Baltic Sea. Spawning areas are shown in green. (Source: SLU Aqua).

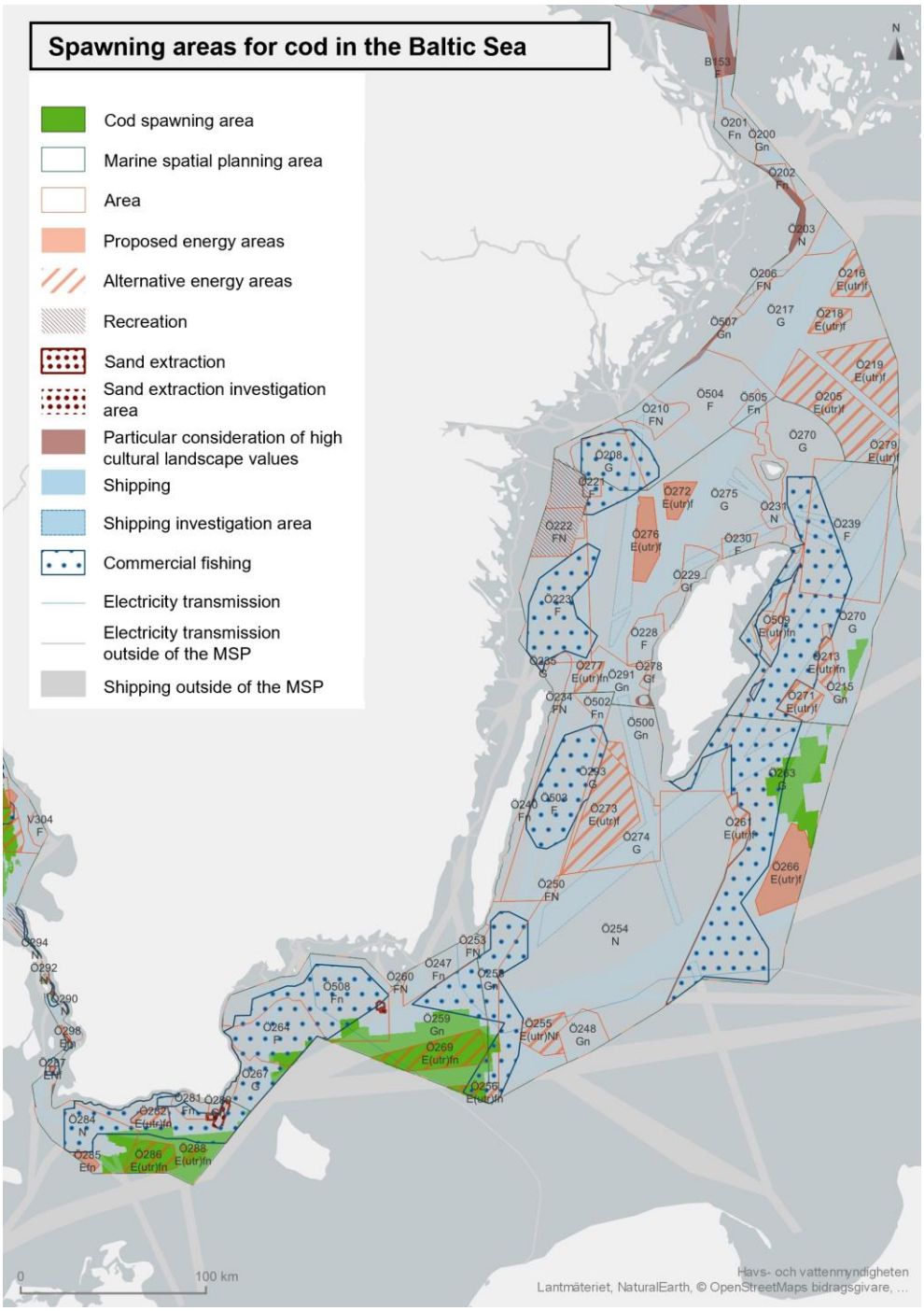


Figure 18. Spawning areas for cod in the Baltic Sea. Spawning areas are shown in green. (Source: SLU Aqua).

Similar to the marine spatial planning area of the Gulf of Bothnia, a decrease in fishing activities can occur as a result of the establishment of offshore wind energy in the proposed energy areas. Such a decrease could lead to reduced exploitation pressure on the fish resource and benefit its recovery. However, it is not known how fishing will be affected and adapted to possible wind power establishment, which is why it is not possible to estimate how large such a positive effect could be. According to the environmental impact assessment of the approved marine spatial plan, some adaptation of fishing operations in areas where the marine spatial plan indicates particular

consideration of high nature values is considered to possibly have a small positive effect on the fish resource (SwAM, 2019a). Adaptations, for example, refer to reduced by-catch or reduced impact on the seabed in bottom trawling. Whether, and if so how, such provisions could be introduced is, however, impossible to currently predict, and thereby also the potential positive effects for fish.

Effects on water and air

In the Baltic Sea marine spatial planning area, it is the marine spatial plan's guidance on energy extraction, sand extraction and investigation areas for shipping that is considered to possibly entail effects on water and air. In this marine spatial plan proposal, the guidance on the latter two uses is the same as in the approved marine spatial plan. The conclusions in the environmental impact assessment and the sustainability assessment from 2019 are therefore valid for effects on water and air, respectively.

3.1.2

The marine spatial plan proposal for the Baltic Sea provides guidance on new or expanded sand extraction activities in three areas, Utklippan in Ö508, Sandhammar bank in Ö280 and Ö281, and the Sandflyttan investigation area in Ö284. Previous extraction activities at Sandhammar have ceased. According to the Geological Survey of Sweden, all three areas have geological, economic and environmental conditions for sand extraction (SGU, 2017). Increased shipping in connection with the actual sand extraction and transportation between extraction is considered to lead to higher air emissions and a marginally reduced air quality locally. Sand extraction is considered to be able to lead to increased turbidity and impaired water quality locally. However, the effect is considered to be short-term, which is why no permanent effects for water quality are considered to arise (SwAM, 2019a).

The marine spatial plan proposal for the Baltic Sea provides guidance on several investigation areas for shipping through the central Baltic Sea. These entail, among other things, a relocation of shipping traffic that today goes through Hoburgs bank and the Northern Midsea bank to a deep-water shipping lane south and east of the bank. The relocation entails an approximately five percent longer travel distance and an approximately 2.6 per cent higher fuel consumption at an unchanged average speed, which entails a small negative effect on air quality in the entire marine spatial planning area (SwAM, 2019a). In addition to the investigation areas for shipping, the marine spatial plan's guidance entails no further changes for shipping compared with the zero alternative.

Establishment of offshore wind energy in the Baltic Sea in line with the marine spatial plan's guidance on energy extraction can in some areas lead to changes in fishing operations and the fishing vessels' routes. However, such changes, and thereby the possible consequences in terms of air emissions, cannot currently be predicted. Similar to the Gulf of Bothnia, wind power establishment according to the guidance in the proposed marine spatial plan for the Baltic Sea is considered to be able to lead to significantly increased maritime transport for construction and service of the wind farms, which can lead to higher air emissions. However, the size of this potential effect cannot be predicted without more detailed knowledge of the future wind power activities in the proposed energy areas.

Establishment of wind farms can also have effects on water quality. Increased turbidity arises during construction and decommissioning, but the effect is usually short-term and local, and thereby insignificant in terms of the marine spatial planning area in its entirety and the wind farms'

estimated life expectancy of several decades. Effects on hydrographic conditions are also considered to be able to arise, both locally and at a regional level (Arneborg et al., 2023; see section 2.1.2). Based on current knowledge, it is, however, not possible to estimate the scope of such effects.

Effects on climate

Effects linked to climate are assessed for the Baltic Sea marine spatial plan as a positive contribution considering the guidance on energy areas for offshore wind energy. Wind power as a renewable energy source during operation does not contribute to emissions of greenhouse gases and in a life-cycle perspective results in low emissions of carbon dioxide (Swedish Energy Agency, 2023a). The potential for energy areas for fossil-free energy in the Baltic Sea planning area is estimated to be an annual production of 32.7 TWh. Including alternative energy areas, the potential is estimated to total 184.2 TWh (see section 3.2.1.2). The actual scope of the effect on climate also depends, however, on if and what energy sources are replaced or constitute an alternative energy base, and whether or not these are fossil-based.

3.1.3

The proposed marine spatial plan with energy areas can affect other uses with potential effects regarding emissions of greenhouse gases, such as possible changes in travel distance for shipping and commercial fishing. In total, the plan is considered to contribute to national and international climate objectives, the transition to a fossil-free energy sector and the transition to a fossil-free industrial and transport sector (Swedish Energy Agency, 2023b).

3.1.4. Effects of proposals on the areas with particular consideration of high nature values

The proposed plan for the Baltic Sea includes a number of complementary areas with particular consideration of high nature values (lower-case n areas). The alternative energy areas (Ö282, Ö286 and Ö288) south of Skåne are proposed as areas with particular consideration of high nature values to strengthen particular consideration of migratory birds and relate to the bird migration route Rügen – Skåne marked in the German marine spatial plan.

The areas for general use, shipping and commercial fishing (Ö258 and Ö259) and the alternative energy area (Ö256) between Hanö Bay and the Midsea banks have mainly been proposed as areas with particular consideration of high nature values with regard to the Baltic Sea population of harbour porpoise.

The Southern Midsea bank (Ö248) is an area with particular consideration of high nature values in the established marine spatial plan, but is also proposed as a Natura 2000 area according to the Birds Directive pointed out for sea birds, long-tailed duck and guillemots. Several areas around Gotland are included in the proposal for new Natura 2000 areas according to the Birds Directive. West of Gotland, this applies to parts of the areas Ö291 and Ö500 around Stora Karlsö. East of Gotland, it applies to the areas Ö500 and Ö296 along the east coast.

Proposed new areas with particular consideration of high nature values for birds are alternative energy area Ö277 and the area Ö291 with general use and shipping north and west of the Karlsöarna. North-west of Gotska sandön, there is an area with the use defence (Ö505) and one with general use (Ö506) supplemented as areas with particular consideration of high nature

values with a focus on birds, and east of Muskö, an area with general use (Ö507) is proposed to be an area with particular consideration of high nature values.

The application of particular consideration of high nature values is considered to be relevant in the establishment of offshore wind energy, but also as guidance for other uses, such as commercial fishing and shipping. In practice, it can contribute to better conditions for the preservation of biodiversity and green infrastructure as a base for developed ecosystem services. Figure 19 shows the areas with the use nature and particular consideration of high nature values in the Baltic Sea marine spatial planning area.

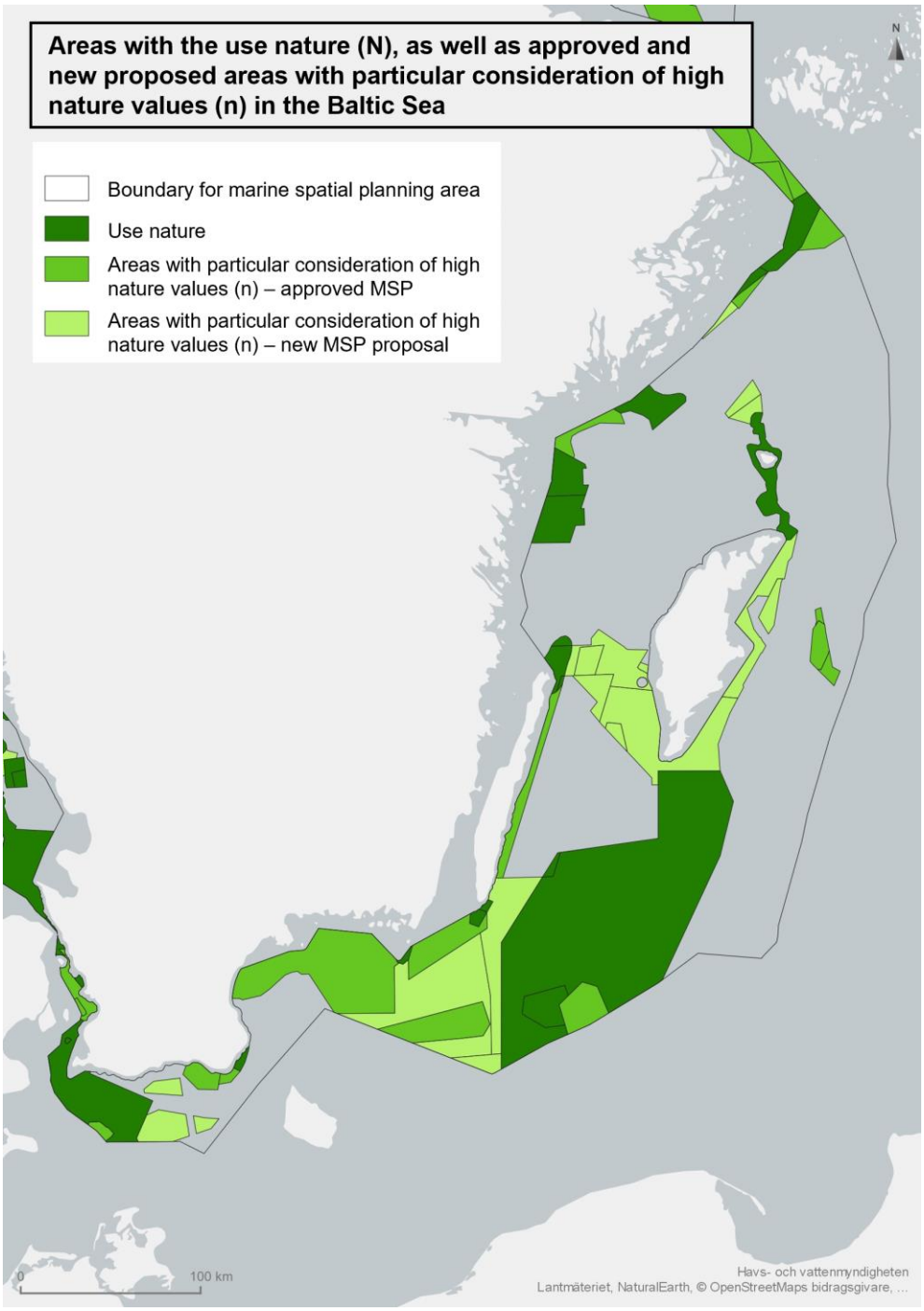


Figure 19. Areas with the use nature (N), as well as approved and new proposed areas with particular consideration of high nature values (n) in the Baltic Sea.

3.2. Assessment of economic effects

Effects on sectors

3.2.1.1. Commercial fishing

3.2.1. Commercial fishing in the Baltic Sea is considered to be able to be negatively impacted by the proposed development of offshore wind energy. All 23 energy areas in the amended marine spatial plan proposal are at risk of affecting fishing's operations and profitability. Of these 23 areas, 17 are so-called alternative energy areas.

The total annual loss in landing value of Swedish commercial fishing in the Baltic Sea is estimated to just under SEK 8 million as a result of wind power establishment in the proposed energy areas. This figure is equivalent to around 1.24 per cent of the total annual landing value for Swedish commercial fishing in Swedish waters, which is shown in Table 3. The estimated loss in the 17 alternative energy areas accounts for around 85 per cent of the total decrease in landing value.

The largest potential losses are measured in the energy areas Ö205, Ö219 and Ö266, which in total amount to just under SEK 4.3 million in estimated losses in the pelagic trawl fishery. This figure is equivalent to around 1.5 per cent of the annual landing value for the Swedish mid-water trawler fishing for pelagic species in Swedish seas. The estimated losses in bottom trawler fishing for pelagic species are at a maximum of around SEK 3,600 per area, in a total of eight areas, and the effect is therefore considered to be negligible. The collective loss for the bottom trawl fishery targeting cod and other demersal species is estimated to be more than SEK 685 thousand per year, out of which nearly half relates to the fishing conducted in the alternative energy area Ö286 south of Skåne. However, this fishing has been severely limited since 2019 after years of deteriorating stocks, which has led to significantly lower landing values in recent years.

	Plan alternative 1: proposed energy areas	**Plan alternative 2: proposed and alternative energy areas**
Loss of annual landing value (SEK)	1,195,431	7,983,940
Share of the annual landing value (percentage)	0.19	1.24

Table 3. Estimated loss of landing value in commercial fishing as a result of proposed energy extraction in the Baltic Sea.

As in other offshore areas, in addition to Swedish fishing, extensive foreign fishing is taking place in Swedish waters in the Baltic Sea. The total potential losses including all the fish are therefore considered to possibly be significantly larger than indicated in Table 3, under the assumption that foreign fleets fish in the same areas as the Swedish fleet.

Figure 20 uses colour coding to show the size of the estimated effect of the proposed energy extraction areas on the landing value from Swedish fishing in the Baltic Sea. Appendix A shows maps of estimated landing values and loss in landing value within proposed and alternative energy areas in the marine spatial planning areas.

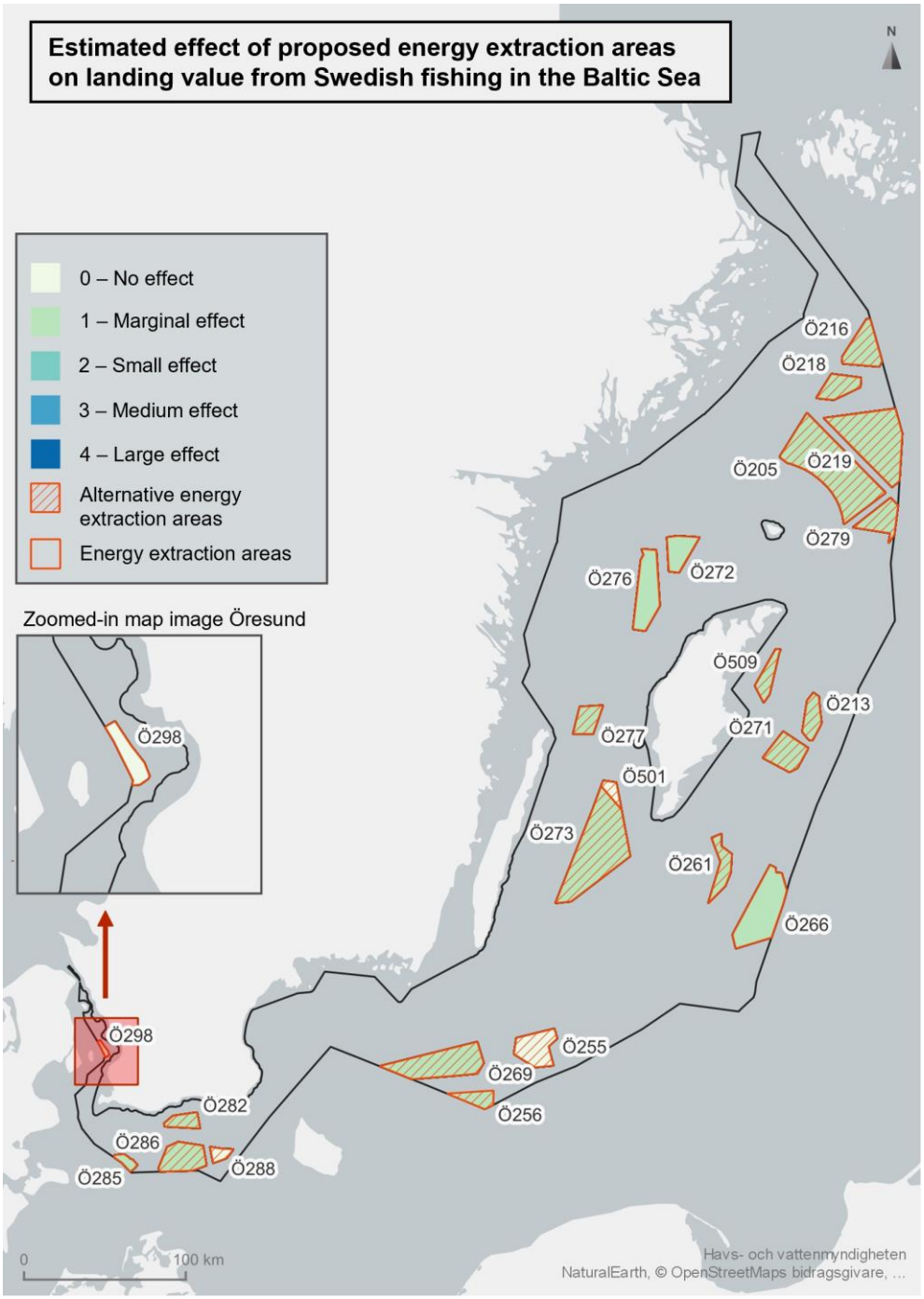


Figure 20. Estimated effect of planned energy extraction areas on landing value from Swedish fishing in the Baltic Sea. Dark colour shows a large effect and light colour shows a small effect.

3.2.1.2. Energy extraction

In the Baltic Sea marine spatial planning area, there are several areas with high average wind speeds and a favourable distance to the mainland. Compared with the other two marine spatial planning areas, the two largest energy areas in terms of size are here, namely Ö205 northeast of Gotska Sandön and Ö273 between Öland and Gotland's southern tip. Considering the entire marine spatial planning area, alternative energy areas have the potential to produce over four times as much electricity as the proposed energy areas, which is why the economic potential is much greater for plan alternative 2 than plan alternative 1 (Table 4).

Four alternative energy areas – Ö273, Ö205, Ö255 and Ö286 – are considered to have large or medium-sized economic potential according to the chosen assessment method. The first two are located at a greater depth and are entirely or partly suitable for floating foundations.

The six areas with the lowest estimated economic potential belong to all the first quartile in terms of electricity generation potential and are all located in areas that are unsuitable for bottom-fixed foundations. The wind conditions are good, although not the best. Within four of these six areas, projects had begun consultation procedures by January 2023; however, no project had submitted a permit application.

Table 4 compares the collective area and estimated annual electricity production from the energy extraction areas included in plan alternatives 1 and 2. Figure 21 uses colour coding to show the size of the estimated relative economic potential of the proposed energy extraction areas in the Baltic Sea marine spatial planning area.

	Plan alternative 1: proposed energy areas	**Plan alternative 2: proposed and alternative energy areas**
Surface area (km^2)	1,633	9,362
Estimated annual production (GWh)	32,652	184,244

Table 4. Surface area and estimated annual electricity production in plan alternatives 1 and 2 in the Baltic Sea marine spatial plan.

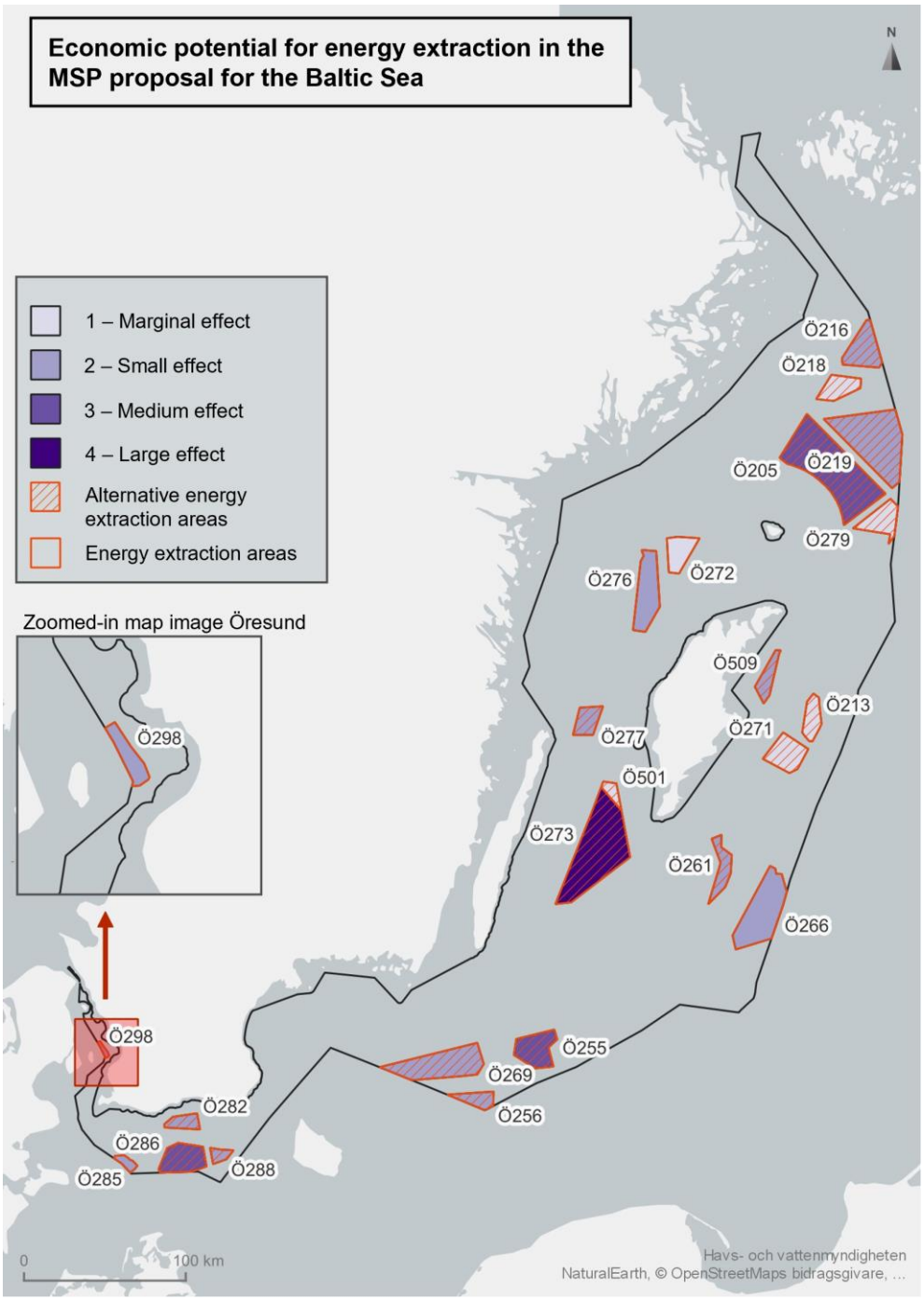


Figure 21. Economic potential for energy extraction in the marine spatial plan proposal for the Baltic Sea. Dark colour shows large potential and light colour shows small potential.

3.2.1.3. Shipping

Shipping is considered to be able to coexist with energy areas for wind farms provided that the right conditions are offered and that the safety of shipping is taken into account. This means that consideration must be given to safety distances so that maritime safety and national and international rules at sea can be complied with.

In the marine spatial plan proposal for the Baltic Sea, there are six proposed energy areas, and a further 17 alternative energy areas. Consideration of safety distances in plan proposals varies between the different energy areas. Out of all 23 energy areas, four proposed energy areas and 10 alternative energy areas are considered to have a medium to large effect on shipping. In the Northern Baltic Sea and South Kvarken, there are three energy areas (Ö205, Ö219, Ö279) that are considered to have a medium and large potential impact, regarding safety distances in the exclusive economic zone and to neighbouring countries. In the South-western Baltic Sea and Öresund, alternative energy areas (mainly Ö286, Ö288) are considered to have a major potential impact and effect on conditions for shipping. For coexistence, location-specific safety distances are required to be included in the permit process. This also applies to the energy area Ö298, which is located adjacent to a shipping lane with extensive shipping, both national and international.

In the planning area, there are also investigation areas for shipping at Hoburgs bank, the Midsea banks and Salvorev. The investigation alternative is described in the approved marine spatial plan with an environmental impact assessment and sustainability assessment (SwAM, 2019a; 2019b), and includes a rerouting of shipping away from sensitive nature areas to protect birds and marine mammals. An extended travel distance entails increased fuel consumption and increased emissions of airborne pollutants and greenhouse gases. The effect in the long term depends on the development of fuels in shipping.

Figure 22 uses colour coding to show the potential negative effect that energy areas can have on shipping in the Baltic Sea marine spatial planning area.

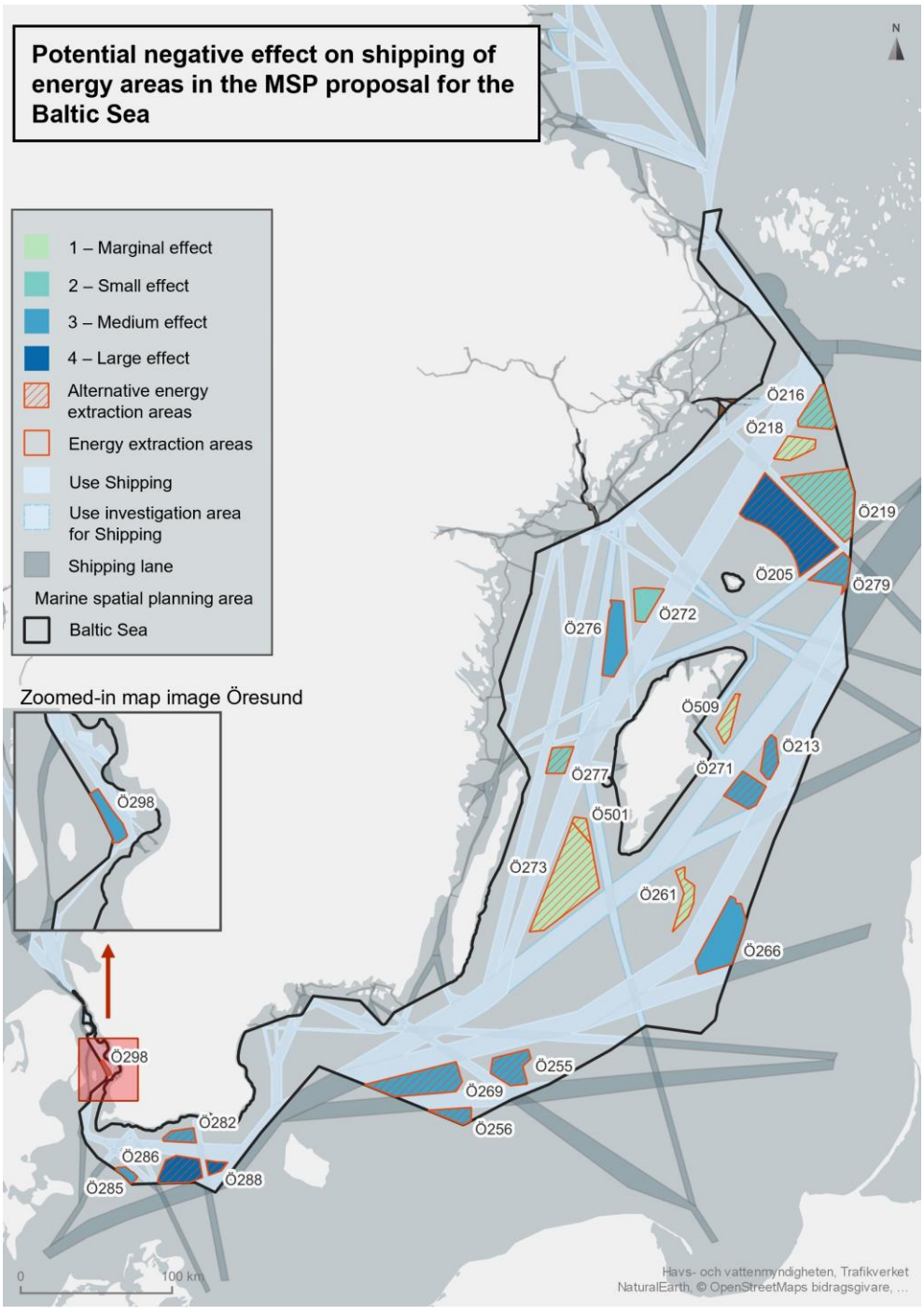


Figure 22. Potential negative effect on shipping of energy areas in the marine spatial plan proposal for the Baltic Sea. Dark colour shows a large effect and light colour shows a small effect.

3.3. Assessment of social effects

Population and health

The assessment of effects on human health from wind power establishment in the energy areas in the Baltic Sea marine spatial planning area is similar to that for the Gulf of Bothnia in section 2.3.1. Only the proposed energy area Ö298 in Öresund is closer to the coast than five kilometres and is considered to be able to cause noise and light disturbances for the population in densely
3.3.1 populated areas in south-western Skåne and the northern Copenhagen area on the Danish side of Öresund. The Malmö-Copenhagen region is, however, a strongly urbanised and to some extent industrialised area, and possible noise or light disturbances from the wind power establishment in Ö298 are added in areas with already relatively high background disturbances. However, the high population density in the region justifies greater caution and precision in the investigation of health effects from noise and light disturbances.

As for the other two marine areas, this marine spatial plan proposal does not change the guidance on other uses that is in the approved marine spatial plan from 2022. The previous sustainability assessment assesses the risk of health effects from the guidance on shipping as insignificant considering negligible changes in emissions of airborne pollutants (SwAM, 2019b). Sand extraction activities at Utklippan, Sandhammar bank and Sandflyttan according to the marine spatial plan's guidance on sand extraction are considered to have a marginal negative impact on air quality locally (SwAM, 2019a), but without a more detailed estimate of air emissions, it is not possible to assess possible risks to human health. Wind power establishment in the proposed energy area Ö298 might, however, entail an elevated risk to navigational safety and thereby indirectly human health. Within the scope of the assignment to prepare proposals on suitable energy extraction areas for the marine spatial plans (Swedish Energy Agency, 2023a), the Swedish Maritime Administration points out in its assessment of the area that consideration to safety distances is lacking and that placement of wind power stations needs to be adapted to
3.3.2. shipping. In this work, the health risks should be carefully investigated.

Effects on cultural environment

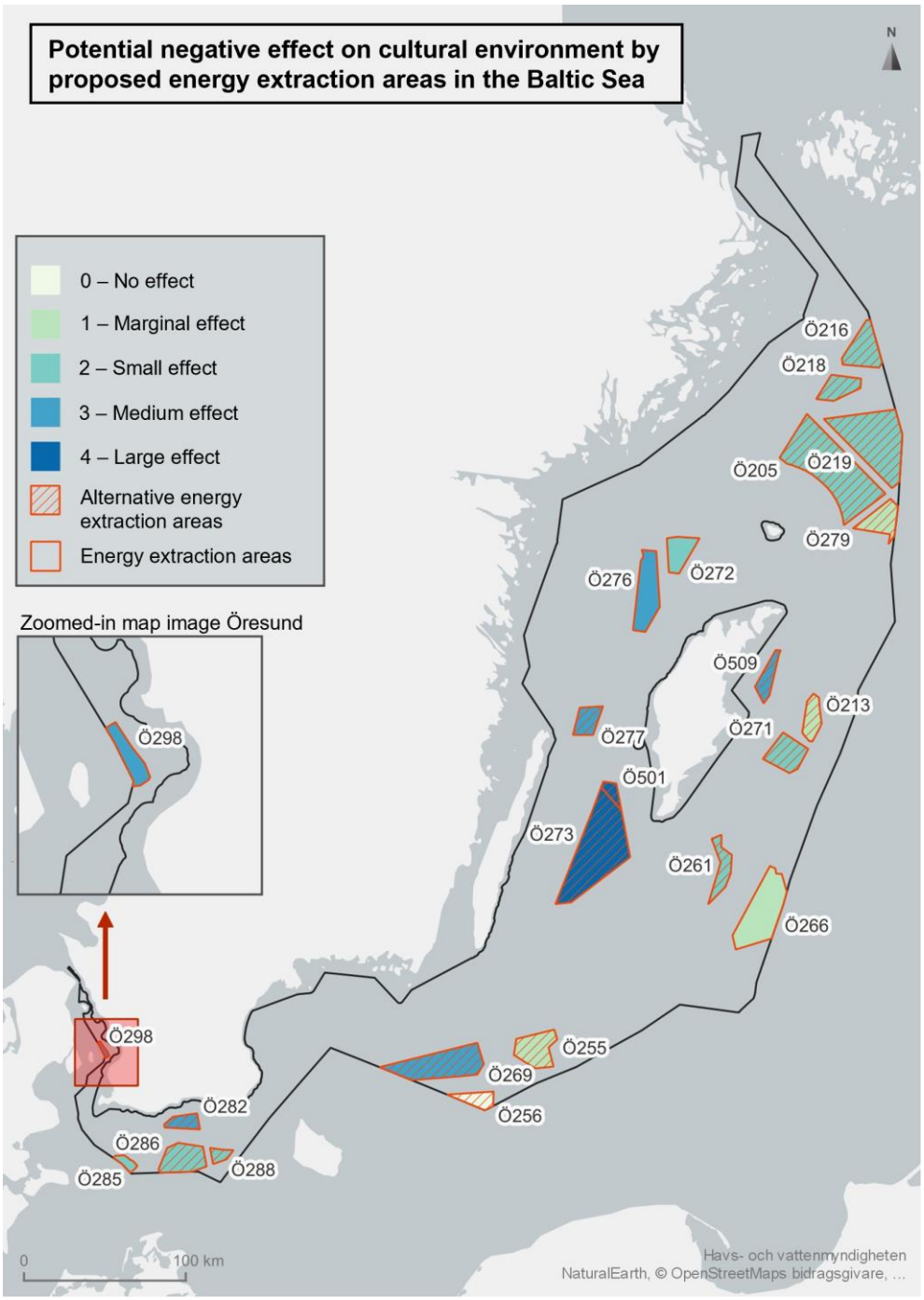
In the Baltic Sea marine spatial planning area, there are the only two energy areas where there is considered to be a risk of a large negative effect on the cultural environment, namely the alternative energy extraction areas Ö273 and Ö501 that together occupy a large marine area between Öland and Gotland's south-western tip. The areas are relatively close to both of the islands' coasts and are considered to be able to indirectly affect the World Heritage sites of the Hanseatic Town of Visby and Southern Öland's agricultural landscape.

In six other areas, there is a risk of a moderate negative effect on cultural environment. Out of these, four – Ö277 northeast of Öland, Ö282 south of Skåne, Ö298 in Öresund and Ö509 east of Gotland – are located within the territorial sea's boundary, i.e. relatively close to the coast, which is why dominance or competition with cultural heritage values on land is considered to possibly arise. The other two areas – Ö269 south of Blekinge and Öland, and Ö276 north-west of Gotland – are considered to be able to indirectly affect the World Heritage sites of the Naval Port of Karlskrona and the Agricultural Landscape of Southern Öland, and the Hanseatic Town of Visby, respectively. This indirect impact means that the collective effect is greater, even though the areas are at a greater distance to the coast.

Another four energy areas are considered to entail a risk of a small negative effect on cultural environment, while area Ö256, which is a relatively small energy area just over 80 kilometres south of Öland's southern tip, is considered to have no effect at all.

Energy areas Ö298 in Öresund and Ö288 south of Skåne might possibly also affect cultural environments on Zealand and Bornholm in Denmark, respectively.

Figure 23 uses colour coding to show the estimated effect of the planned energy areas on the cultural environment in the Baltic Sea marine spatial planning area. In contrast to the Gulf of Bothnia, where alternative energy areas tend to have a lower effect on cultural environments due to a greater average distance to the coast, there is no similar pattern between plan alternatives 1 and 2 in terms of the cultural environment effects in the Baltic Sea marine spatial planning area.



3.3.3 Figure 23. Potential negative effect on cultural environments of proposed energy extraction areas in the Baltic Sea. Dark colour shows a large effect and light colour shows a small effect.

Effects on recreation

The plan proposal's provides guidance on the use recreation in nine areas in the Baltic Sea. The proposed areas are based on existing national interests for outdoor recreation.

In the marine spatial plan proposal for the Baltic Sea, there are six proposed energy areas, and a further 17 alternative energy areas. In the marine area of the North Baltic Sea and South

Kvarken, there are a number of alternative energy areas (Ö216, Ö218, Ö219, Ö205, Ö279). Energy area Ö205, closest to Gotska Sandön, has been adapted with consideration of national interests in outdoor recreation and the distance according to the plan proposal is around 35 km. According to the previous assessment, it is noted, however, that Gotska Sandön is also pointed out as a national park. Gotska Sandön has documented high values and a distinctive character in that it is isolated and undisturbed. The values in the national interest descriptions that can be affected by wind power are silence and tranquillity. The impact is being investigated more closely by a project engineer in an on-going consultation on wind power. Energy area Ö272, between the mainland and Gotland, around 30 km from Gotska Sandön is considered to possibly have a negative impact and needs to be investigated more closely (Swedish Energy Agency, 2023a).

Figure 24 shows an approximation of the distance from proposed and alternative energy areas in the Baltic Sea to land. The figure does not take into account terrain or vegetation on the coast, which has a large effect on visual impact on various areas on land.

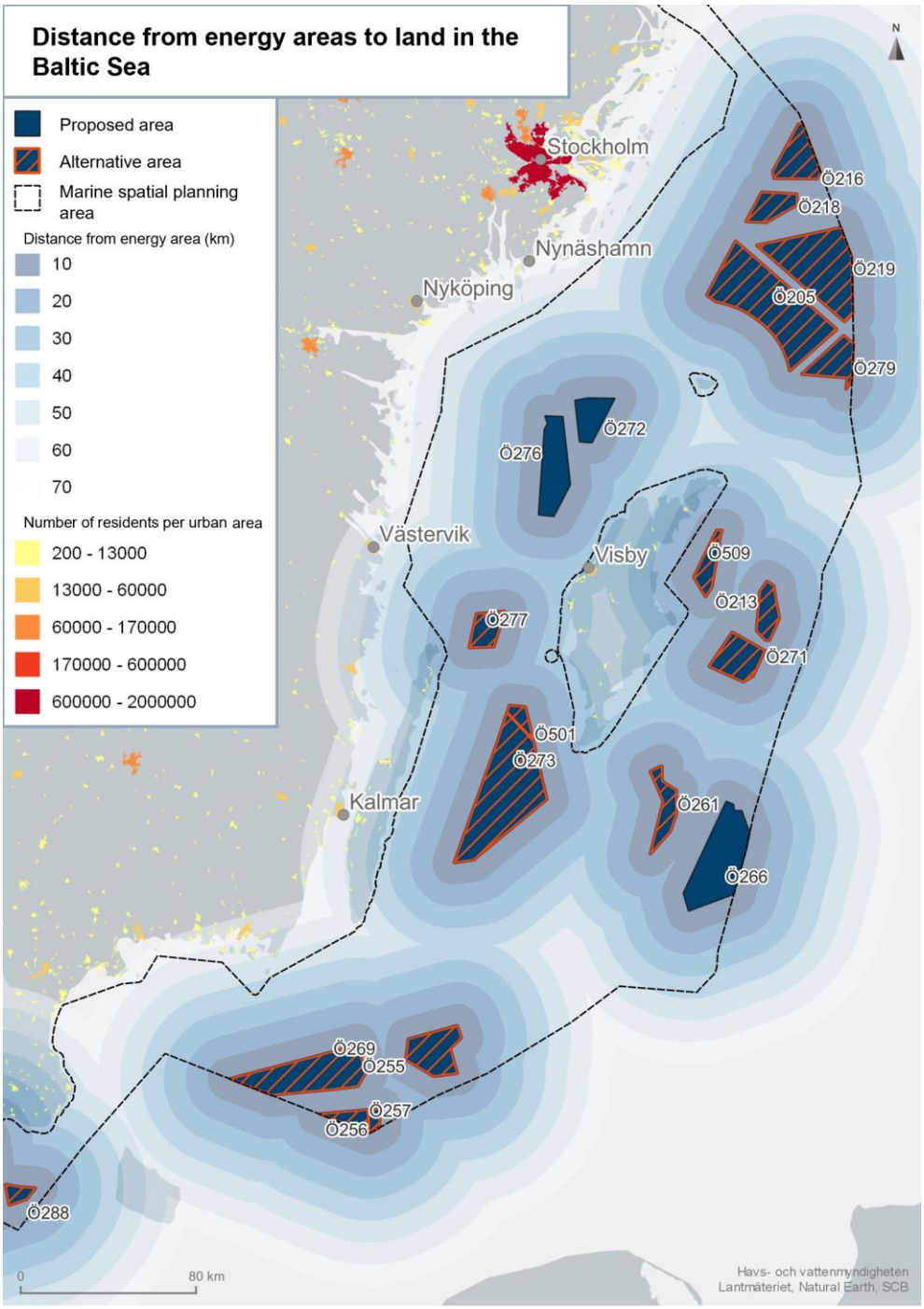


Figure 24. Map of the energy areas' distance to land and population in urban areas on land for the North Baltic Sea.

East of Gotland, there is the alternative energy area Ö509 around 15 km from the coast with a potential negative impact on the outdoor recreation area of the coast and archipelago of north-eastern Gotland, the Gotland coast including Fårö; the values that can be affected by wind power are silence, tranquillity and untouched environments.

Energy area Ö276 between Gotland and the mainland is around 25 km from Gotland's east coast where there are national interest claims for outdoor recreation, the Gotland coast and Gotland.

The area’s shape is considered to be relatively favourable as the impact on the experiential values for outdoor recreation decreases with the distance.

The alternative energy area Ö277, located around 13 km from Öland’s coast, can affect the national interest area of the coasts of Northern Öland. Activities according to the value description are hiking, mountain biking and horseback riding. North of Gotland, there are the alternative areas Ö273, Ö261 and Ö501, which are closest to the Gotland coast, which within a radius of around 20 and 30 km, respectively, are considered to possibly affect the national interest area Storsudret, the Gotland coast and the Karlsöarna. The values that can be affected by wind power are silence, tranquillity, natural and cultural experiences, outlooks towards the sea.

In the South-western Baltic Sea and Öresund, there is the alternative energy area Ö282, around 8 km from the coast and the national interest claim of the coastal route Trelleborg - Abbekås - Sandhammaren - Mälarhusen - Simrishamn. The area is pointed out in the proposal on Skåne’s recreation plan as a nationally important area. The values indicated for the areas are: attractive landscape appearance, good conditions for activities, including paragliding. The values are considered to be largely tied to the coastal zone. The alternative energy areas Ö286 and Ö288, further out to sea, around 30 km from the coast, are considered to have the same potential negative impact on the national interest, but it decreases with distance.

In Öresund off of Malmö and Lomma, the energy area Ö298 around 5 km from land is proposed. The area is considered to potentially affect land-based national interest areas, such as Kävlingeån from Vombsjön to Bjärred and Höje å (Swedish Energy Agency 2023a).

Figure 25 shows an approximation of the distance from proposed and alternative energy areas in the South Baltic Sea to land. The figure does not take into account terrain or vegetation on the coast, which has a large effect on visual impact on various areas on land.

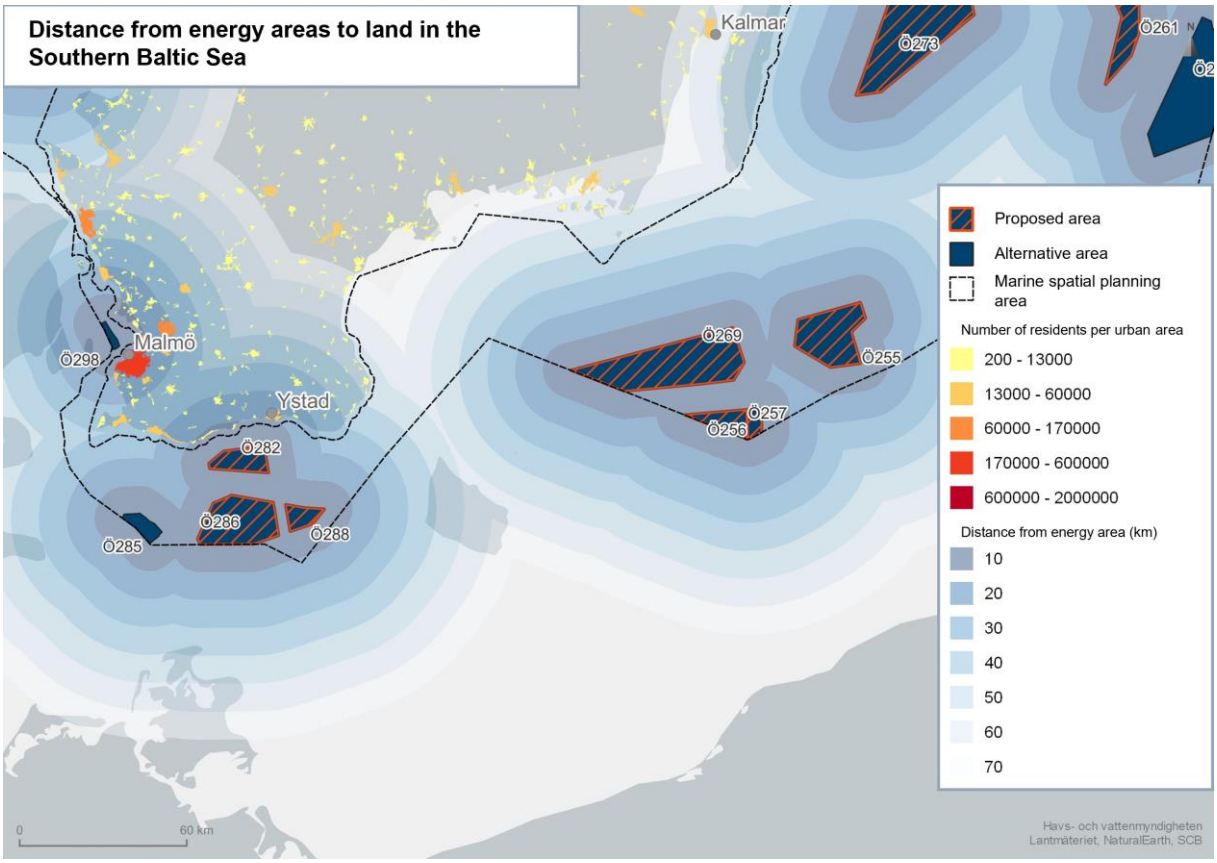


Figure 25. Map of the energy areas' distance to land and population in urban areas on land for the South Baltic Sea.

3.4. Overall assessment for the Baltic Sea

This section compiles the effects that the proposed amended marine spatial plan for the Baltic Sea is considered to be able to give rise to. The starting point for the compilation is the guidance on various uses in the marine spatial plan proposal.

The marine spatial plan provides guidance on sand extraction at Utklippan, Sandhammar and Sandflyttan. In all three places, sand extraction activities are considered to possibly entail locally large effects on benthic environments and partly also water quality. However, the effects are geographically and time-limited, and thereby marginal in relation to the entire marine spatial planning area. Possible future extraction activities should be adapted to the spawning and nursery period for cod and flatfish in the areas. The extraction operations and transportation to and from the coast can lead to higher emissions of air pollution, and thereby a small deterioration of air quality locally.

Changed travel distance for shipping at Hoburgs bank and the Midsea banks in line with the marine spatial plan's guidance on the investigation area for shipping is considered to be able to benefit the marine environment through reduced noise disturbance and reduced emissions of pollutants. This potential positive effect is especially important for birds and marine mammals that are present in the offshore bank area, such as the long-tailed duck and the Baltic Sea harbour porpoise. Changed travel distance also entails increased emissions of airborne pollutants and

greenhouse gases as a result of increased fuel consumption. Effect in the long term also depends on the development of fuels in shipping.

Offshore wind energy establishment according to the guidance on energy extraction is considered to entail a risk of negative effects on migratory birds and breeding, resting and wintering birds. The risk is greatest mainly in several alternative areas located in the middle of narrow passages across the sea, so-called bottlenecks, or in the broad migration corridor across parts of the South and Central Baltic Sea. Energy areas closer to the coast and adjacent to the offshore banks also constitute a risk to breeding, resting and wintering birds. Possible barrier effects need to be investigated, especially upon expansion in several areas. Proposals on expanded areas with particular consideration of high nature values with a focus on sea birds can provide some protection in the form of requirements on precautionary measures in the permit review of wind power projects in these areas. Several of these n-areas concern increased protection of migratory birds along the migration route.

Wind power establishment entails changes to the seabed, but the effect is considered to be negligible in terms of the share of seabed area that can be affected. The effect can in some areas be positive in the form of expanded hard bottom substrate, which can benefit some marine species. However, a risk of damage to protected nature types can occur, which is why local conditions and effects always need to be investigated.

Disturbance of marine mammals is considered to be able to occur mainly in connection with the construction of offshore wind energy. The risk is especially large in the Baltic Sea harbour porpoise's range in the South-eastern and Central Baltic Sea, given the population's status as critically endangered. Negative impact should be possible to minimise to acceptable levels with the help of noise reducing measures and by avoiding disturbance during sensitive reproduction periods. Closer to the coast, similar consideration needs to be given to potential effects on harbour seals and grey seals. The long-term effects during the operating phase are insufficiently studied.

Sediment dispersion in connection with the construction or decommissioning of offshore wind energy is considered to be able to negatively affect spawning fish. However, the risk should be possible to reduce to acceptable levels through adaptation of the timing of construction and decommissioning to the spawning period for cod, flatfish and herring, among other things. The fish resource can potentially benefit from reduced fishing pressure in energy extraction areas, but the magnitude of a possible positive effect cannot be determined today. Increased shipping traffic in connection with construction, service and maintenance and decommissioning of wind farms can lead to higher emissions of airborne pollutants and greenhouse gases, the magnitude of the effect is not possible to estimate. At the same time, the guidance on energy extraction is considered to possibly entail positive effects on the climate by enabling increased production of fossil-free electricity. The alternative energy areas in particular have great potential in this regard.

Other uses of the Baltic Sea marine spatial planning area also risk impact from wind power establishment. Navigational safety can be negatively affected in over half of the energy areas, which coincide with safety distances to shipping lanes, several of which are of international significance. Reduced safety distances constitute a navigational risk with potential negative consequences for the environment and human health. Safety distances and the actual area

available for wind power in the energy areas should be illustrated in a consistent way in the continued planning.

The losses for commercial fishing are small in terms of the landing value in the entire country, and mainly affect the pelagic trawl fishery in the central Baltic Sea. The largest loss is estimated in alternative energy areas, which is partly due to the fact that there are more of them and they are on average larger. Even if the total loss in landing value does not exceed around 1.24%, the impact can be significant from a local and regional perspective.

Negative effects on cultural environments and recreation are considered to be able to arise as a result of visual impact from offshore wind farms. Several of the energy areas are proposed relatively close to the coast, in some cases within visual range for especially valuable cultural and recreation environments. A large impact is mainly considered to possibly arise in the areas that are on Gotland and Öland, and south of Skåne, where the risk of cumulative effect from establishment in several energy areas is extensive. The impact and need for adaptation to promote coexistence need to be assessed from a regional and local perspective. Facts on the effects of wind power on the cultural environment and recreation need to be supplemented, such as regarding significance to regional development, and possible economic consequences for the tourism industry, for example.

In the amended marine spatial plan proposal, the number of new areas with particular consideration of high nature values is large. The primary objective is to strengthen consideration of migratory birds along migratory corridors, but also of the Baltic Sea harbour porpoise in areas between Hanö Bay and the Midsea banks. Greater consideration of these nature values should be taken in the planning and regulation of all human activities, which is considered to contribute to a more sustainable use in the Baltic Sea. The marine spatial plan proposal's guidance on other uses entails no changes compared with how and where the respective activities are conducted today, and is therefore not considered to entail any specific environmental effects.

Most of the environmental effects are considered to be cross-border and affect all Baltic Sea countries. Bird, fish and mammal species that can be affected by uses that the marine spatial plan controls in many cases move across larger parts of the Baltic Sea. The migratory bird paths through Swedish waters are used by populations that migrate far beyond Scandinavia, and are thereby of global significance. In terms of the effects on shipping and fishing, foreign vessels and fishermen are affected to at least the same extent as Swedish vessels and fishermen. Visual impact on cultural environments and recreation from wind power in the Öresund area and near Bornholm can affect values in Denmark, which should be taken into account in possible future development. At the same time, other countries can also benefit from the potential positive effects of wind power in the form of expanded production of fossil-free electricity.

Plan alternative 2, consisting of both proposed and alternative energy areas, has significantly greater effects in the Baltic Sea marine spatial planning area than plan alternative 1, which only contains proposed energy areas. This is largely explained by the alternative energy areas being greater in number and on average larger than the proposed energy areas. The latter, however, only enable one-fifth of the electricity production in alternative energy areas, which impedes fulfilment of Sweden's climate and energy policy objectives. In the continued planning, the risk of cumulative effects should be taken into account, especially in areas with a large concentration of energy areas and where there are high nature values of regional or global significance.

4. Impact assessment of the marine spatial plan for Skagerrak and Kattegat

4.1. Assessment of environmental effects

Effects on protected animal and plant species and biodiversity

4.1.1.1. Birds

4.1.1. Similar to the other two marine spatial plan proposals, the guidance on energy extraction in the marine spatial plan for Skagerrak and Kattegat stands alone for the increased risk of negative impact on birds. Even if there are other uses that today cause mortality and habitat loss among sea birds, the marine spatial plan's proposed guidance entails no changes in these other uses that impact the negative effects on birds.

Over the Skagerrak and Kattegat marine spatial planning area, there are two main bird migration routes: in Skagerrak, there is a route in a south-westerly-north-easterly direction between Skagen in Denmark to the archipelago area between Tjörn in the south and Smögen in the north. In Kattegat, another south-westerly-north-easterly migration route extends from the Grenå area over Anholt in Danish waters to the Falkenberg-Varberg area. The proposed energy areas within these two migration routes – V357 and V359 in the north and V303, V305, V317 and V361 in the south – are considered to entail a risk of large or medium negative effect on migrating birds. V357 and V359 are at risk of affecting a bird migration corridor that is used during the spring migration by birds of prey, many of which are red listed. The Swedish Environmental Protection Agency makes an assessment that the risk of collisions, displacement and the barrier effect is high as the area is in the middle of a relatively narrow migration corridor (Swedish Energy Agency, 2023a). The passage is also used by bats. In connection with V359, V357 can also constitute a risk to bird species that move in a north-south direction between Skagerrak and Kattegat.

The migration corridor in the south is also important for birds of prey and bats, and an estimated three to four thousand birds of prey follow this route during the spring. It is mainly V303 that is at risk of negatively affecting the bird route, but also parts of V305, V317 and V361. There are also plans for additional wind farms in Danish waters that affect the same migration corridor, which is why there is a risk of significant cumulative impact. The energy areas closer to the coast – V305, V317, V363 and V364 – entail a certain risk of negative impact on species that fly along the coast and coastal-breeding species that forage in the sea. For these species, wind power establishment in these areas constitutes a possible barrier to the foraging areas further out to sea. V364 in the south is adjacent to the Natura 2000 area Nordvästra Skånes havsområde, which is pointed out for the protection of wintering ducks.

The area in Kattegat, which is delimited by Fladen in the north and Stora Middelgrund in the south and towards the coast, is of international significance for several sea birds, including guillemots, razorbills and black-legged kittiwakes. These species show different sensitivity to disturbance from offshore wind energy (Leemans & Collier, 2022). Even if each proposed energy extraction area only affects a small part of the entire area, there is a large risk that the different species' habitats are fragmented or parts thereof become inaccessible should all energy areas be

developed. The risk of cumulative effects is especially high in light of the relatively large number of wind farms that are also planned in Danish waters in Southern Kattegat, which is shown in Figure 26.

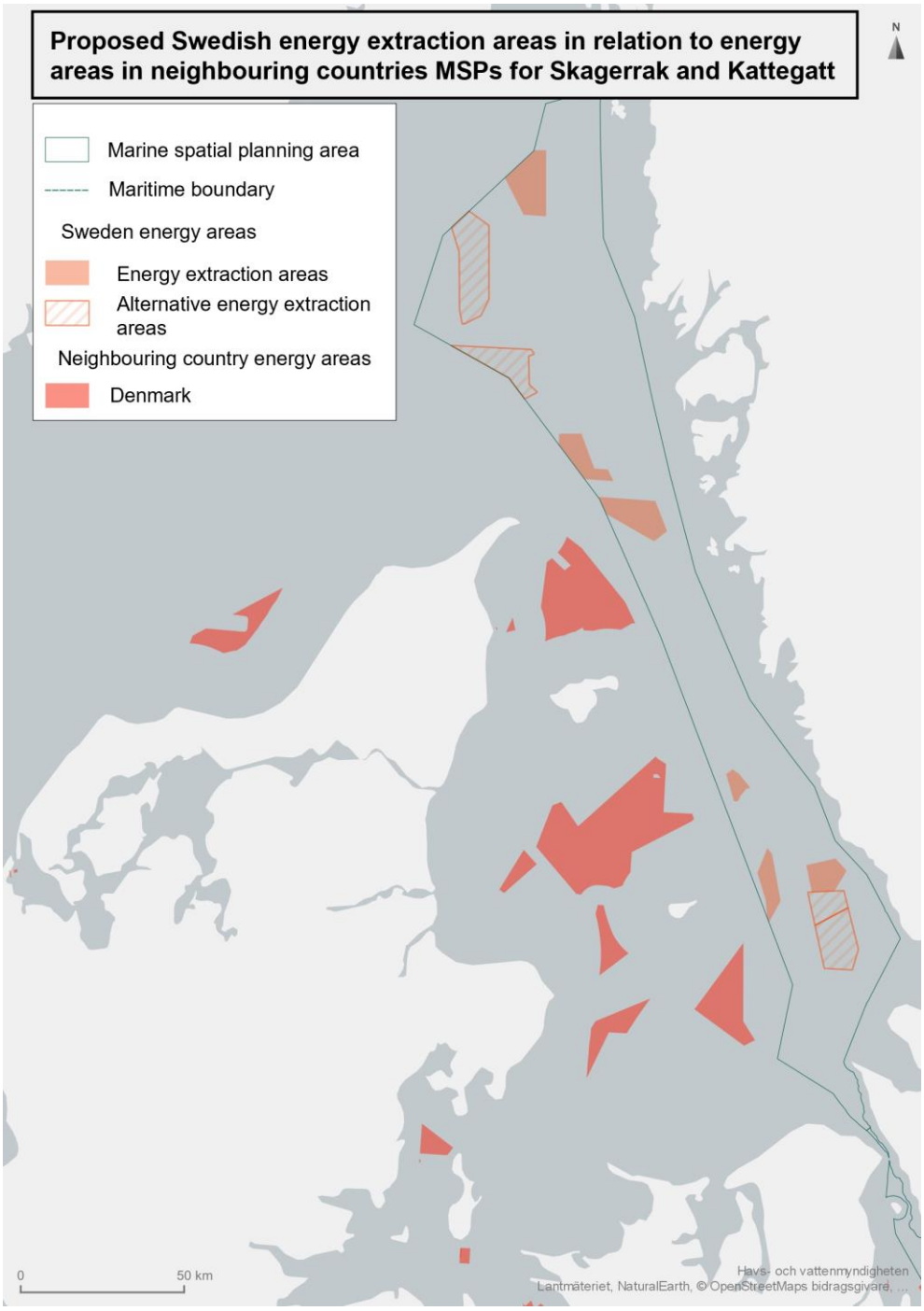


Figure 26. Map of planned or proposed energy extraction areas in Denmark and Sweden in Skagerrak and Kattegat.

Figure 27 and Figure 28 use colour coding to show the size of the estimated effect of the proposed energy areas on migratory birds and wintering birds in the Skagerrak and Kattegat marine spatial planning area.

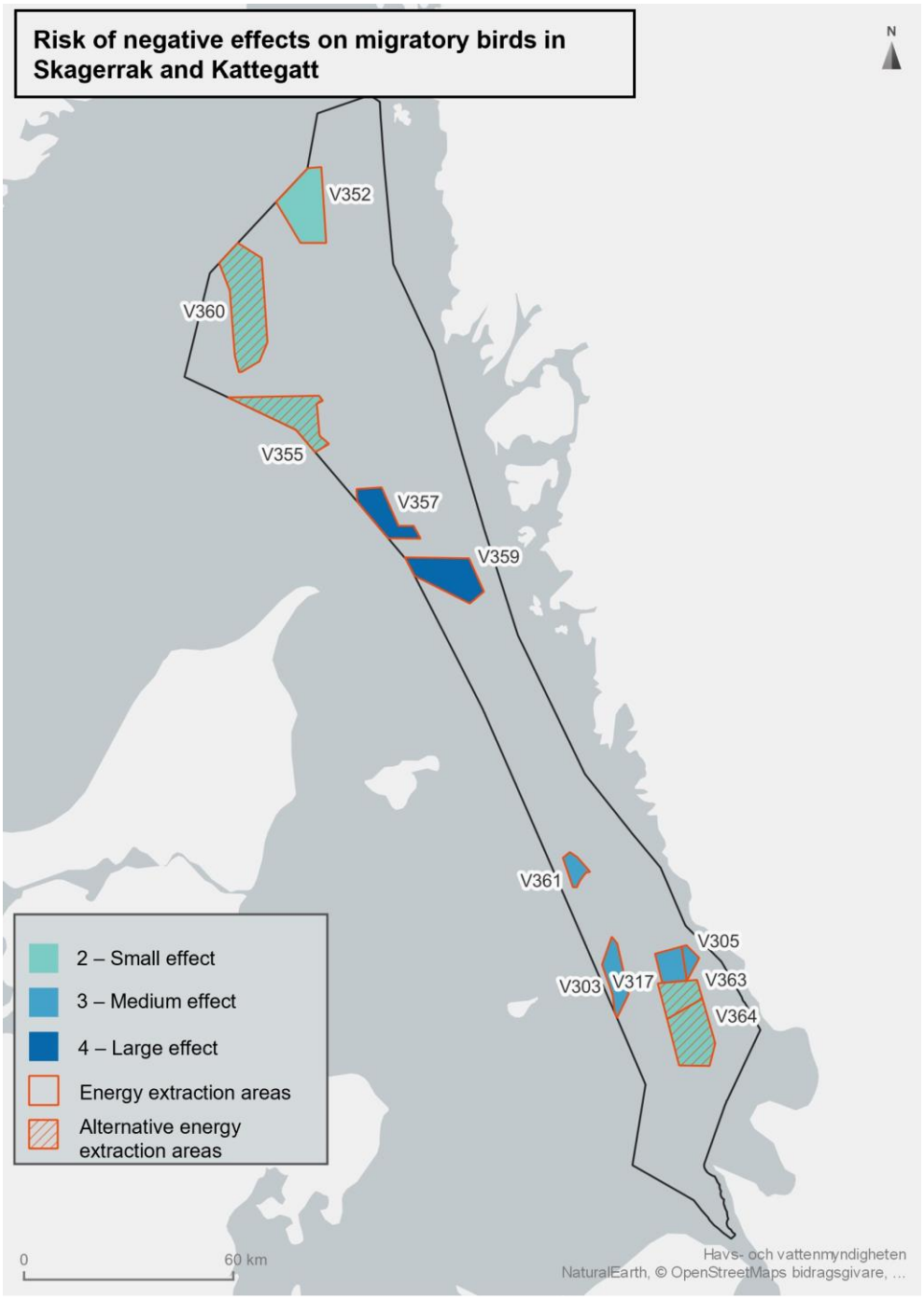


Figure 27. Risks of negative effects on migratory birds in Skagerrak and Kattegat. Dark colour shows a large effect and light colour shows a small effect.

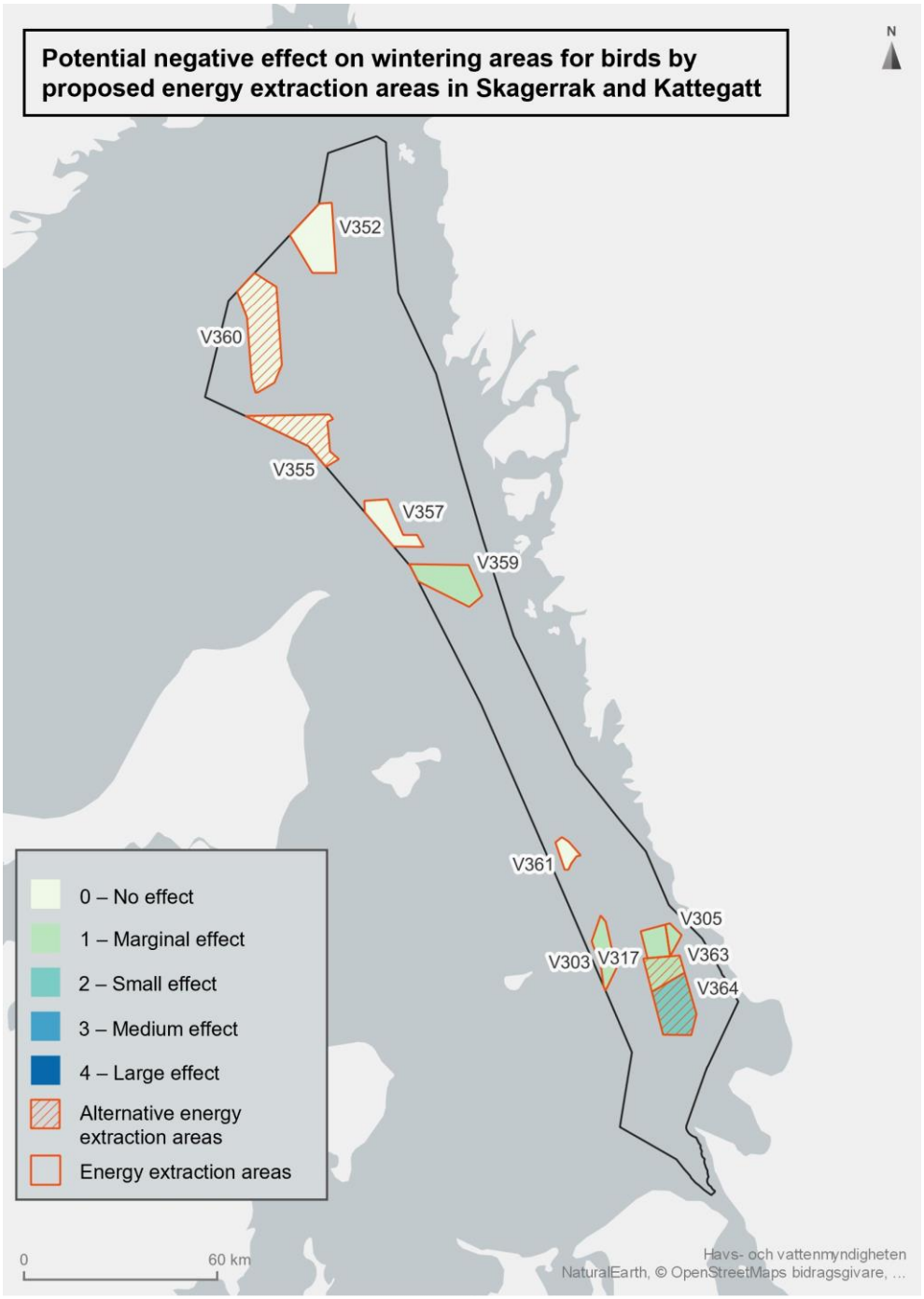


Figure 28. Potential negative effect on wintering areas for birds by proposed energy extraction areas in Skagerrak and Kattegat. Dark colour shows a large effect and light colour shows a small effect.

4.1.1.2. Marine mammals

In Skagerrak and Kattegat, there are harbour seals, harbour porpoises and, to a limited extent, grey seals.

Harbour seal

Harbour seals are close to the coast and rest on cobbles and skerries. The around 15,000 harbour seals that occur along the west coast down to Öresund belong to a population that is categorised as “least concern” in the Swedish red list (Swedish Species Information Centre, n.d.). The harbour seal is not as sensitive to impulsive underwater noise as the harbour porpoise. Effects from the construction phase are considered possible to minimise to negligible levels if mitigation measures corresponding to double bubble curtains are used during piling.

In Skagerrak and Kattegat, the assumption of reduced fishing in most energy areas entails a positive effect for harbour seals.

Harbour porpoise

In Skagerrak and Kattegat, there is the Skagerrak population of harbour porpoises that have one large and several small (but important) reproduction areas mainly in Skagerrak (Wijkmark, 2015). An area especially worthy of protection for this population is the area at Jutland’s northern tip, which is a part of a large reproduction area.

In Kattegat, Fladen and Lilla and Stora Middelgrund are the important areas for the harbour porpoise, which are mainly used by the Danish Straits population. Neither the population in Skagerrak nor the Danish Straits population are endangered today, they are classified as “least concern” in the Swedish list of species (Swedish Species Information Centre, etc.).

The proposed energy area V357 is considered to have a potential medium negative effect on harbour porpoises in the construction phase since the area overlaps with a porpoise-dense area that extends into the Danish waters.

The proposed energy areas V303 and V361 near Fladen and Lilla Middelgrund are also considered to have a potential medium negative effect on harbour porpoises in the construction phase. A somewhat smaller risk applies for the areas V317, V305, V363 and V364 in connection to Morups bank.

If consideration is taken to when in the season construction work takes place to avoid damage and if mitigation measures corresponding to double bubble curtains are used, the effects on porpoises are not considered to impact the populations negatively in Skagerrak and Kattegat.

In the same way as for harbour seals, energy areas that lead to reduced commercial fishing in Skagerrak and Kattegat can have positive effects on harbour porpoises through reduced risk of death through by-catch. The effect is dependent on the change in fishing efforts and is therefore uncertain.

Grey seal

A small number of grey seals are also found along the Swedish west coast.

The consideration that will be required to minimise disturbance of harbour porpoises in the construction of energy areas in Skagerrak and Kattegat will indirectly also mitigate negative effects on the grey seal.

4.1.1.3. Seabed environments

The seabed impact in energy areas depends on a number of factors, such as the type of turbine foundations and the degree of fishing with bottom contact that may be conducted in the area. Where floating foundations are likely, the assumption has been made that trawling will not be possible. In areas where the plants are expected to be bottom-fixed, an assumption of a 50% decrease in trawling has been made. No assumptions have been made regarding the relocation of fishing efforts. There is therefore uncertainty in the assessment results. In the assessment that is based on Symphony results, it is clear, however, that the positive value of the end of bottom trawling in part or whole may entail a greater positive effect than the negative impact of the installation of bottom-fixed foundations. The result is based on the construction of wind power foundations taking a limited area in use while bottom trawling affects a significantly larger area. Floating foundations are considered to have a less negative effect during construction than bottom-fixed foundations.

An additional dimension around the construction of bottom-fixed foundations is their potential reef effect that can be beneficial for biological diversity. However, some concerns exist regarding their potential to spread unwanted invasive species.

If consideration is taken to the occurrence of sensitive species and habitats in design and construction, negative effects on existing benthic environments are considered to be marginal for both bottom-fixed and floating facilities in Skagerrak and Kattegat. The difference in seabed impact for the various energy areas in Skagerrak and Kattegat mainly results from the degree of bottom trawling that is expected to decrease upon an energy establishment. The alternative energy area V355 is considered to have a potential for a large positive effect on mainly deep soft bottoms.

Wind power areas at sea can serve the function of recovery areas for the underwater marine environment, and during the operating phase, strengthen local green infrastructure and ecosystem services. This potential function is the largest for the energy areas in Skagerrak and somewhat smaller for the energy areas in Kattegat. Energy areas with this function could qualify as “*Other Effective Area-based Conservation Measures*” (OECM) if they meet the criteria set for such areas.

4.1.1.4. Fish and spawning areas

In the current proposal for a changed marine spatial plan for Skagerrak and Kattegat, it is mainly guidance on energy extraction that can entail a risk of impact on fish, especially by affecting fish spawning areas. Otherwise, establishment of offshore wind energy is not considered to pose a threat to fish species or fish populations, provided that local conditions are taken into account and adequate precautions are applied upon wind power establishment (see section 2.1.1.4).

In Skagerrak and Kattegat, there are vast fish spawning and nursery areas, which is why several of the proposed and alternative energy areas entail a risk of affecting spawning and nursery areas. More detailed assessments need to be made prior to possible future wind power establishment in these areas. Many species that are important to the ecosystem and commercial fishing spawn throughout Skagerrak, which means that consideration of spawning fish and shellfish must be taken in possible future development in the proposed energy areas V352, V357 and V359, and the alternative energy areas V355 and V360. The conditions differ between

different areas, which is why area-specific studies and adaptations are considered to be important (see Öhman, 2023).

In Kattegat, the proposed energy area V317 and parts of V305 overlap with an important spawning area for cod and fish habitats. The area is pointed out as a national interest claim based on its significance for cod spawning and nursery. Establishment of offshore wind energy in accordance with the plan proposal entails a large risk of impact, which requires extensive consideration and adaptation, especially during the construction phase. Figure 29 and Figure 30 show modelled spawning areas for 37 different fish species and cod in Skagerrak and Kattegat.

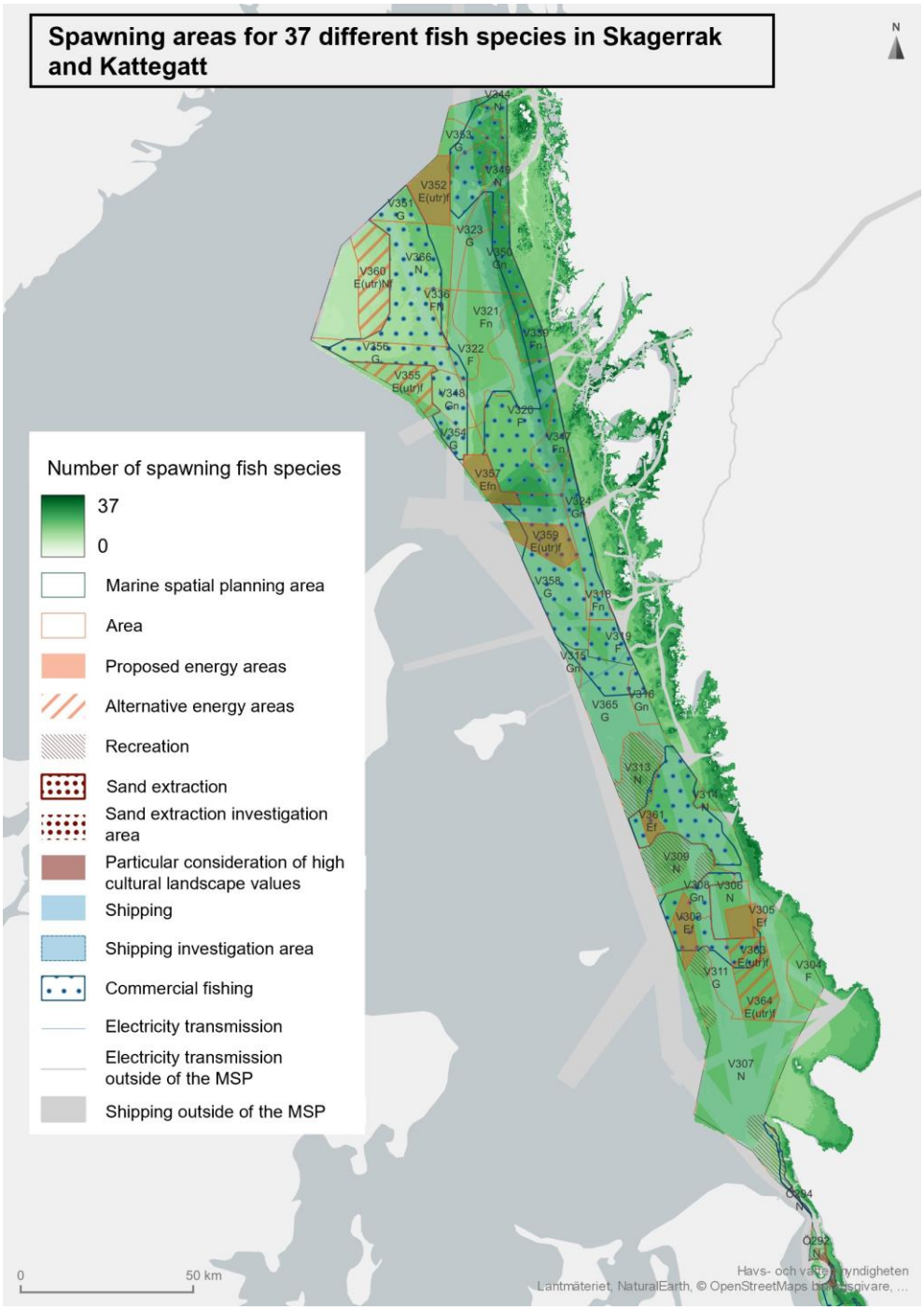


Figure 29. Spawning areas for 37 different fish species in Skagerrak and Kattegat. Spawning areas are shown with a green gradient. (Source: SLU Aqua).

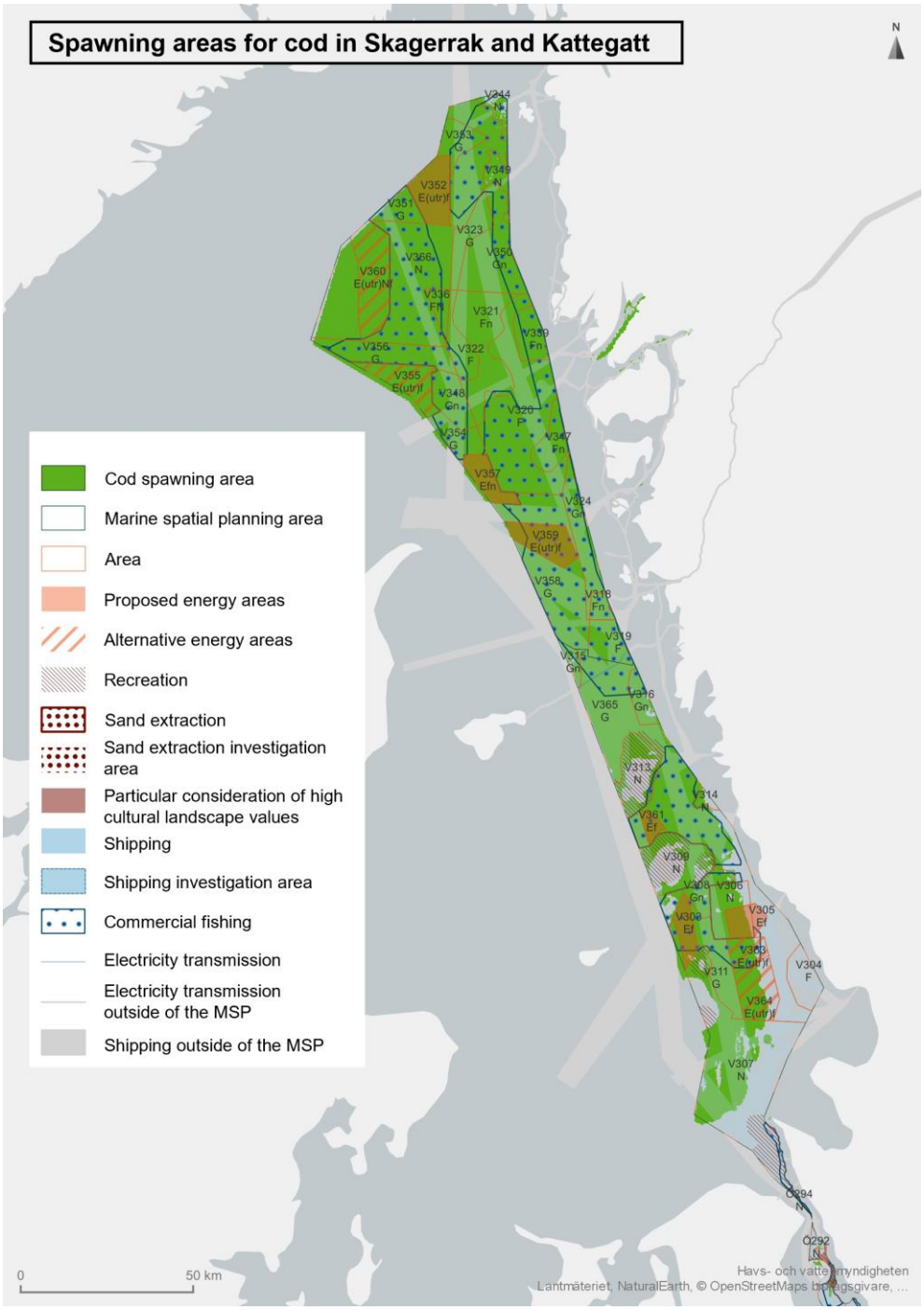


Figure 30. Spawning areas for cod in Skagerrak and Kattegat. Spawning areas are shown in green. (Source: SLU Aqua).

Similar to the other two marine spatial planning areas, a decrease in fishing activities is considered to possibly occur as a result of the establishment of offshore wind energy according to the plan proposal. The decrease could lead to reduced fishing pressure on the fish resource and benefit the its recovery. However, how fishing will be affected and adapted to possible wind power establishment cannot be predicted at present. It is therefore also not possible to assess how large such a positive effect could be. Similarly, the environmental impact assessment of the approved marine spatial plan highlights that the marine spatial plan's guidance on particular

consideration of high nature values can contribute to the introduction of regulations for a more considerate fishing, which is considered to have a small positive effect on the fish resource (SwAM, 2019a). For example, provisions may relate to adaptations for reduced by-catch or reduced impact on the seabed from bottom trawling. However, if and how such adaptations could be introduced and thereby also the potential positive effects on fish are currently impossible to predict.

Effects on water and air

In the marine spatial plan proposal for Skagerrak and Kattegat, it is only the guidance on energy extraction that is considered to possibly give rise to effects on water and air quality. The expansion of offshore wind energy according to the marine spatial plan's guidance on energy extraction is considered to possibly entail changes to where the fishing is conducted, which can lead to changes in travel distances, fuel consumption and air emissions from fishing vessels. However, it is not currently possible to predict the scope of this potential effect.

4.1.2.

Similar to the other two marine spatial planning areas, wind power establishment according to the guidance in the marine spatial plan proposal for Skagerrak and Kattegat is considered to possibly lead to increased shipping due to the construction and service of the wind farms. This is considered to possibly lead to higher air emissions, but it is not currently possible to estimate the magnitude of this potential effect without more detailed knowledge of the wind power activities in the proposed energy areas. Wind power establishment can also have effects on water quality through increased turbidity during construction and decommissioning. However, the effect is usually short-term and local, and thereby insignificant in terms of the marine spatial planning area as a whole and the estimated life expectancy of the wind farms. Effects on hydrographic conditions are also considered to possibly occur, both locally and at a regional level (Arneborg et al., 2023; see section 2.1.2). Based on current knowledge, it is, however, not possible to estimate the scope of such effects.

4.1.3.

Effects on climate

In terms of effects linked to climate, the Skagerrak and Kattegat marine spatial plan is considered to constitute a positive contribution, considering guidance on energy areas for offshore wind energy. Wind power as a renewable energy source during operation does not contribute to emissions of greenhouse gases and from a life cycle perspective low emissions of carbon dioxide (Swedish Energy Agency, 2023b). The potential for energy areas for fossil-free energy in the Skagerrak and Kattegat planning area is estimated to be an annual production of 13.6 TWh. Include alternative energy areas, the potential is estimated to total 27.9 TWh (see section 4.2.1.2). However, the real scope of effects on climate also depends on if and what energy sources are replaced or constitute an alternative energy base, whether these are fossil-based or not.

The proposed marine spatial plan and its guidance on energy extraction also affect other uses with potential effects on emissions of greenhouse gases, such as possible changes in travel distance for shipping and commercial fishing. In total, the plan is considered to contribute to national and international climate objectives and the transition to a fossil-free energy sector, which is significant based on scenarios for future energy and electricity needs, not least for the transition to a fossil-free industrial and transport sector (Swedish Energy Agency, 2023b).

Effects of proposals on the new areas with particular consideration of high nature values

In Skagerrak and Kattegat, there are proposals for supplementary areas with particular consideration of high nature values in an area for general use (V308). The area is proposed by the Swedish Environmental Protection Agency as a new Natura 2000 area under the Birds Directive. It also has valuable occurrences of bubbling reefs.

4.1.4.

A supplementation of the areas with particular consideration of high nature values is proposed in energy area V357, since it is located in a migratory bird route from Skagen to the Swedish west coast.

Proposals on the supplementation of areas with particular consideration of high nature values are also found in Northern Skagerrak within the protected area Bratten. The proposals are less extensive than those received from the County Administrative Board of Västra Götaland. SwAM has seen a value in prioritizing among the areas. Examples of areas that have not been included are the north and south of Bratten.

The areas with particular consideration of high nature values in Skagerrak and Kattegat complement the existing relatively extensive network of protected areas. The proposed new areas with the designation of lower-case n are considered to be able to provide guidance on particular consideration of sustainable use in the establishment of wind power and other uses, such as commercial fishing. Together with approved areas with particular consideration of high nature values, the proposals are considered to be able to contribute to a strengthened green infrastructure and ecosystem services and that conservation objectives for biological diversity are achieved. Figure 31 shows the areas with the use nature and particular consideration of high nature values in the Skagerrak and Kattegat marine spatial planning area.

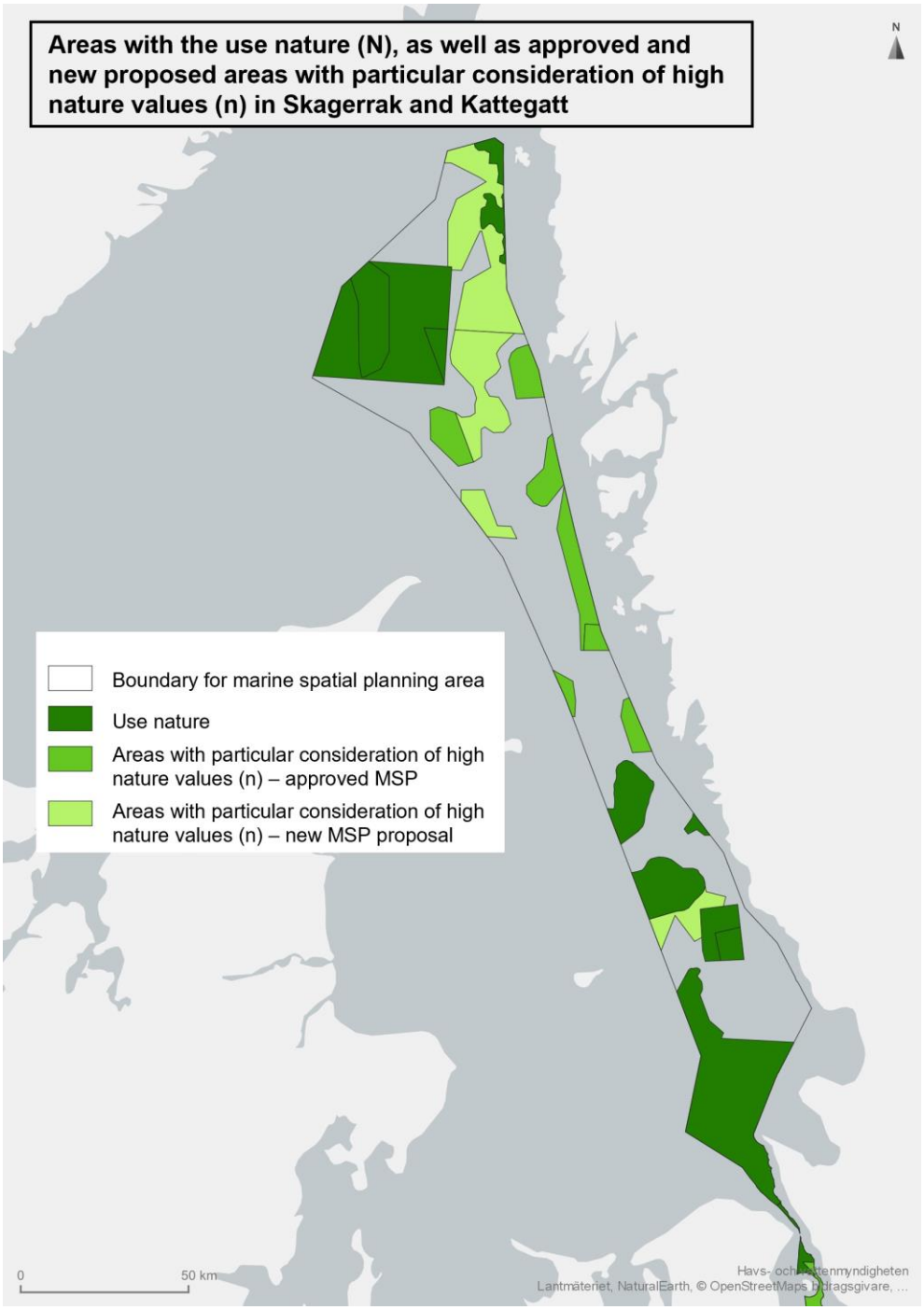


Figure 31. Areas with the use nature (N), as well as approved and new proposed areas with particular consideration of high nature values (n) in Skagerrak and Kattegat.

4.2. Assessment of economic effects

Effects on sectors

4.2.1.1. Commercial fishing

4.2.1. Similarly to in the other two marine spatial planning areas, the proposed energy extraction is the use that is considered to be able to impact commercial fishing's operations and profitability negatively. Skagerrak and Kattegat make up the marine spatial planning area with the highest estimated loss of landing value in commercial fishing as a result of the proposed expansion of offshore wind energy, estimated to more than SEK 14 million per year with all planned energy extraction areas included (Table 5). This figure is equivalent to around 2.2 per cent of the Swedish commercial fishing's annual landing value from catches in Swedish waters.

While the estimated losses in landing value are very small in the pelagic trawl fishery and the bottom trawl fishery targeting pelagic species, they are significantly larger in the bottom trawl fishery targeting Norwegian lobster, shrimp and demersal fish, of around SEK 5 million, SEK 7.3 million and SEK 1.5 million per year, respectively. These figures are equivalent to around 5.6 per cent, 6.4 per cent and 5.1 per cent of the respective fishery's total annual landing value.

Potential losses in landing value are estimated in all 11 energy extraction areas that are proposed in Skagerrak and Kattegat. Regarding crayfish fishing, the estimated loss is the largest in the energy area V303 in Kattegat, followed by V359 and V317, which are proposed energy areas in Kattegat and Skagerrak, respectively. The loss in landing value for crayfish fishing in these three areas together is estimated to be around SEK 2.9 million per year. When it comes to bottom trawling with shrimp trawl, the alternative energy areas are V355 and V360 in Skagerrak together account for around SEK 6.2 million and thereby the majority of the estimated loss of landing value. Bottom trawl fishery targeting demersal fish is more spread out throughout Skagerrak and Kattegat, and virtually every energy area is at risk of negatively affecting the catches. The estimated loss in landing value is, however, the highest in the energy extraction area V357 in Skagerrak, of around SEK 755 thousand per year.

	Plan alternative 1: proposed energy areas	**Plan alternative 2: proposed and alternative energy areas**
Loss of annual landing value (SEK)	6,376,801	14,002,186
Share of the annual landing value (percentage)	0.99	2.18

Table 5. Estimated loss of landing value in commercial fishing as a result of proposed energy extraction in Skagerrak and Kattegat.

As in other offshore areas, in addition to Swedish fishing, extensive foreign fishing is conducted in Swedish waters in Skagerrak and Kattegat, mainly by Danish and Norwegian vessels. The

collective potential losses for all fleets can therefore be significantly higher than indicated in Table 5, as it is known that foreign vessels largely fish in the same areas as Swedish vessels.

Figure 32 uses colour coding to show the size of the estimated effect of the proposed energy extraction areas on the landing value from Swedish fishing in Skagerrak and Kattegat. Appendix A shows maps of estimated landing values and loss in landing value within proposed and alternative energy areas in the marine spatial planning areas.

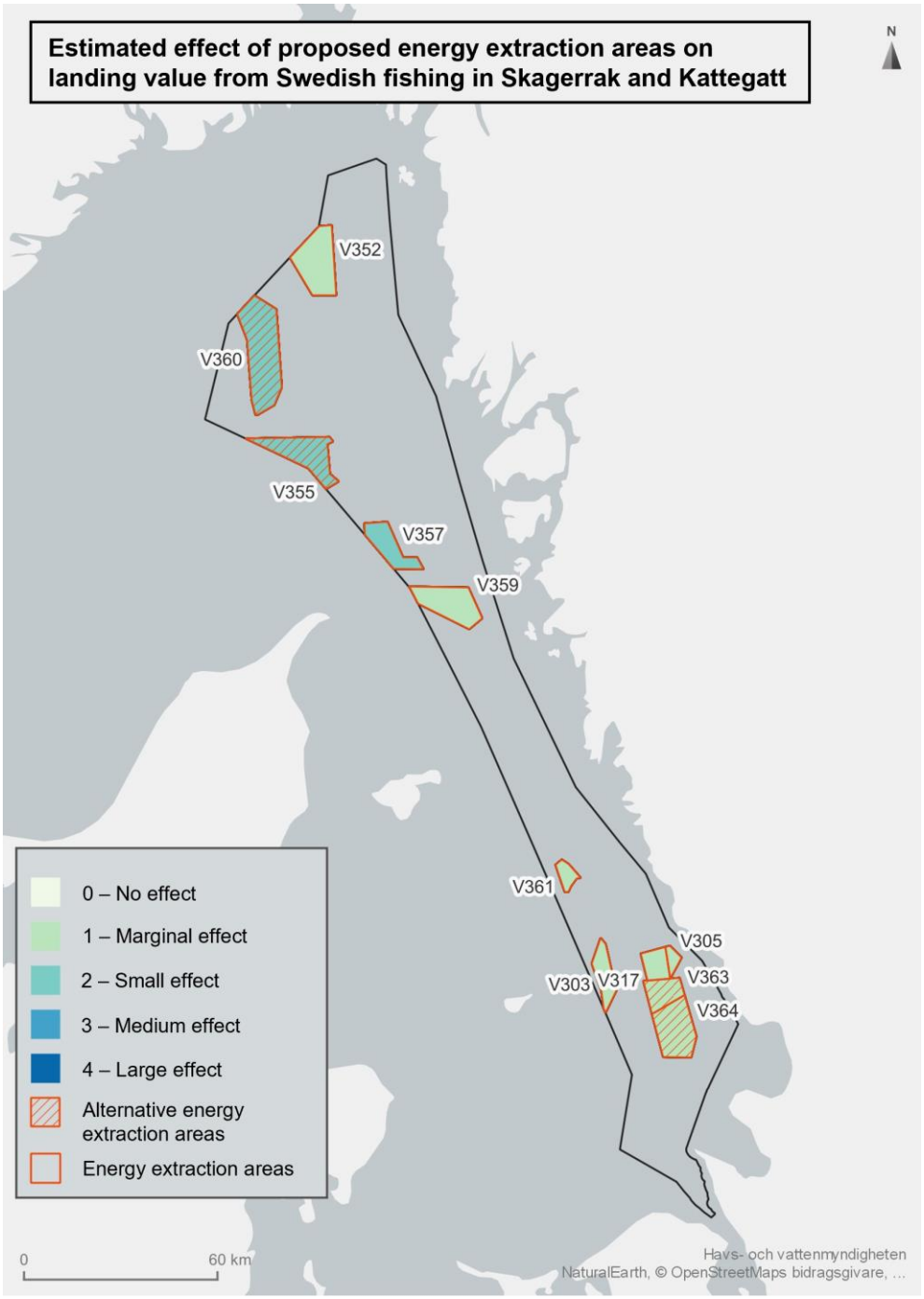


Figure 32. Estimated effect of planned energy extraction areas on landing value from Swedish fishing in Skagerrak and Kattegat. Dark colour shows a large effect and light colour shows a small effect.

4.2.1.2. Energy extraction

Skagerrak and Kattegat's four proposed alternative energy extraction areas have, due to a larger average area, an estimated electricity production potential that is somewhat larger than the potential for the seven energy extraction areas (see Table 6). However, the three areas with the highest estimated economic potential, namely V303, V305 and V317, are among the latter. These three areas are located in Kattegat near or very close to the mainland and in relatively shallow areas.

At the other end of the scale, there are three areas that are considered to have the lowest estimated economic potential. All are located at a greater depth and are assumed to be suitable for floating foundations. Like other energy extraction areas in the Skagerrak and Kattegat marine spatial planning area, they are located relatively close to the mainland. By the end of January 2023, no projects in any area had applied for a permit.

Table 6 compares the collective surface area and estimated annual electricity production from the energy extraction areas that are included in plan alternatives 1 and 2. Figure 33 shows, using colour coding, the size of the estimated relative economic potential of the proposed energy extraction areas in the Skagerrak and Kattegat marine spatial planning area.

	Plan alternative 1: proposed energy areas	**Plan alternative 2: proposed and alternative energy areas**
Surface area (km^2)	678	1,395
Estimated annual production (GWh)	13,550	27,903

Table 6. Surface area and estimated annual electricity production in plan alternatives 1 and 2 in the Skagerrak and Kattegat marine spatial plan.

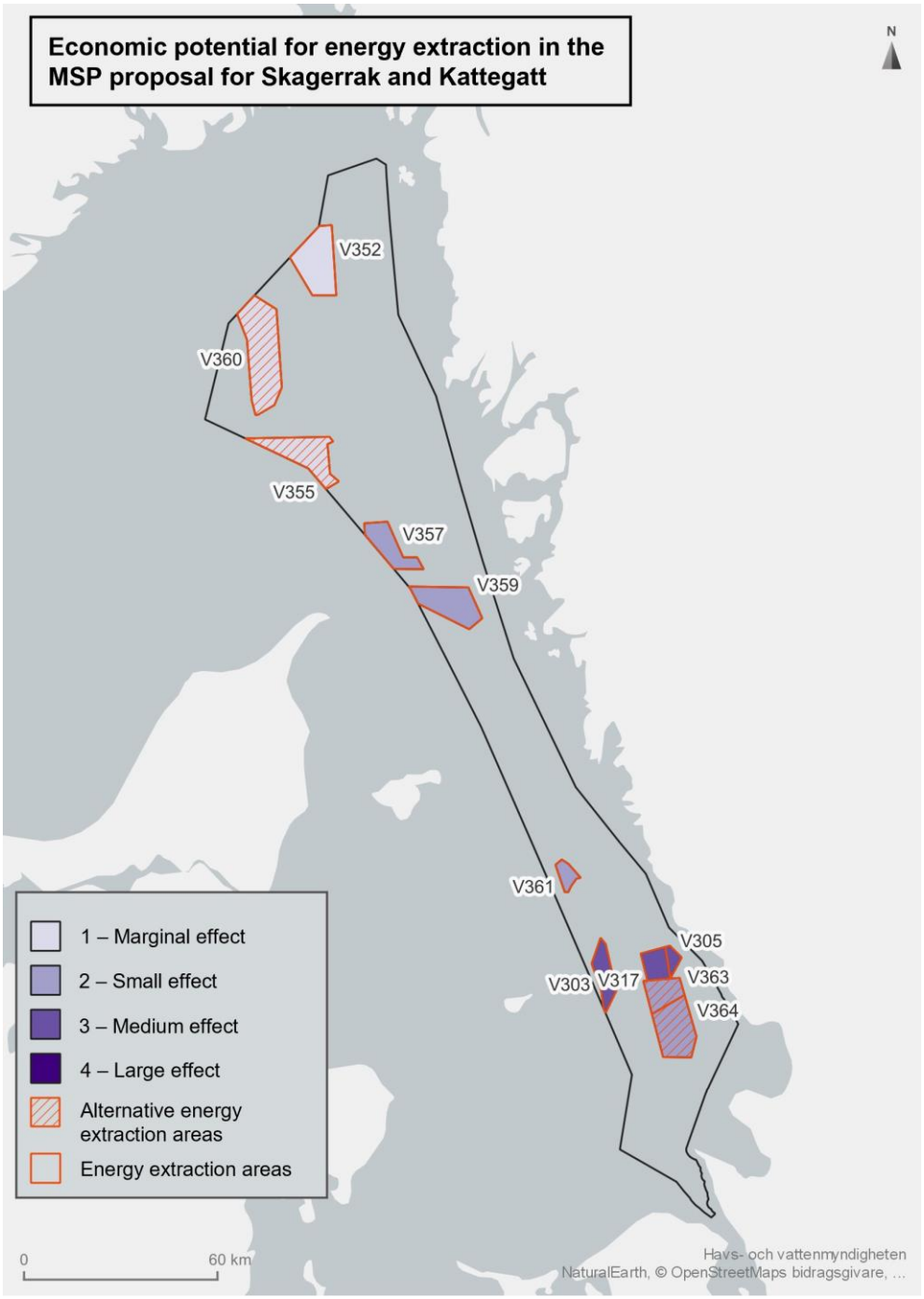


Figure 33. Economic potential for energy extraction in the marine spatial plan proposal for Skagerrak and Kattegat. Dark colour shows large potential and light colour shows small potential.

4.2.1.3. Shipping

Shipping is considered to be able to coexist with energy extraction at sea provided that the safety of shipping is taken into account. Among other things, this means that consideration must be taken to safety distances so that maritime safety and national and international rules at sea can be complied with.

In the marine spatial plan proposal for Skagerrak and Kattegat, there are seven proposed energy areas, as well as four additional alternative energy areas. Consideration of safety distances in plan proposals varies between the different energy areas. All four energy areas in Kattegat, V303, V305, V317 and V361, are located between shipping lanes. There are permitted wind power projects in the energy areas V303, V305 and V361, and safety distances are specified in the respective permits. Energy area V317 is located with a certain distance to existing shipping lanes. In the area, there are also two alternative energy areas V363 and 364, which are located along shipping lanes. All energy areas are considered to have a large impact on shipping based on areas that to some extent coincide with assessed area's needs for safety distances, as indicated by the Swedish Energy Agency (2023a). The equivalent applies to the energy areas V357 and V359, which are located adjacent to two and three shipping lanes between Gothenburg and Tjörn, respectively.

In the north, there is another energy area, V352, that in the plan map has a smaller safety distance to the east than that indicated for consideration and adaptation by the Swedish Energy Agency (2023a). In the north, there are two alternative energy areas V360 and V355, which to some extent are located by shipping lanes and national interests for shipping. The energy areas are also, according to annotation, located in a shipping lane of substantial significance to international shipping (UNCLOS Article 60:7). The Swedish Maritime Administration assesses that the route could possibly be moved to the northeast, but believes that such a relocation conflicts with UNCLOS and is therefore not feasible (Swedish Energy Agency, 2023a). According to AIS data, shipping traffic in the area appears to be relatively limited and shipping mainly appears to follow the shipping lane according to the plan proposal's use shipping.

Figure 34 uses colour coding to show the potential negative effect that the energy areas can have on shipping in the Skagerrak and Kattegat marine spatial planning area.

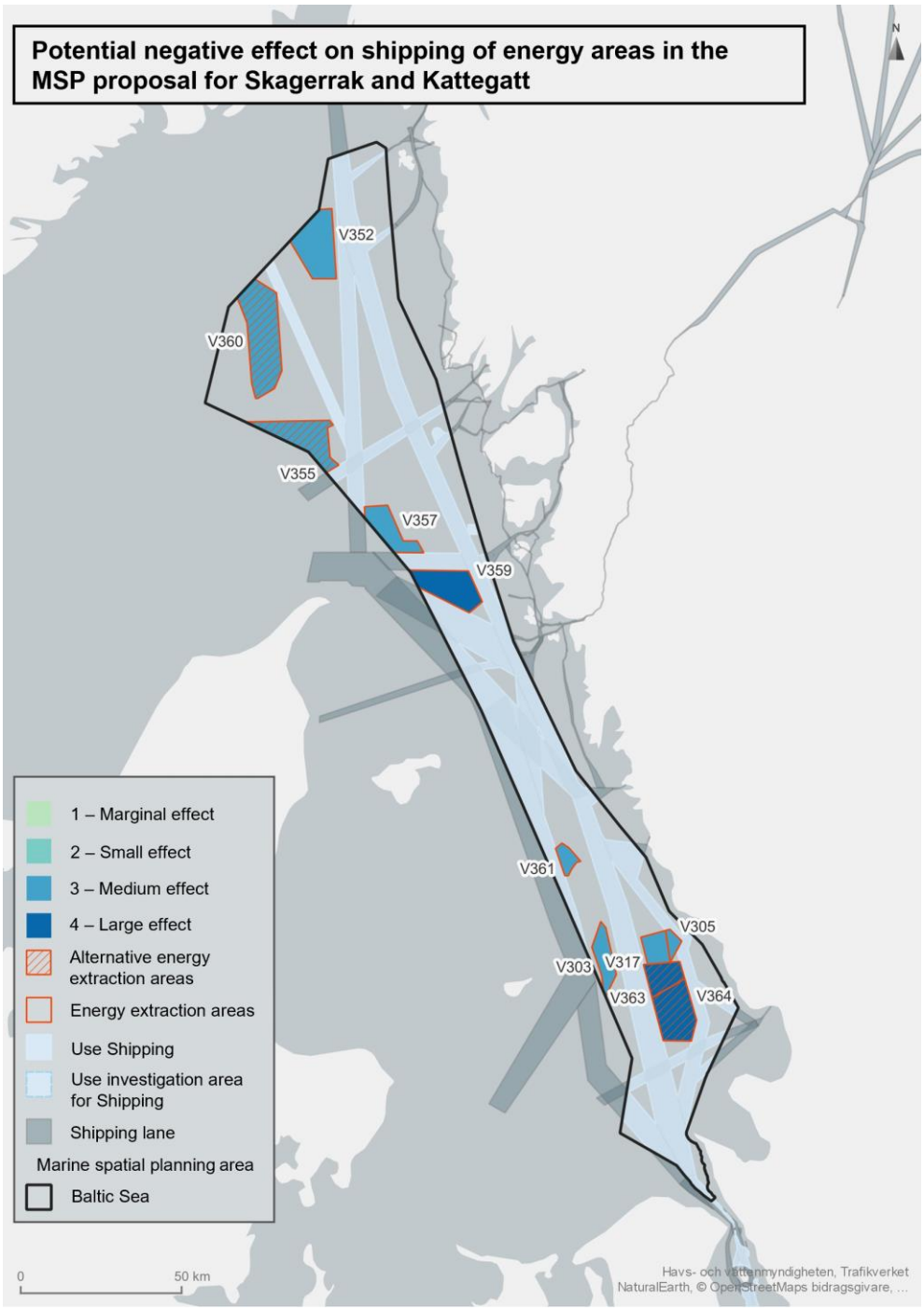


Figure 34. Potential negative effect on shipping of energy areas in the marine spatial plan proposal for Skagerrak and Kattegat. Dark colour shows a large effect and light colour shows a small effect.

4.3. Assessment of social effects

Population and health

Based on the proposed energy areas' distance to settlements on the coast, wind power establishment in these areas is not considered to entail a significantly elevated risk of noise or light disturbances and consequently also no risk to the population or human health. The proposed energy area that is located closest to the coast – V305 – is around seven kilometres west of Falkenberg, which according to the discussion in section 2.3.1 is considered to be a large enough distance for noise and light disturbances to not be problematic. All other proposed energy areas are located at significantly larger distances from the mainland.

4.3.1

As similar to the other two marine spatial planning areas, the conclusions regarding the approved marine spatial plan's effects on human health according to the respective sustainability assessment also apply for this marine spatial plan proposal for Skagerrak and Kattegat (SwAM, 2019b). The effects are then considered to be insignificant considering largely unchanged emissions of airborne pollutants from fishing vessels. In this marine spatial plan proposal for Skagerrak and Kattegat, commercial fishing is considered to be able to be affected by several larger energy areas in Kattegat and Skagerrak, but it is currently not possible to predict how fishing operations will be adapted. It is therefore also not possible to express an opinion on whether emissions from fishing vessels can change, or if this could entail any risks to human health.

A number of proposed energy areas are considered to be able to constitute an elevated navigational safety risk due to the lack of or insufficient safety distance to shipping lanes, according to section 4.2.1.3. As in the assessments of the marine spatial plans for the Gulf of Bothnia and the Baltic Sea, a higher risk of marine accidents is considered to be able to indirectly entail a higher risk of negative effects on human health.

4.3.2.

Effects on cultural environment

In the Skagerrak and Kattegat marine spatial planning area, there are two areas that entail a risk of a medium negative effect on cultural environment. These areas, V305 off of Falkenberg and V359 off of Gothenburg's northern archipelago, are located both within the territorial sea, around 6 and 13 kilometres from the coast, respectively. Another seven energy extraction areas are considered to entail a risk of a small negative effect. No specifically pointed-out cultural values are considered to be able to be affected, at the same time as there is a risk that some of the planned energy extraction areas in Skagerrak also negatively affect cultural environments in Denmark and Norway. The areas V355, V357 and V359 are especially significant due to their relative proximity to Skagen in Denmark.

The energy extraction areas V352, V355 and V360 are considered to possibly entail a risk of a marginal impact on the cultural environment. The latter two areas are located between 35 and 40 km from land, which is why their visual impact is considered to be limited.

Figure 35 uses colour coding to show the estimated effect of the energy extraction areas on the cultural environment in the Skagerrak and Kattegat marine spatial planning area. As in the Baltic Sea marine spatial planning area, there is no clear difference between plan alternatives 1 and 2 in terms of the energy extraction's effects on the cultural environment. The two areas with the

greatest risk of negative effect on cultural environments are proposed energy areas, while all four alternative areas, as well as the other five energy areas, all have a small or marginal potential effect.

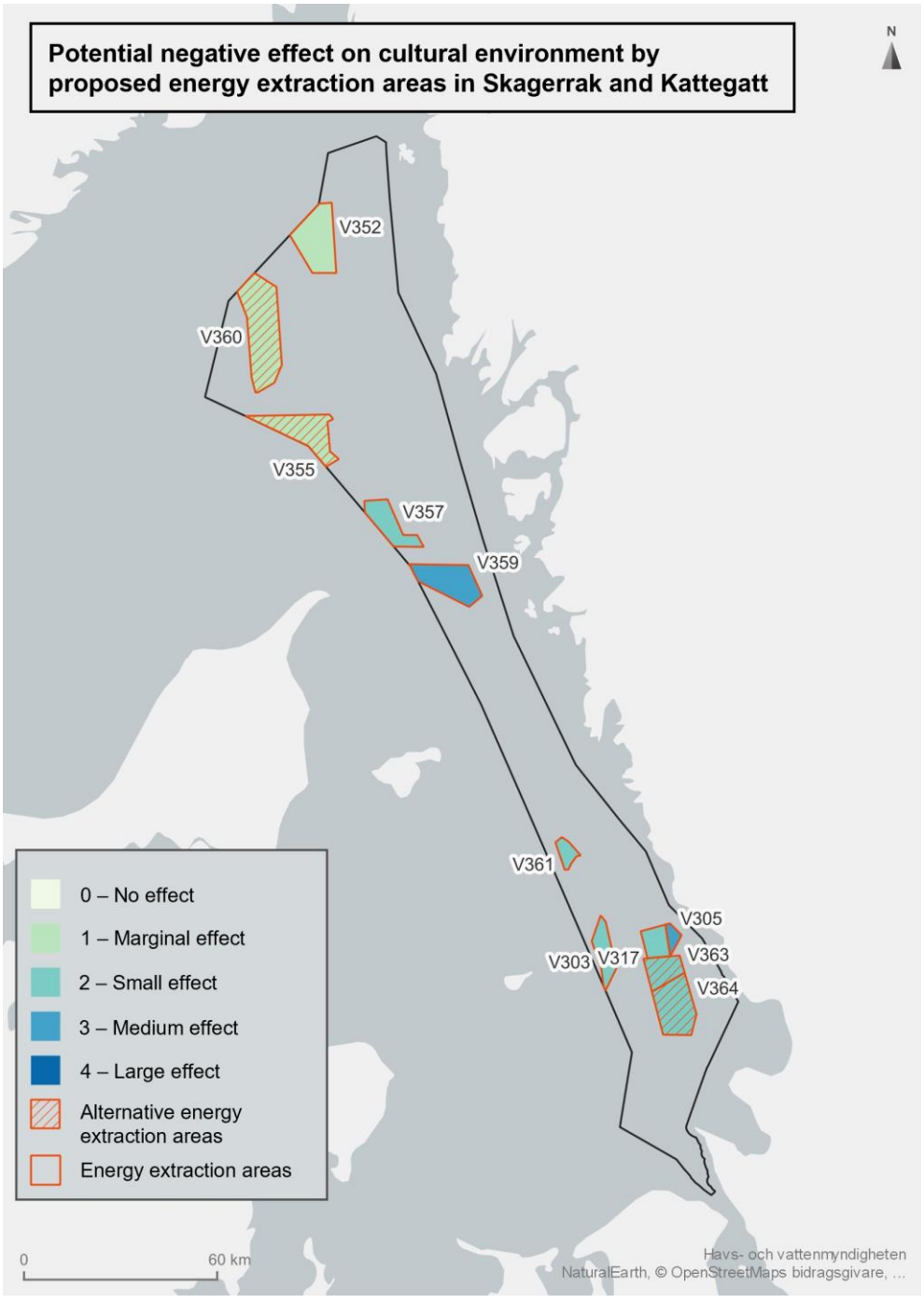


Figure 35. Potential negative effect on cultural environments by proposed energy extraction areas in Skagerrak and Kattegat. Dark colour shows a large effect and light colour shows a small effect.

4.3.3. Effects on recreation

The plan proposal provides guidance on the use recreation in six areas in Skagerrak and Kattegat. The proposed areas are based on existing national interests for outdoor recreation.

In the amended marine spatial plan proposal for Skagerrak and Kattegat, there are 7 proposals for energy areas, and a further 4 alternative energy areas. In Kattegat, along the archipelago between Halmstad and Varberg, there are four proposed energy areas. Two energy areas V305 and V317, around 7 km from the coast at the closest, and two energy areas at the banks V303 and V361. In addition, there are two alternative areas V363 and V264, off of Halmstad. All energy areas have varying degrees of negative impact on coastal and land-based national interests for outdoor recreation, Skrea strand – Tylesand and Ätran-Högvadsån, based on their location and distance to coastal areas. The national interest area off of Varberg, the Getterön-Årnäs-Balgöfjorden area is considered to possibly be impacted by energy area V361, however, permits exist for wind farms, as well as for the energy areas V303, V305.

In the marine spatial planning area, there are also the national interests for outdoor recreation on the offshore banks, in the areas of Lilla Middelgrund, Morups bank, Stora Middelgrund, Röde bank and Fladen, which are also considered to be able to be negatively affected by wind power establishment to varying extents depending on distance and activity. Value descriptions for the national interest areas include activities such as angling, diving and harbour porpoise safaris.

In Skagerrak, at the coastal off of Kungälv and Tjörn, there energy areas V357 and V359 are located. These are considered to be able to have a negative impact on national interest claims for outdoor recreation in the areas of Sothern Bohuslän’s coast, and on the Gothenburg Archipelago. Current activities according to value descriptions for the outdoor recreation areas are cultural experiences, kiting/paragliding, diving and surfing. Energy area V359, located closest to the coast, has a distance to the area of Southern Bohuslän’s coast of around 8 kilometres and of around 18 kilometres to the Gothenburg Archipelago.

To the north in the planning area, the energy area V352 is found. The area can affect national interest claims for outdoor recreation on Northern Bohuslän’s coast – outer coastal zone, and the Kosterhavet National Park east of the area. The values that are shown in the value description are untouched environments at the far end of the coastal area, and having an attractive landscape appearance with sensitivity to wind power development. Visual impact from wind power on recreational values sensitive to wind power is considered to exist in the entire area (Swedish Energy Agency, 2023a). Significant impact to the east, which gradually decreases to the west. Cumulative impact needs to be taken into account in the continued work. Further out from the coast, around 50 and 40 kilometres, respectively, there alternative energy areas V360 and V365 are located. These are considered to have a gradually lower impact based on distance to national parks and national interests for outdoor recreation. The risk of cumulative negative impact on the experiential values for the areas pointed out should be taken into account, both in Bohuslän and in Kattegat.

Figure 36 shows an approximation of the distance from proposed and alternative energy areas in Skagerrak and Kattegat to land. The figure does not take into account terrain or vegetation on the coast, which has a large effect on visual impact on various areas on land.

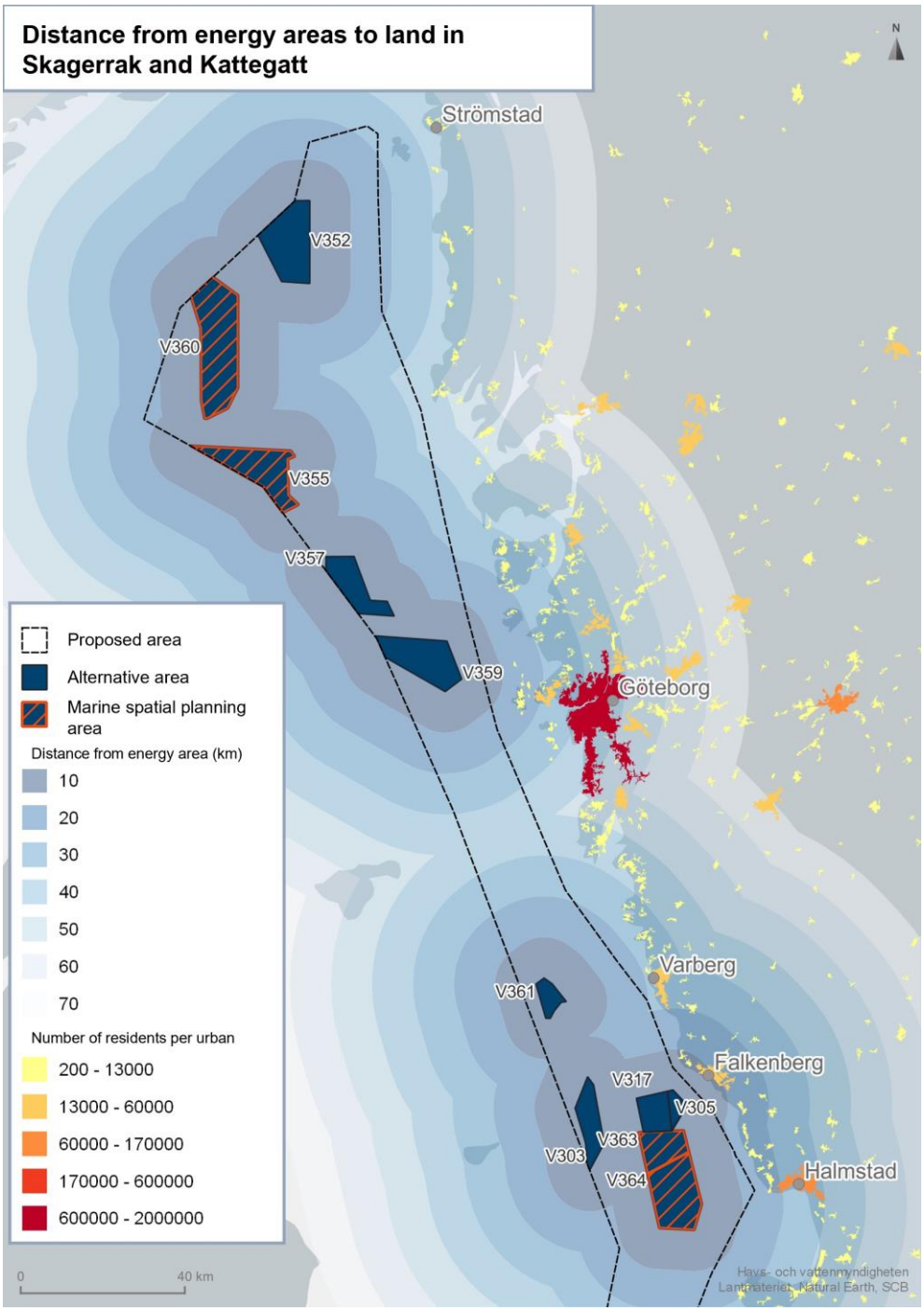


Figure 36. Map of the energy areas' distance to land and population in urban areas on land for Skagerrak and Kattegat

Cumulatively, there is potential negative impact of varying degree on preconditions for recreation and values for national interests for outdoor recreation, based on the plan's guidance on energy in the marine spatial plan. The impact and need for adaptation to promote coexistence needs to be assessed from a regional and local perspective. Potential impact on recreation includes national interests located both in the marine spatial planning area and at the coast.

4.4. Overall assessment for Skagerrak and Kattegat

This section presents a compilation of effects that the proposed amended marine spatial plan for Skagerrak and Kattegat may give rise to. The point of departure is the guidance in the marine spatial plan proposal on various uses, of which the guidance on energy extraction accounts for the majority of the potential effects.

Offshore wind energy establishment according to the guidance on energy extraction is considered to entail a risk of negative effects on migratory birds and breeding, resting and wintering birds. The risk is greatest from energy extraction areas located in narrow passages across the sea between Skagen and Southern Bohuslän, and above the offshore banks in Kattegat. The accumulation of energy areas proposed in the latter area also entails a risk of significant impact on breeding, resting and wintering birds. The area is of international significance for several species of sea birds. Possible barrier effects need to be investigated, especially upon expansion in several areas and considering the wind power expansion that is planned on the Danish side of the border. In the marine spatial plan proposal, the number of areas with particular consideration to high nature values is expanded, which are partly pointed out with the aim of strengthening the protection of sea birds and migratory birds. Stronger protection is considered to be able to take the form of requirements on precautionary measures in the permit review of wind power or other licensed activities in these areas.

Impact on the seabed occurs in the expansion of offshore wind energy, with permanent changes in the form of an artificial substrate in the areas that are relevant for bottom-fixed foundations. Even if all energy areas were to be developed, the effect is considered to be insignificant in terms of the share of seabed area that can be affected. More hard substrate, although artificial, can in some areas be positive as it creates new living environments that benefit certain marine species. The risk of damage to protected nature types needs to be investigated locally. In areas at a greater depth where floating wind power foundations are of interest, the impact on the seabed is generally minimal.

Disturbance of marine mammals is considered to be able to occur mainly in connection with the construction of offshore wind energy. Harbour porpoise and seal populations in the area are considered to be of “least concern” according to the Swedish Red List, and the risk is considered to be small if adequate precautions are introduced, such as noise suppression and avoidance of sensitive reproduction periods. The long-term effects during the operating phase are insufficiently studied, which can motivate caution regarding the pace of establishment and concentration of wind power projects in areas that are important to the species.

Construction and decommissioning of wind power stations causes some sediment dispersion that can affect fish larvae and thereby fish spawning negatively. The risk is generally considered possible to minimise to acceptable levels by adapting the construction and decommissioning phases to the spawning periods for the various species that spawn in Skagerrak and Kattegat. In Kattegat, particular care should be taken to adapt this to cod spawning periods. If fishing will be limited in wind farms, the fishing pressure decreases in the energy extraction areas, which can benefit the fish resource, benthic environments and marine mammals. It is not currently possible to predict the scope of this potential positive effect on the environment.

Emissions of airborne pollutants and greenhouse gases can increase as a result of shipping traffic for construction, maintenance and decommissioning of wind farms. Based on current

knowledge, the magnitude of the effect is, however, not possible to estimate. Positive effects for the climate are at the same time considered to possibly arise through expanded production of fossil-free electricity. In the marine spatial plan proposal for Skagerrak and Kattegat, the production potential in proposed and alternative energy areas is estimated to be roughly the same.

Besides certain parts of the marine ecosystem, other human uses of the Skagerrak and Kattegat marine spatial planning area are also at risk of being affected by wind power establishment. The majority of energy areas coincide with safety distances to shipping lanes, most of which are of international significance. Observance of safety zones is important to avoid safety risks for shipping, with potential consequences for the environment and human health. The entire marine spatial planning area is relatively crowded, with many claims in a limited area, in both Swedish and Danish waters, which limits alternatives. In the continued planning, safety distances should be illustrated in a consistent way and consideration should be taken to the actual area available for wind power in the energy areas.

For commercial fishing, the estimated loss in landing value in Skagerrak and Kattegat is significantly greater than the equivalent in the Baltic Sea and the Gulf of Bothnia, respectively. The estimated loss amounts to around SEK 14 million per year as a result of wind power establishment in proposed and alternative energy areas. The fallout is estimated to be the largest in the bottom trawl fishery targeting shrimp, crayfish and fish. The consequences for the food supply from the sea, fishing ports and coastal communities can be significant and should be taken into consideration in the review of wind power projects.

Along larger parts of the coast of Skagerrak and Kattegat, negative effects on cultural environments and recreation are considered to possibly arise as a result of, among other things, visual impact from offshore wind farms. Extensive recreation and several cultural environments with an ocean connection characterise the coastline. Potential negative impact is mainly considered to be found in the coastal areas off and north of Halmstad and off of Kungälv, where energy extraction areas are proposed near the mainland. Accessibility to recreation areas in Kattegat's offshore banks needs to be ensured in the event of possible wind power establishment. Otherwise, there is a risk that large parts of the horizon will be covered by wind farms if all proposed and alternative energy areas and planned wind farms in Danish waters were to be developed. Factual information on the effects of wind power on the cultural environment and recreation needs to be supplemented. The impact and need for adaptation to promote coexistence need to be assessed from a regional and local perspective.

In the amended marine spatial plan proposal, there are new areas with particular consideration of high nature values in both Skagerrak and Kattegat. The primary objective is to strengthen consideration of migratory birds along migration corridors and breeding, resting and wintering birds on Kattegat's offshore banks. In some areas, the designation of consideration also refers to strengthening the protection of protected benthic environments. Greater consideration of these nature values should be taken in the planning and regulation of all human activities, which is considered to contribute to a more sustainable use in Skagerrak and Kattegat. The marine spatial plan proposal's guidance on other uses entails no changes compared with how and where the respective activities are conducted today. The marine spatial plan is therefore not considered to entail any specific additional environmental effects.

Most of the environmental effects are considered to be cross-border and affect the neighbouring countries Denmark and Norway. Bird, fish and mammal species that can be affected by uses that the marine spatial plan has control over are in many cases part of cross-border populations, and several migrate far beyond the Kattegat/Skagerrak area. The bird migration routes across Skagerrak and Kattegat are important to bird species that migrate far beyond Scandinavia, and are thereby of global significance. In terms of fishing, especially Danish and also Norwegian fishing vessels are affected to at least the same extent as Swedish fishing vessels. Most of the shipping traffic to and from the Baltic Sea passes through Skagerrak and Kattegat, which is why possible effects on shipping are relevant to all trade with the Baltic Sea region. Recreational boat traffic between Denmark and Sweden is intensive in Kattegat, and visual impact from offshore wind energy in Skagerrak can also affect valuable cultural environments and landscapes on the Danish and Norwegian coast. At the same time, other countries are considered to be able to benefit from wind power's potential positive effects in the form of expanded production of fossil-free electricity.

In the Skagerrak and Kattegat marine spatial planning area, the differences between proposed and alternative energy areas are relatively small in terms of both estimated environmental effects and estimated production potential. The risk of significant cumulative effects is considered to be large in Kattegat considering the number of planned wind power areas in Danish waters, in an area where there is also a large accumulation of proposed and alternative energy areas on the Swedish side. At the same time, the area is valuable not only from an environmental perspective, but also for other human uses. In the continued planning, the risk of cumulative effects should be carefully assessed, including in consultation with neighbouring Denmark.

5. Results and conclusions

In this chapter, the assessment of the marine spatial plan's environmental effects is compiled for the three marine spatial planning areas of the Gulf of Bothnia, the Baltic Sea and Skagerrak and Kattegat based on the results reported in the previous chapter. The assessments in this part are done at a national level, i.e. they cover all three marine spatial plans.

Section 5.1 presents the marine spatial plans contribution to achieving good environmental status in Swedish waters according to the Marine Strategy Framework Directive and the criteria in the Water Framework Directive that have a connection to the marine environment. Section 5.2 includes an analysis of how the marine spatial plans jointly contribute to achieving Sweden's environmental quality objectives. The last section presents the consequences of the marine spatial plans for other relevant plans, policies and programmes.

Apart from the use energy extraction and the guidance on consideration of high nature values in several areas, the guidance in this proposal for changed marine spatial plans does not differ from the approved marine spatial plans. The analyses in this chapter are therefore largely based on the conclusions in the environmental impact assessment and sustainability assessment of the approved marine spatial plans published in 2019 (SwAM, 2019a; 2019b).

5.1. Assessment regarding the Marine Strategy Framework Directive and the Water Framework Directive

5.1.1. Plankton communities and pelagic environments

Altogether, the marine spatial plans are considered to have no significant effect on plankton communities or on pelagic habitats. The overall assessment against relevant descriptors according to the Marine Strategy Framework Directive and the Water Framework Directive is shown in **Fel! Hittar inte referenskälla.**.

Plankton communities and pelagic habitats

MSFD	D1C6 *The state of pelagic habitats*	No effect
MSFD	D4C1 *Impact on the diversity of the trophic group*	No effect
WFD	Plant plankton in coastal and transitional waters	No effect

Table 7. Overall assessment of plankton communities and pelagic habitats. MSFD: Marine Strategy Framework Directive, WFD: Water Framework Directive.

Increased turbidity is considered to be able to arise as a result of extraction activities and in connection with the construction of offshore wind energy in the areas where the marine spatial plan provides guidance on sand extraction and energy extraction. Even if the pressure can be significant locally, it is usually short-term and geographically limited, and the effects on water quality and marine life are not significant. In the areas where spawning occurs, it is important to

adapt activities that cause sediment spread to avoid the spawning periods, to minimise the risk of negative impact on the fish's pelagic life stages.

Establishment of offshore wind energy can entail limitations for fishing, especially fishing with active gear. Should bottom trawling be limited, this could entail a positive effect in the form of reduced turbidity, especially in areas with seabeds of fine sediment. Similar effects can arise as a result of the marine spatial plans' guidance on particular consideration of high nature values if this would lead to the introduction of management measures directed towards fishing with bottom contact. The actual scope of these two effects is not currently possible to determine.

Fish

Altogether, the marine spatial plans are considered to have no significant effect on fish in the marine spatial planning areas. However, the effects can vary somewhat between different areas.

5.1.2 The overall assessment against relevant descriptors according to the Marine Strategy Framework Directive and the Water Framework Directive is shown in **Fel! Hittar inte referenskälla.**.

Fish

MSFD	D1C2 *Abundance of species of birds, mammals and fish*	No effect
MSFD	D3C1 *Fishery mortality in commercially used species*	No effect
MSFD	D3C2 *The spawning stock's biomass in commercially used species*	No effect
MSFD	D4C1 *Impact on the diversity of the trophic group*	No effect
MSFD	D4C2* *Impact on the balance in abundance between trophic groups*	No effect
MSFD	D9C1 *Hazardous substances in marine food*	No effect
WFD	Migration-prone fish species	No effect
	Benthic fauna in coastal and transitional waters	No effect

Table 8. Overall assessment for fish. MSFD: Marine Strategy Framework Directive, WFD: Water Framework Directive. (*) Related indicator refers to carp and predatory fish in coastal waters.

The marginally longer travel distance for shipping through the Southern Bothnian Sea as a result of the marine spatial plans' guidance on energy extraction is considered to entail marginally elevated underwater noise and marginally higher levels of pollutants from operational emissions. These pressures are considered to be able to have a marginal negative effect on pelagic fish species. Adaptation of fishery and also shipping to energy areas elsewhere can have similar effects, but these cannot currently be predicted.

However, rerouting of shipping in the two investigation areas of Salvorev and Hoburgs bank in the northern and south-eastern Baltic, respectively, is considered to possibly entail small positive effects on marine life, including fish.

The marine spatial plans guidance on particular consideration of high nature values can lead to the introduction of adaptation measures for various human activities with the aim of reducing the pressure on marine life. There is thus potential that the guidance indirectly contributes to greater protection of fish species. Similarly, establishment of offshore wind energy can entail limitations to fishing operations, which can benefit the fish. The scope of these effects is not possible to estimate based on current knowledge.

Otherwise, establishment of offshore wind energy is generally considered not to pose a threat to fish species or fish populations, based on a recent knowledge synthesises. It is important, however, that the risk of impact is investigated in every area with consideration of the fish species' sensitivity and other local conditions.

Increased turbidity in connection with sand extraction and construction and decommissioning of offshore wind energy can negatively affect spawning fish, but the risk of such impact is considered to be able to be minimised to acceptable levels through the introduction of consideration measures for the respective activities.

5.1.3. Birds

Altogether, the marine spatial plans are considered to have a medium negative effect on birds in the marine spatial planning areas. The effect varies widely between areas. The overall assessmentoverall assessment against relevant descriptors according to the Marine Strategy Framework Directive is shown in **Fel! Hittar inte referenskälla.**.

Birds

MSFD	D1C2 *Impact on the population*	Medium negative effect
MSFD	D4C1 *Impact on the diversity of the trophic group*	Medium negative effect
WFD	*No relevant assessment basis*	Assessment is not possible

Table 9. Overall assessmentOverall assessment for birds. MSFD: Marine Strategy Framework Directive, WFD: Water Framework Directive.

Several proposed and alternative energy areas are located in or next to migration corridors that are used by large numbers of individuals of various bird species. Several of these bird migration paths are of global significance. Energy areas within so-called bottlenecks entail especially high risks, not only for sea birds, but also for land birds and bats that seek the shortest possible passage across the sea. The marine spatial plan also provides guidance on energy extraction on or next to wintering areas for protected bird species, which is the case for the offshore banks in the Southern Bothnian Sea, the south-eastern Baltic Sea and southern Kattegat. In addition to these, a few energy areas are proposed close to the coast, which constitutes a special risk to birds that breed, forage or migrate along the coast.

In several other areas, the risk of impact on birds is considered to be small. This is usually areas at greater depths further out to sea and at a greater distance from bird migration paths or narrow passages across the sea.

In some areas, the risk of a negative effect on birds is considered to be able to be minimised by adapting the wind farms' operation based on wind and weather conditions or the presence of birds. In a number of other areas, such consideration measures are not considered to be sufficient. The risk of impact from offshore wind energy should be seen against the background of the downward trend for several bird populations, and in a context of the strong increase in offshore wind energy in neighbouring countries.

Marine mammals

5.1.4. Altogether, the marine spatial plans are considered to have mixed effects on marine mammals. Some negative effects mainly pertain to porpoises, especially the Baltic Sea population as a result of disturbance from wind power. Guidance on particular consideration of high nature values can have a small positive effect. The impact on seals is not considered to be significant. The overall assessmentoverall assessment against relevant descriptors according to the Marine Strategy Framework Directive is shown in **Fel! Hittar inte referenskälla.**.

Mammals

MSFD	D1C1* *Mortality as a result of by-catch*	Small positive effect
MSFD	D1C2 *Impact on the population*	Marginal negative effect
MSFD	D1C3** *Demographic characteristics of the populations*	No effect
MSFD	D1C4*** *Distribution of species*	No effect
MSFD	D4C1**** *Impact on the diversity of the trophic group*	No effect
WFD	*No relevant assessment basis*	Assessment is not possible

Table 10. Overall assessmentOverall assessment for marine mammals. MSFD: marine environment directive, WFD: Water Framework Directive. (*) The associated indicator concerns by-catch of porpoises; (**) The associated indicators concern the pregnancy rate and blubber thickness among grey seal; (***) The associated indicators concern the spread of grey seal, harbour seal and ringed seal; (****) The associated indicators concern the abundance and trends for grey seal, harbour seal and ringed seal).

The positive effects that pertain to descriptor D1C1 are due to reduced mortality in by-catch or physical disturbance from fishing and defence activities in areas where the marine spatial plan provides guidance on particular consideration of high nature values. The effect is assumed to be somewhat larger for porpoises than for seals. Assumptions made for these areas concern the application of by-catch minimising methods and gear in trawler and net fishing, and greater adaptation of defence exercises during biologically sensitive periods for mammals.

Consideration measures are also believed to be able to be implemented in the establishment of offshore wind energy so that the risk of negative impact on most marine mammal populations can

be reduced to acceptable levels. For the acutely threatened Baltic Sea porpoise, offshore wind energy is considered to possibly pose a threat if it is built within the species' core range, which is why the marine spatial plan's guidance is considered to entail a negative effect in total.

The marine spatial plans' guidance is otherwise considered to make no difference for factors that affect the seals' abundance or spread.

Seabed environments

Altogether, the marine spatial plans are considered to have a marginal positive effect on benthic environments in the marine spatial planning areas. The effect can vary between areas. The overall assessment against relevant descriptors according to the Marine Strategy Framework Directive is shown in **Fel! Hittar inte referenskälla.**.

5.1.5

Benthic habitats

MSFD	D6C3 *Extent of physical disturbance in benthic living environments*	Marginal positive effect
MSFD	D6C5* *Scope negative effects of anthropomorphic pressures*	Marginal positive effect
WFD	Morphological state in coastal and transitional waters	No effect
WFD	Macro algae and angiosperms in coastal waters	No effect

Table 11. Overall assessment for benthic environments. MSFD: Marine Strategy Framework Directive, WFD: Water Framework Directive. (*) Relevant indicators include benthic fauna in coastal waters (5.8A) and benthic fauna in offshore waters (5.8B).

Small positive effects can arise in the areas where the marine spatial plan provides guidance on particular consideration of high nature values based on the assumption of limiting fishing with bottom contact. The effect is the greatest in the Skagerrak and Kattegat marine spatial planning area. Relocation of shipping lanes to deeper waters in the Southern Bothnian Sea and in connection with the investigation areas in the Baltic Sea can also lead to a somewhat reduced impact on shallower benthic environments according to the modelling in SwAM (2019a).

Locally large negative effects are considered to arise in the proposed sand extraction areas in the Bothnian Bay and in the south-western and southern Baltic Sea. The areas are located below the photic zone, and the extraction activities are considered to have no negative effects on benthic plants. The effects on benthic fauna are, however, considered to be very negative due to withdrawals of large amounts of sediment and resedimentation of disturbed sediment in the immediate area. Despite large local negative effects on benthic environments, the effects from the extraction activities are geographically limited, and very small in relation to the sandbank area in the marine spatial planning areas. However, there is a risk of permanent physical disturbance, which could conflict with the environmental quality standards D.1 and D.3. The risk needs to be investigated in more detail in the licensing process.

The proposed establishment of wind power in line with guidance on energy extraction entails a risk of permanent changes to the seabed structure. Wind power foundations and erosion protection can at the same time contribute new living environments for certain benthic organisms. The seabed area covered by foundations and erosion protection generally amounts to less than

one per cent of a wind farm's total area. The combined effect on benthic environments is thus considered to not be significant. Possible limitation of fishing with active gear with bottom contact in wind farms can constitute some protection of benthic environments, and thereby entail a positive effect. The scope of this effect is, however, not possible to estimate. The impact during construction and to a lesser extent decommissioning is considered to be more extensive, but short-term and therefore also not significant. The impact on protected seabed types needs to be investigated more closely within the scope of licensing processes to avoid unacceptable damage.

Hydrographic conditions

5.1.6 Altogether, the marine spatial plans are considered to have a negative effect on hydrographic conditions in the marine spatial planning areas. The magnitude of the effect is unclear. The overall assessment against relevant descriptors according to the Marine Strategy Framework Directive is shown in **Fel! Hittar inte referenskälla.**.

Hydrographic conditions

MSFD	D7 *Lasting changes in hydrographical conditions*	Negative effect
WFD	Hydromorphological quality factors in coastal and transitional waters • Connectivity • Hydrographical conditions	Negative effect
WFD	Physical chemistry quality factors in coastal and transitional waters • Visual depth • Nutrients • Oxygen balance • Especially pollutant substances	Assessment is not possible

Table 12. Overall assessment for hydrographic conditions. MSFD: Marine Strategy Framework Directive, WFD: Water Framework Directive.

5.1.7 Establishment of offshore wind energy according to the marin spatial plans guidance on energy extraction entails a risk of regional changes in hydrographic conditions in all three marine spatial planning areas. Preliminary results of modelling studies in Swedish waters indicate possible changes in wind and current conditions, with impact, among other things, on layering, temperature and salinity in the sea and coastal zone. The size of this effect and secondary effects on physicochemical conditions are currently unclear.

Underwater noise

Altogether, the marine spatial plans are considered to have a marginal negative effect on underwater noise in the marine spatial planning areas. The overall assessment against relevant descriptors according to the Marine Strategy Framework Directive is shown in **Fel! Hittar inte referenskälla.**.

Underwater noise

MSFD	D11 *Underwater noise*	Small negative effect
WFD	*No relevant assessment basis*	Assessment is not possible

Table 13. Overall assessment for underwater noise. MSFD: Marine Strategy Framework Directive, WFD: Water Framework Directive.

Assumptions of reduced impact from fishing and defence activities in areas where the marine spatial plans provide guidance on particular consideration of high nature values are considered to lead to reduced underwater noise in these areas. The possible relocation of the shipping lane south of Gotland to deeper waters is also considered to reduce the noise level from shipping.

Both the Offshore wind and the sand extraction activities will increase underwater noise in several areas. It is assumed to be possible to limit the introduction of impulsive noise during construction and decommissioning of wind farms to acceptable levels. Precise consideration measures need to be specified for every area within the scope of permit review. The extensive expansion of offshore wind energy according to the marine spatial plans guidance is considered to lead to a changed noise profile in several areas even during the operating phase, with a higher average noise level. Knowledge about long-term biological and ecological effects of an elevated noise level is currently insufficient.

Other effects

5.1.8.

The marine spatial plans are not considered to have any significant effects in terms of the Marine Strategy Framework Directive's descriptors D2 – invasive species, D5 – eutrophication, D8 – concentration and effects of hazardous substances and D10 – marine litter.

5.2. Contribution to Sweden's environmental quality objectives

This section presents the analysis of how the proposed amended marine spatial plans can contribute to the fulfilment of Sweden's environmental objectives. The results are summarised in **Fel! Hittar inte referenskälla.** and described in text below for the five objectives that the marine spatial plans are considered to contribute to.

Environmental objectives	The possibility for the marine spatial plan to influence
Reduced Climate Impact	By providing guidance on suitable areas renewable Offshore wind energy.
Clean Air	By providing guidance on the spatial distribution of boat and ship traffic and associated air emissions in relation to communities and nature.
Natural Acidification Only	No impact.
A Non-Toxic Environment	By providing guidance on the spatial distribution of activities that affect the seabed and risk releasing environmental toxins that are in the sediment.

Environmental objectives	The possibility for the marine spatial plan to influence
A Protective Ozone Layer	No impact.
A Safe Radiation Environment	No impact.
Zero Eutrophication	No impact.
Flourishing Lakes and Streams	No impact.
Good-Quality Groundwater	No impact.
A Balanced Marine Environment, Flourishing Coastal Areas And Archipelagos	By providing guidance on priority and spatial distribution of activities that affect stocks of fish and shellfish, and the general ecological status of coastal waters.
Thriving Wetlands	No impact.
Sustainable Forests	No impact.
A Varied Agricultural Landscape	No impact.
A Magnificent Mountain Landscape	No impact.
A Good Built Environment	No impact.
A Rich Diversity of Plant and Animal Life	By providing guidance on the priority and spatial distribution of the areas of environmental protection, and of activities that affect the conservation status of various nature types and species, and human accessibility to natural and cultural environments.

Table 14. Summary of the Marine spatial plans' contributions to the fulfilment of Sweden's environmental objectives.

In terms of the objective of *Reduced Climate Impact*, the marine spatial plans' contribution mainly relates to climate impacting emissions. The Marine spatial plans are considered to have a small positive effect by creating better conditions for a greatly expanded establishment of offshore wind energy in Swedish territorial waters and the Swedish exclusive economic zone. The guidance on energy extraction is considered to be able to facilitate the licensing processes and thereby increase the pace of renewable energy extraction at sea. To the extent that the electricity production from offshore wind energy replaces fossil-based energy sources, the marine spatial plans are considered to be able to contribute to reducing Sweden's emissions of greenhouse gases.

The marine spatial plans have a small or marginally negative contribution to the objective of *Clean Air* mainly with regard to levels of harmful air pollution. The marine spatial plans do not affect what fuels are used in shipping, which is the maritime industry that emits the most air pollution. The guidance on sand extraction and coastal recreation as the most suitable use is considered to contribute to marginally elevated emissions in affected coastal areas. The corresponding assessment is made of the effects from increased emissions from shipping traffic in connection with the construction, operation and decommissioning of offshore wind energy. The marine spatial plan is considered to have no net effect on emissions from fishing boats, even though the offshore wind energy establishment can entail changes in fishing operations.

The environmental quality objective of a *Non-Toxic Environment* is mainly affected by the marine spatial plans' guidance on the development of sand extraction activities possibly contributing to an elevated risk that environmental toxins are released from the sediment and taken up by marine organisms. However, there is today no evidence that the areas in question have elevated levels of environmental toxins, which is why the risk is considered to be marginal. Increased small boat and service boat traffic in connection with the guidance on priority uses of recreation, energy extraction and sand extraction entails a higher risk of operational emissions that affect the environment locally. The scope of this effect is, however, difficult to estimate.

The marine spatial plans' contribution to the objective of *a Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos* the preservation of biological diversity, the promotion of sustainable use and the protection of valuable areas. Through guidance on establishment of offshore wind energy and development of sand extraction activities in a few valuable areas, the marine spatial plans entail an elevated risk of disturbance of valuable and in some cases endangered species and habitats. At the same time, through guidance on particular consideration of high nature values, the marine spatial plans open the way for the possibility of greater protection of habitats and species in significantly more and larger areas. The limitation of e.g. fishing within wind farms can in some cases also constitute an increased protection for marine species. It is also positive that the use nature confirms all existing protected areas, and national interest claims for nature conservation and fish spawning areas. Guidance on particular consideration of high nature values draws attention to the significance of specific areas for biological diversity, the ecosystems' integrity and climate adaptation, which may be the basis for future protection of habitats or species.

Lastly, the marine spatial plans' contribution to the environmental quality objective of *ARich Diversity of Plant and Animal Life* refers to the conservation and use of biodiversity, the conservation of habitats and ecosystems, viable populations of fauna, and access to natural and cultural environments. The marine spatial plans provide guidance on the expansion of offshore wind energy and sand extraction activities, which both entail risks to biodiversity of significance from the local to the international level. At the same time, the plans provide guidance on the protection of specific valuable areas and on adaptation needs for maritime activities with the aim of preserving biodiversity and the integrity of the ecosystems. Such adaptations may be important for the preservation and recovery of stocks of commercial fish and shellfish species, and of species that are affected by by-catch or other disturbances. The marine spatial plans provide guidance on the protection of valuable cultural and recreational environments at sea, which promotes access to nature and culture. At the same time, there is a risk that several coastal landscapes, recreation areas and cultural environments loose attractiveness due to an expansion of wind farms and intensification of coastal shipping traffic.

5.3. Assessment against other plans, policies and programmes

According to the Marine Spatial Planning Ordinance, the marine spatial plan proposals shall be designed so that the plans integrate economic policy objectives, social objectives and environmental objectives. Within the scope of the marine spatial planning process, ten planning objectives have been developed to support this integration of policy areas. Overall objectives are a good marine environment and sustainable development, as well as a number of thematic and sector-specific interim objectives. All of the objectives relate to national policy areas and

strategies in different ways. The starting point for the assessment of the plan proposal is accordingly based on the planning objectives, set in relation to the national strategy for sustainable regional development in the entire country from 2021 to 2030 (Government, 2021).

Regional development policy forms part of Sweden's implementation of the global objectives for sustainable development Agenda 2030. Agenda 2030's objectives and interim objectives are integrated and indivisible and cover all three dimensions of sustainable development: the economic, the social and the environmental. The objective for the regional development policy is development capacity with strengthened local and regional competitiveness for sustainable development in all parts of the country. The strategy for regional development states that the policy shall promote a better environment, reduce climate impact and promote energy transition (see section 1.3). In addition, the policy shall promote a sustainable structural transformation and development of industry. The regional development policy shall promote conditions to conduct long-term sustainable development work and contribute to Sweden not having any net emissions of greenhouse gases by 2045. According to the strategy, all policy areas are of significance to achieving the objectives (Government, 2021).

Fel! Hittar inte referenskälla. indicates how the marine spatial plans are considered to contribute to the priorities in the national strategy for regional development. In the table, the marine spatial plans' impact on national interests and policy documents listed in Section 1.3 are also generally analysed.

National interests are geographic areas that have been pointed out as of national significance. The marine spatial plan proposal shall be consistent with provisions for the management of land and water areas and national interests according to Chapter 3 and Chapter 4 of the Environmental Code. As a point of departure, the marine spatial plan has different national interests and trade-offs between them. In balancing interests, coexistence must be pursued and in cases of incompatible interests, it must be ensured that national interests are not substantially impeded or damaged.

National strategy for regional development – prioritisation	**Planning objectives**	**The possibility for the MSP to influence and contribute to the strategy**	**National interests and policy documents**	**Impact of the marine spatial plans**
Equal opportunities for housing, work and welfare in the entire country - *High quality of life with good and attractive living environments*	*Creating conditions for:* • Regional development • Marine green infrastructure and the promotion of ecosystem services	By providing guidance on areas for use as recreation and cultural heritage environment, as well as consideration of and adaptation to natural and cultural landscapes, the marine spatial plansaffect the strategy's prioritisation related to promoting natural and cultural landscapes, spending time in nature, public transport and outdoor recreation. According to the strategy, green and blue areas also contribute to improved public health and quality of life.	National interests according to Chapter 3 and Chapter 4 of the Environmental Code: • Outdoor recreation • Cultural environment • Nature conservation *Examples related policy documents* Planning and Building Act, natural and cultural environment - Recreational objectives - Public health policy - Swedish Maritime Strategy (indicator 8, 9) - Strategy for sustainable tourism	The national interest for outdoor recreation and cultural heritage is to some extent considered to be accommodated based on the use recreation and culture. Potential impact on outdoor recreation and cultural heritage includes national interests located both in the marine spatial planning areas and on the coast. Cumulatively, there is potential negative impact of varying degrees on conditions for recreation, national interests for outdoor recreation and cultural

National strategy for regional development – prioritisation	Planning objectives	The possibility for the MSP to influence and contribute to the strategy	National interests and policy documents	Impact of the marine spatial plans
				heritage, based on the plan's guidance on energy extraction in the marine spatial plans. The impact and need for adaptation to promote coexistence needs to be assessed from a regional and local perspective.
Equal opportunities for housing, work and welfare in the entire country - *Good societal planning*	*Creating conditions for:* • Regional development • Energy transmission and renewable energy extraction in the sea • Marine green infrastructure and the promotion of ecosystem services	Through the plan's guidance on energy areas, and the use nature and particular consideration of high nature values, the marine spatial plan affects the strategy's priority to promote a societal structure that contributes to sustainable living environments, reduced climate impact, and the preservation of biodiversity and ecosystem services in a changed climate.	National interests according to Chapter 3 and Chapter 4 of the Environmental Code: • Facilities for energy production and distribution • Nature conservation *Examples of related policy documents:* - Energy policy objectives - Maritime strategy (indicator 3, 8, 9, 16) - Strategy for biological diversity - Strategy for sustainable tourism - EU strategy for renewable energy - EU strategy for the Blue Economy - EU strategy for the Baltic Sea region	National interests and complementary documentation regarding energy production and national interest for nature conservation are considered to be partly accommodated based on proposed and alternative energy areas, and the use nature and particular consideration of high nature values. The impact between these uses is presented in the previous section and the environmental description.
Equal opportunities for housing, work and welfare in the entire country - *Good societal planning*	*Creating conditions for:* • Regional development • Defence and security	Affects prioritisation through municipal planning to ensure that the interests of national defence are taken into account.	National interests according to Chapter 3 and Chapter 4 of the Environmental Code: • National defence *Examples of related policy documents:* - Security policy objectives	The national interest for national defence is considered to be accommodated to some extent based on the MSP guidance on investigation, adaptation and consideration.
Innovation and renewal and entrepreneurship and enterprise throughout the country *– A competitive, circular and bio-based, climate and environmentally sustainable economy*	*Creating conditions for:* • Regional development • Energy transmission and renewable energy extraction in the sea *Establish preparations for:* • Extraction of minerals and carbon dioxide storage	The plan's guidance on energy contributes to the strategy's priority regarding the expansion, production and use of renewable energy. This is important, among other things, to sustainable regional development. It is unclear how the plan's guidance on sand extraction affects the strategy's priorities.	National interests according to Chapter 3 and Chapter 4 of the Environmental Code: • Facilities for energy production and distribution *Related policy documents:* - Energy policy objectives - Maritime strategy (indicator 16) - EU strategy for renewable energy - EU strategy for the Blue Economy - EU strategy for the Baltic Sea region	The national interest for energy production is considered to be largely accommodated based on proposed energy areas and alternatives. A number of initial energy areas, classified as a public interest for special significance and presented by the Swedish Energy Agency (2023a), have, however, been excluded.
Innovation and renewal and entrepreneurship and enterprise	*Creating conditions for:* • Regional development	Through the plan's guidance on the use commercial fishing, including consideration guidance, the plan also	National interests according to Chapter 3 and Chapter 4 of the Environmental Code: • Commercial fishing	The marine spatial plans' guidance on energy extraction may negatively affect commercial fishing

National strategy for regional development – prioritisation	Planning objectives	The possibility for the MSP to influence and contribute to the strategy	National interests and policy documents	Impact of the marine spatial plans
throughout the country *– A competitive, circular and bio-based, climate and environmentally sustainable economy*	• Sustainable commercial fishing *Establish preparations for:* • Future establishment of sustainable aquaculture	affects the priority of a competitive, circular and bio-based, climate-sustainable economy. With regard to aquaculture, the plan does not yet provide guidance on this.	*Related policy documents:* - The fishing of the future - Maritime strategy (indicator 3, 17, 18) - The EU Common Fisheries Policy - EU strategy for the Blue Economy - EU strategy for the Baltic Sea region	through the limitation of fishing opportunities, including within national interest areas. The national interest for commercial fishing is partly accommodated for. Guidance on the use nature and particular consideration of high nature values, possibly even energy areas can have positive effects on the fish resource, thereby promoting sustainable fishing in a longer perspective.
Accessibility throughout the country through digital communication and the transportation system *– Accessibility through sustainable transport systems*	*Creating conditions for:* • Sustainable shipping	The plan's guidance on shipping affects priority based on the impact of the transport supply at sea, significant to people and business throughout the country. In prioritisation, it also highlights the importance of coordination activities and transport infrastructure between the local, regional and national levels.	National interests according to Chapter 3 and Chapter 4 of the Environmental Code: • Shipping *Related strategies:* - Transport policy objectives - Maritime strategy (indicator 10, 14, 15) - Regional plans - EU strategy for the Baltic Sea region	The national interest for shipping is considered to mainly be accommodated based on the use shipping in the marine spatial plans. A potential impact of varying degrees is considered to apply regarding conditions for shipping and proposed energy areas and alternative areas. The need for location-specific adaptations to promote coexistence with shipping is assessed for the respective energy area in the permit process.

Table 15 - The impact of the marine spatial plans on the priorities in the national strategy for regional development.

6. Measures, follow-up and monitoring

According to Chapter 6, Section 11, numbers 5 and 7 of the Environmental Code, an environmental impact assessment shall contain information on the measures planned to forestall, prevent, mitigate or remedy significant negative environmental effects, and an account of the measures planned for follow-up and monitoring of the significant environmental impact that the implementation of the plan or programme entails. In this section, proposals are presented for both types of measures, namely effect minimisation measures and measures for follow-up and monitoring.

Within the scope of the environmental impact assessment of the approved marine spatial plan, measures for the significant environmental effects that the marine spatial plan proposal was considered to give rise to (SwAM, 2019a) were analysed and described in detail. The analysis was then synced with the preparation of a new action programme within the scope of the Marine Strategy Framework Directive and the implementation of the Marine Strategy Framework Ordinance. Since the guidance in this proposal on amended Marine spatial plans about most uses does not differ from the guidance in the approved plans, the analysis and the action description that was done in 2019 still apply today. These measures are set out in Appendix B.

The proposal on amended Marine spatial plans has a special focus on the expansion of offshore wind energy. Correspondingly, the main objective of this consultation process is to identify the energy areas that are most suitable from a holistic perspective to proceed with the planning process. In this context, it is appropriate in this impact assessment to look at measures that specifically relate to the effects of offshore wind energy on the environment and other human activities. The impact assessment is carried out at an overall strategic level, and is therefore not suitable for establishing specific consideration measures for individual areas or projects. The analysis is therefore based on five main types of measures and uses results from the assessments in the previous chapters to illustrate what effects these types of measures are suitable for. The types of measures are 1. Placement, 2. The boundaries of the energy areas, 3. The design of the wind farm, 4. Technical choices for construction, operation and decommissioning, and 5. Improvement measures. The planning generally only concerns the first two types of measures, while types 1-4 are often subject to the licensing stage. Improvement measures have so far mostly been developed by wind power companies on a voluntary basis, but some countries have begun requiring the introduction of such measures.

Placement

The choice of location is a first and in many cases crucial step for the assessment of an energy area’s suitability, both for its financial viability and environmental effects. Location is also a fundamental assessment factor in the permissibility review of water activities according to the Environmental Code. Where assessment results show that a water activity entails an excessively high a risk of unacceptable damage to parts of the marine environment or other human interests, the activity can be denied at the proposed location. At present, such an assessment is very difficult to make on a strategic, overall level due to insufficiently detailed knowledge of environmental and socio-economic conditions in all proposed and alternative energy areas. In the current system of marine spatial plan guidance and an ’open door’ establishment system for offshore wind energy, it is also not possible to decide on permissibility in a certain area only on

the basis of results from a strategic assessment. Despite these limitations, these results are considered to be able to provide a valuable indication of locations that are more or less problematic for a certain use in the continued planning. The fact that strategic assessments take into consideration cumulative effects in a way that individual project assessments rarely do is especially valuable. Based on the results in this impact assessment, it may, for example, involve not including areas in the continued planning that are especially risky for birds or other endangered marine life, or entail especially large losses or risks to other human activities or interests.

The boundaries of the energy areas

There may be cases where an energy area's placement is generally acceptable, but where some adjustments to its boundaries must be made to minimise the risk of an unacceptable effect on other interests. The placement remains unchanged in its broad features, but the size of the energy area is adapted. Within the scope of the on-going marine spatial planning, such adaptations were made to the energy areas that were included in Swedish Energy Agency (2023a). But considering the results in this impact assessment, adaptation of the boundaries of some energy areas can be motivated, including the introduction of safety zones around shipping lanes; avoidance of fish spawning areas or disturbance of valuable benthic environments; reduced visual or physical disturbance of cultural heritage environments and recreation environments; avoidance of especially valuable areas for other marine industries, such as fishing.

Wind farm design

This type of measure is similar to the previous one, concerning the adaptation of an energy's external borders, but rather concerns the inherent design of a wind farm. This concerns, for example, the distance between wind power stations, the arrangement of the wind power stations or the introduction of vessel passage corridors. On a more detailed level, the placement of each individual wind power station, so-called 'micro-siting', is also included in this type of measure. Micro-siting is a permanent part of the wind farm project that is used for environmental protection purposes, among other things to avoid damage to nature types worthy of protection. Measures of this type generally intend to promote coexistence with other interests in terms of both the environment and other human activities. Passage corridors can, for example, be introduced to make it easier for fishing vessels to reach fishing areas beyond the wind farm, or to create more space for migrating birds. The arrangement and distance between wind power stations play a role in the possibility of conducting fishing in a wind farm (SwAM, Swedish Energy Agency, 2023) and for the degree of visual impact from various points on the coast.

Technical choices for construction, operation and decommissioning

Within this type of measure are many of the consideration measures prescribed in permits to build offshore wind energy. The measures vary widely and are generally adapted to the specific conditions in the project area and the specific effects that the wind power project is considered to give rise to. The establishment of measures of this type therefore requires detailed impact assessments. **Fel! Hittar inte referenskälla.** summarises some of the most frequent technical measures regarding environmental effects that are used during a wind farm's various stages (based on SwAM & Swedish Energy Agency, 2023). The corresponding technical measures may be required to reduce the risk of harm to other human interests. Commonly occurring measures

are those regarding marine and aviation safety, but with the aim of enabling coexistence with e.g. fishing, there are other technical choices that can be made. Examples of this are the burial of cables, adaptation of the construction work to the fishing activities, power station foundations without protruding parts or with fenders or minimising power station components that fishing gear can get stuck in (SwAM, Swedish Energy Agency, 2023). Coexistence with defence interests is another area where technical adaptation can be of interest.

Phase	Types of measures	Description and objectives
Investigation and project design	Placement	The placement and burial of cables in a way to avoid impact on sensitive benthic environments or species
Investigation and project design	Design	Choice of materials and gear with the least possible impact on the environment, such as station foundations that do not require piling or drilling or stations with a greater free height between rotor blades and the water surface
Investigation and project design	Scheduling	Conducting studies outside sensitive periods for protected species, such as reproduction, foraging and migration periods
Construction and maintenance	Scheduling	Implementation of construction and maintenance work outside sensitive periods for protected species, such as reproduction, foraging and migration periods
Construction and maintenance	Operational management and control	Emission controls to prevent or reduce various emissions or pressures during construction or maintenance work, such as protective noise-mitigation measures when piling for foundations
Construction and maintenance	Restoration	Restoration of benthic environments after completed construction and maintenance work, such as excavation of cables
Construction and operation	Operational management and control	Regulation of obstacle lighting or other lighting in areas where light-sensitive species occur
Construction and operation	Operational management and control	The use of acoustic scare methods in connection with work that causes noise at a level that can be harmful to protected species
Construction and operation	Operational management and control	Control of emissions of pollutants to water and air that can be harmful to the environment.
Construction and operation	Operational management and control	Regulation of boat traffic in connection with construction, service and maintenance in order to reduce the impact on species that are sensitive to noise or other human impact
Operation	Operational management and control	Changes to wind power stations or other parts of the wind farm in order to reduce the collision risk for birds and bats, such as the colour of rotor blades and stop regulation
Operation and	Operational management and control	Operation shutdown upon unforeseen large environmental effects with the aim of implementing damage-mitigation measures or environmental restoration measures

Phase	Types of measures	Description and objectives
decommissioning		
Decommissioning	Scheduling	Adaptation of the time of decommissioningor upgrading (*repowering*) to sensitive periods for protected species that occur in the area, such as reproduction, foraging or migration periods
Decommissioning	Restoration	Restoration of benthic environments in connection with decommissioning

Table 16. Consideration measures that are applied in the establishment of offshore wind energy. Based on a compilation done for the OSPAR group on the development of offshore renewable energy, ICG-ORED. Damage mitigation comprises the following four types of measures according to the damage mitigation hierarchy: avoidance, reduction, restoration and acceptance including compensation.

The introduction of these kinds of measures is set in most cases as a condition in order to reduce the effects on the environment and other human interests to acceptable levels in areas that would otherwise not have been suitable for wind power.

Improvement measures

This last type of measure comprises measures that have so far mainly been developed by wind power operators with the aim of achieving certain environmental improvements in connection with the construction of an offshore wind farm. The introduction of environmental improvement measures has mainly taken place on a voluntary basis by wind power operators, but in recent years, countries such as the UK and the Netherlands have begun to develop conditions for a net positive environmental effect, so-called ‘marine net gain’ and the introduction of nature-inclusion designs in offshore wind energy projects. The corresponding principles have been developed to create better conditions for other human activities to be conducted within wind farms, such as angling and other recreation or marine aquaculture. Improvement measures have so far been developed mainly in the scope of pilot projects, but it is likely that their application will become standard in the future. With regard to the environmental effects identified in the scope of this impact assessment, improvement measures can be suitable to increase the diversity of benthic environments and benefit demersal species.

Lastly, it is appropriate to mention some areas where the need for new knowledge is considered to be large in order to achieve sustainable use of the marine spatial planning areas in line with the objectives in the Marine spatial plans and other Swedish marine management. In the environmental impact assessment of the approved Marine spatial plans, six proposals on investigation and coordination areas were described (SwAM, 2019a): 1. cumulative impact from offshore wind energy on sea birds; 2. bats and impact from wind power; 3. alternative energy extraction areas; 4. area-specific measures in areas with particular consideration of high nature values; 5. rerouting of shipping in the Southern Bothnian Sea; and 6. further development of spatial data on ecosystem services. With the exception of the third area, these areas are still of current interest.

Three further areas in need of special investigation are discussed in the following paragraphs: 1. winter shipping and offshore wind energy in the Gulf of Bothnia; 2. the impact of offshore wind energy on outdoor recreation and tourism; and 3. a monitoring programme for offshore wind power.

Winter shipping and offshore wind energy

The problems surrounding the impact of offshore wind energy on winter shipping were described by the Swedish Maritime Administration in a memorandum in connection with the assignment to prepare proposals on suitable energy extraction areas for marine spatial planning (Swedish Agency for Energy, 2023a, Appendix 5). In order to assess the consequences of the Marine spatial plans' guidance on energy extraction and for the marine spatial planning to be able to provide guidance on future use of areas that are covered in ice during the year, knowledge regarding the impact of wind power needs to be improved. At present, there is no experience from other countries regarding wind power establishment and shipping in areas with similar conditions, which is why it is especially important to sort out the issue in the Gulf of Bothnia. The large number of energy areas in the marine spatial plan for the Gulf of Bothnia is an important argument behind the investigation.

Offshore wind energy's impact on outdoor life, recreation and the tourism industry

Visual impact from offshore wind energy is a commonly occurring argument against wind power establishment. Visual impact can affect the experience of both natural and built environments, and affect the value of outdoor life, recreation and cultural heritage environments. Knowledge about the actual scope of this effect is, however, insufficient, both from abroad and especially from Sweden. An investigation of the impact on Swedish cultural environments will be presented at the beginning of 2024, but there is no corresponding study of possible effects on outdoor life and recreation. Such an investigation is very important given the extensive expansion of offshore wind energy along Sweden's coasts that the Marine spatial plans provide guidance on. Given the lack of knowledge about actual effects on these two aspects and about secondary effects on the tourism industry, it is not currently possible to make a robust assessment of the effects of wind power establishment in various coastal areas.

Monitoring programme for offshore wind energy

The extensive expansion of offshore wind energy that the Marine spatial plans provide guidance on constitutes a significant intervention in the Swedish marine environment. Even if offshore wind farms have been in operation for over two decades, knowledge about biological and ecological effects is still very limited. The lack of knowledge especially encompasses effects in the long term and over larger geographic areas. Given the large-scale expansion not only in Sweden, but also in its neighbouring countries, it is precisely these large-scale effects that are of current interest.

Sweden's marine monitoring programme is insufficient to monitor the various environmental effects of wind power in all areas where offshore wind energy may be established. There are already shortcomings in monitoring of some of the marine species and habitats that are considered to be most affected by offshore wind energy, such as Baltic porpoise and multiple migratory birds. Sweden is not alone in this shortcoming, which means that there is relatively little knowledge about long-term, cumulative effects to draw from other countries. In addition, the conditions in Sweden's territorial sea and exclusive economic zone differ considerably from those

of the North Sea countries, where most of the knowledge of the effects of wind power has been produced so far.

Today, wind power project engineers gather very large amounts of data on the marine environment. This information generally remains private and only the part that is included in permit documents becomes public. When wind farms are built, the wind power operator is required to monitor the environmental effects according to a control programme that is set by the State. In light of this, the possibilities for cooperation between the State, private wind power operators and other organisations, including academia, should be analysed within the scope of the formulation of a future national monitoring programme.

7. Baseline and zero alternative

7.1. Management of plan alternatives, zero alternative and energy areas

The impact assessment is based on an estimate of the marine spatial plans' effects compared with the environmental conditions and the environment's probable development if the plans are not implemented (Chapter 6, Section 11 of the Environmental Code). The reference year for the plan alternatives has been set at 2040, based on an estimate of how long it could take for a full application of the plans, especially in terms of the expansion of offshore wind energy. This time limit means that the impact assessment is based on the marine spatial plans remain established and fully applied by 2040. This can be considered to be an unreasonable assumption, but at the same time, it is relevant for decision-makers to be able to get an overview of the cumulative impact of these marine spatial plans.

In terms of data, the environmental assessment is based on the knowledge of environmental parameters, such as ecosystem components, and human activities at the time of assessment. Most input data are from the past decade, with both older and newer data. For details on what data is used, refer to the reference list and in the Symphony metadata document (SwAM & SGU, 2018).

Common to all assessment parameters is the difficulty of foreseeing development until the reference year 2040. This challenge is especially large for the parameters that are undergoing rapid change. In this marine spatial planning process and impact assessment, the expansion of offshore wind power is of substantial significance due to its rapid pace of development and based on the marine spatial planning's explicit objective of identifying suitable areas for energy extraction. In line with this objective, the consultation, for which this impact assessment is the basis, has the aim of collecting input from various stakeholders regarding the suitability of the planned energy extraction areas.

In light of this, it is important in the impact assessment to estimate the environmental effect of every energy extraction area that is included in the plan and is thereby deemed to be able to be expanded. For this reason, the current situation, as it exists in 2023, is used as a zero alternative regarding the expansion of offshore energy extraction, where only the wind farm Lillgrund in Öresund is in the marine spatial planning area. In addition to Lillgrund, there are another three wind power projects in the marine spatial planning area that were granted permits in the summer of 2023, namely Kriegers Flak (2022) south of Skåne, and Kattegatt Syd and Galene (both 2023) in Kattegat. Since it is unclear at the time of writing when these parks will be built, they are not included in the zero alternative, even though issues regarding their impact and the need for consideration of the environment and other activities are deemed to be settled given the permit decisions.

In terms of the conditions in the environment and other activities, development is estimated up to the reference year 2040 based on the current situation in 2023 and future trend analyses for the cases where they are available. This is described under the following headings in this chapter.

The conditions in the environment and human activities that are considered to exist upon the full application of the marine spatial plans for the reference year 2040 are called plan alternatives. In this marine spatial planning process, there are two types of energy extraction areas, namely proposed energy areas and alternative energy areas. In the impact assessment, these two types are handled as two plan alternatives: plan alternative 1 including only the proposed energy areas, and plan alternative 2 including both the proposed energy areas and the alternative energy areas. Both plan alternatives are assessed against the zero alternative.

7.2. Hydrographic conditions

The salinity varies sharply along Sweden's coast, from around 30–33 psu (practical salinity unit, measures in g/l or g/kg) in eastern Skagerrak to 2–4 psu in the Bothnian Bay. The salinity variation means that each marine area has unique characteristics and sets limits for the ecosystems by affecting the ranges of species. With the change in salinity, there is a transition from saltwater species in Skagerrak to a predominance of freshwater species in the Gulf of Bothnia. The salinity also varies locally from lower levels at the coastline, especially at the mouths of rivers to higher levels in the open sea.

The Baltic Sea system has an estuary circulation, which means that water in the surface layer flows out of the Baltic Sea and deep water flows in. The large amounts of water that flow out from the rivers in the Baltic Sea area constitute surface water layers while deep water layers consist of deep water with a higher salinity from Skagerrak and Kattegat. The inflow of deep water is seasonally dependent. It requires special conditions of both water level and weather, which means that the entire Baltic Sea is sensitive to impact that can change these conditions. Within the Baltic Sea, several shallow thresholds impede the inflow of salt water through the Baltic Sea and to the Gulf of Bothnia. If inflows from Skagerrak and Kattegat during an extended period cannot replace the deep water in the Baltic Sea, it results in a stagnation period (SwAM, 2009) that affects marine life locally and on a larger scale. In the Gulf of Bothnia, it takes around 5 years for the water to be renewed, which is a large difference compared with the actual Baltic Sea's around 30 years. Skagerrak has a good water turnover due to the direct connection to the North Sea. However, Kattegat is a transition zone and the turnover of deep water may be limited for short periods of time (Havet.nu, 2023a), even if the turnover time is generally estimated at around three months.

Layering between different amounts of water in the water column can impede or prevent remixing between the water layers and thereby contribute to oxygen-deficient seabeds (Swedish Environmental Protection Agency, 2013). Oxygen deficit at the seabed leads to reduced biodiversity and altered species composition and thereby has a negative impact on the ecosystems. Under oxygen-free conditions, nutrients are also released, such as phosphate and silicate, from the sediment to the water, which can reach the surface layer and contribute to the eutrophication problem. In the Baltic Sea's marine spatial planning area, a large part of the deeper seabeds is entirely or occasionally without oxygen, and the spread of this does not appear to be decreasing (SwAM, 2022).

The Gulf of Bothnia has two shallow thresholds, South and North Kvarken and the enclosed location means that the water quality here is almost entirely characterised by water from rivers and streams, which makes the salinity in the area low. Surface water circulation in the Gulf of Bothnia goes anti-clockwise as saltier water that comes from the east, mixes with water from the

rivers and streams to the south along Sweden's coast. During the summer, a layering is created at around 15 m depth in the area, but the deep remixing during cold winters means that the Bothnian Bay does not show a lack of oxygen in the bottom water. The water's turnover is affected among other things by the ice cover. During a normal winter, the maximal spread of ice covers the entire Gulf of Bothnia and the northern parts of the Baltic Sea. In the Gulf of Bothnia's areas close to the coast, the ice cover is the longest, between 100-190 days a year. In marine spatial planning, it is important to note that summer and winter conditions may entail two entirely different environments and circumstances.

The general trend in the entire Baltic Sea is a deteriorated vertical circulation due to a higher temperature that causes stronger layering between the surface and deep waters. All marine areas are negatively affected by these changes, but they lead to larger effects in some areas and on some species. For the cod, the Central, South-eastern and South Baltic Sea are extra important spawning and nursery areas and, in these areas, worse hydrographic conditions pose a threat to the species' recovery.

In Skagerrak and Kattegat, the salt water flowing in from Skagerrak with a salinity of around 34 psu forms the bottom water in Kattegat. The water that flows out of the Baltic Sea has a salinity of around 10 psu and a lower density than the saltier deep water. On its way through Kattegat, the salty bottom water is mixed in surface layers that in Northern Kattegat and Eastern Skagerrak have a salinity between 25 and 30 psu. Skagerrak has an average depth of 218 m with a good oxygen supply through the entire water column. Kattegat has an average depth of 23 m and a stable layering at a depth of around 15 m that limits vertical remixing.

7.3. Biological conditions

The species diversity along Sweden's coasts varies widely, mainly due to the salinity variation. The larger number of plant and animal species goes from around 1 500 species in Skagerrak and around 800 species in Kattegat to around 70 species in the Baltic Sea south of Gotland. Seabeds lined with plants are amongst the most productive and species-rich.

Biodiversity is vital to be able to preserve the ecosystem services people depend on and retain the natural population composition. The Gulf of Bothnia and the Baltic Sea area have significantly lower biological diversity than Skagerrak and Kattegat and are deemed to be more sensitive to changes. Skagerrak and Kattegat also have large sediment-dwelling organisms that can increase the oxygenation of sediment and thereby increase the binding of nitrogen, phosphorous and carbon. This process, which reduces the effects of acidification and eutrophication, is missing in the Baltic Sea area. Both the Gulf of Bothnia and the Baltic Sea, however, have shown extensive resilience as several endangered species have recovered following implemented measures. Examples of such species are the ringed seal in the Gulf of Bothnia, as well as amphipods, whose special sensitivity to external environmental factors makes it an indicator species. Another example is the Baltic clam, which has increased in number and biomass in the North Bothnian Sea, but decreased in the South Bothnian Sea; although other species with a high sensitivity value have increased in this area (Swedish Institute for the Marine Environment, 2016). In the Baltic Sea area, for example, the predatory bird and harbour seal populations, which have suffered extensive damage from the environmental and health-damaging substances that are abbreviated as PCB, have now successfully recovered.

According to the Swedish Species Information Bank's 2020 red list (Swedish Species Information Centre, n.d.), 237 marine species and 60 brackish water species in Swedish waters are red-listed. In general, few marine species are red-listed, which is considered to be due to a lack of knowledge about the status of the species. This means that several species cannot be assessed based on the red list criteria. The changes that have occurred in the marine environment are thereby considered to be able to affect far more species than what the red list reflects (SwAM, 2015a). The lack of knowledge is especially large for invertebrates and algae and many species in these groups are in the red list category "Data Deficient". In general, the spread of oxygen-free seabeds, large-scale climate changes and the effects of fishing are the greatest threats to marine species. Other important factors are environmental toxins, exploitation of shallow areas, acidification, and predation from marine mammals and birds (SwAM, 2022).

The Gulf of Bothnia does not contain as many species as the other Swedish marine areas, but most populations are healthy. Here, there are both brackish water species and freshwater species, and a typical benthic fauna community consists of around 10 species (Havet.nu, 2023b). Future changes in salinity levels may have a major impact on the sensitive species composition. The stable winter ice in the open sea forms a substrate for photosynthesising algae and the ringed seal needs the ice for the pups to survive. When climate change reduces the extent of the stable ice, the northern parts of the Bothnian Bay will become increasingly more crucial (SwAM, 2017a).

In the Baltic Sea, marine and freshwater species live in the same habitat and are often genetically adapted to the brackish water environment. Compared with many other seas, biodiversity in the Baltic Sea is low. Since only a few key species constitute the foundation of food webs, the Baltic Sea is especially sensitive to human impact. Öresund is a shallow area with plant and animal life that is a mix between the coastal environments of the Baltic Sea and Skagerrak and Kattegat. Bottom environments are dominated by marine species where the salinity is high while more brackish water species typical of the Baltic Sea area are dominant in the surface layer shallower than 10-12 m.

Large-scale fluctuations in the climate in recent decades have affected the Baltic Sea and make it difficult to distinguish between natural and human factors. At the lower trophic levels, the composition of plant plankton has changed, which in turn has entailed an impact on the stock of zooplankton and copepods, which are the main food for fish. At the same time, many submerged aquatics have disappeared in exploited and polluted areas, especially in the South Baltic Sea. Invertebrate populations have decreased both in number and in individual density, at the same time that the Baltic Sea's ecosystems are deemed to have undergone a regime change, especially in terms of fish communities (Eklöf et al., 2020; Yletyinen et al., 2016), which has affected species that are dependent on fish.

The blue mussel is one of the most important biotope-forming species in the Baltic Sea, as it is the dominant species on hard seabeds (Marbipp, 2018). Other especially important biotope-forming species are bladderwrack and eelgrass. It is of major importance to preserve and try to benefit these key species. Blue (common) mussel banks constitute a substrate for other organisms and therefore indicate high biodiversity. These mussel banks also contribute a regulating ecosystem service in the form of filtration of particles in the water, which contributes to lower turbidity in the water column. Today, the largest mussel communities are limited to

shallower seabeds and the banks are therefore of high protection value. The range of the blue mussel is limited by salinity and therefore does not extend beyond the Bothnian Sea.

The significance of the various key species varies in the Baltic Sea's different marine areas. On soft seabeds in the North Baltic Sea and South-eastern Baltic Sea, eelgrass, sago pondweed, etc. are commonly occurring and significant species. In the area south of Öland, large, dense seaweed belts mainly of toothed wrack have been documented. In the South Baltic Sea, bladderwrack and toothed wrack dominate the hard seabeds and there are around 100 species of macroalgae there, a majority of which are very uncommon (SwAM, 2015a). On Öresund's soft seabeds, eelgrass is dominant. On hard seabeds, there are often brown algae, such as bladderwrack, which form seaweed belts.

With their almost ocean-like conditions, Skagerrak and Kattegat have greater biodiversity compared with the Baltic Sea and the Gulf of Bothnia. Skagerrak, which is deeper, has a more stable salinity and a good oxygen supply and has nearly twice as many larger animal and plant species as Kattegat. Of the macroalgae that occur in Skagerrak and Kattegat, a majority are very uncommon, as in the Baltic Sea. In Skagerrak and Kattegat, a large addition of nutrients caused by humankind has entailed major changes along the coast with strong increases in the amount of plant plankton and organic particles in the water. A larger number of particles reduces the supply of light for plants and an increased nutrient supply generally benefits rapidly growing algae. Long-term changes in the seaweed community vary along Sweden's coast.

Today, eelgrass is an endangered species. Along the Bohuslän coast, its area spread has decreased by over 60 per cent since the 1980s as a result of eutrophication and overfishing, which corresponds to a loss of around 12,500 ha of eelgrass (Moksnes et al., 2016). Eelgrass has root systems that can form beds that bind sediment, which reduces the effects of erosion on the bottom at the same time that they add oxygen and are important nursery areas for several fish species. Healthy eelgrass beds also bind a large amount of nutrients, which can counteract algae blooms and carbon, which can reduce the carbon dioxide level and counteract the acidification of the seawater. To benefit from good growth opportunities and high biodiversity, the size of the eelgrass beds is important. The eelgrass beds' size has proven to be the most important factor for the survival of juvenile fish that live in the beds (Staveley et al., 2016).

In Skagerrak and Kattegat, it is also important to preserve and benefit the key species of blue mussels and Lophelia pertusa, which are two important biotope-building species for the survival of the ecosystems that are still there. Structure-forming species, such as Lophelia pertusa, often have a long lifespan and low reproduction, something that makes them sensitive to changes. Other species that have proven to be essential are small grazers, such as amphipods. With high diversity in this group, the fouling can be kept down, which is important to maintain eelgrass beds.

Soft seabeds that are relatively unaffected by humans can also have a high protective value as they are often home to digging organisms and various species of sea pen. Life sponges are also effective filterers that can take up plankton and other organic materials and mainly spread on hard moraine bottoms. Many invertebrates are bottom-dwelling organisms and have therefore been affected to a high degree by bottom trawling. Trawler fishing is most intensive in Kattegat, followed by Skagerrak and the South Baltic Sea's marine area, which makes the invertebrates in these marine areas the most vulnerable. The long-lived tall sea pen, which was previously found in Skagerrak and Kattegat, is particularly hit hard by the intensive bottom trawler fishing and is

currently endangered (Swedish Species Information Centre, n.d.; Sköld, et al., 2021). Skagerrak and Kattegat have the highest occurrence of crustaceans, such as Northern prawn, brown crab, lobster and Norwegian lobster. These species are of major economic significance but are currently affected by high fishing pressure from both commercial fishing and angling (SwAM & SLU, 2019).

Fish

The fish fauna's composition in the Gulf of Bothnia consists mainly of cod, herring and sprat, with freshwater species such as perch and roach closer to the coast. Salmon, salmon trout and eel occur but consist to some extent of planted individuals. The stock of whitefish is stable in the
7.3.1 Bothnian Bay, but in the Bothnian Sea, the lack of older individuals and decreasing catches per effort in commercial fishing indicates that the stock is outside biologically safe limits. In recent years, the situation of herring has received a lot of attention in connection with several reports of decreasing supplies of herring along the Swedish coast, especially large herring. The herring's low average weight in the past 15 years is deemed to be the result of, among other things, high fishing pressure, predation by the grey seal and changes in access to food, and one of the causes behind the decreasing spawning biomass. In sample fishing, the catches of perch have been stable in most of the Gulf of Bothnia, except in North Kvarken, where the trends have been negative, also for the number of large individuals. The situation for wild salmon in the Bothnian Bay has been improving for a few decades, and today shows a good status, while the stocks further south is generally weaker. Reduced fishing together with other measures has led to reduced mortality in recent years, but there are concerns about disease-related mortality in several rivers. The wild sea trout stocks have been negatively impacted by several impact factors, such as eutrophication, canalisation, migration obstacles, hydropower utilisation and excessively low water flow in the summer, and impact from a warmer climate. The impact of fishing on the populations is not known, which justifies a precautionary approach in terms of all fishing. Vendace, which is economically the most important species in the Bothnian Bay, has relatively stable stocks despite annual variations, even if the knowledge of the population structure is deemed to be limited. Predation by the ringed seal is deemed to be up to five times larger than the withdrawal from fishing (Resource Overview, 2022).

The fish fauna in the Baltic Sea consists of around 50 fish species. In the offshore areas, this mainly involves saltwater species, such as cod, herring and sprat, while the more coastal areas are dominated by freshwater species, such as perch and roach, as well as flatfish. Eel occurs along the coastal areas with the greatest extent in the southern marine areas. The stock of salmon, salmon trout, eel and to some extent also whitefish is a mix of natural and planted fish. In the Baltic Sea, fishing pressure has historically had a large impact on several commercially interesting species, such as cod, haddock, sole, plaice and pollack. The recovery is progressing slowly even though fishing for some species was stopped, the trawling boundary has been moved out and other preservation measures have been implemented. The status of cod is especially worrying, and new recruitment of young cod has been at very low levels since 2017 (Resource Overview, 2022). In the Öresund area, where trawler fishing has been prohibited since the 1930s, the situation is better, but here, the share of large fish has decreased in recent years, as well (SwAM, 2015a).

The composition of fish fauna in Skagerrak and Kattegat is roughly the same as in the rest of the North Sea. Around 80 marine fish species reproduce in Swedish waters and the number of fish

species generally decreases from Skagerrak towards Öresund. Cod, herring, sprat and sand lance dominate, along with flatfish on sand and clay beds. Eel occurs along Sweden's entire west coast, but more generally in the southern areas (SwAM, 2015b). The largest eel population in Sweden is located in Southern Skagerrak's inner coastal area, but it has a high occurrence throughout the marine spatial planning area of Skagerrak and Kattegat. Since the end of the 19th century, the fish community in Skagerrak and Kattegat has changed with a decrease of large adult predatory fish to an ecosystem where small and young individuals are dominant. Examples of species that have been seriously affected by the intensity of the fishing are cod, haddock, sole, plaice and pollack. Recovery is progressing slowly despite various conservation measures, and the levels are not satisfactory. The number of cod is still at such a low level that they are deemed to have a reduced reproductive capacity.

The main human impact on the fish population is of course fishing, but the population is also affected by the supply of nutrients and environmental toxins, as well as exploitation and the physical impact on habitats. Regulation of rivers and clean-ups in both large and small bodies of water affect fish stocks and fishing by limiting access to suitable spawning areas for marine fish (SwAM, 2015a). Other physical disruptions in the ecosystem may be due to dredging, installations, lost fishing gear and noise. One uncertainty factor is how the fish's habitat and food base are affected by climate change and the increased spread of oxygen-deficient bottoms in the Baltic Sea. More than 20 species of fish are included in the red list for endangered species, including cod, haddock, ling and halibut, as well as hake and starry ray (Swedish Institute for the Marine Environment, 2016).

7.3.2. Marine mammals

The situation for all three seal species has improved since the 1970s when they were severely endangered due to hunting and low fertility. However, since 1988, several disease epidemics have negatively affected the seal populations. The harbour seal was struck by PDV (Phocine distemper virus), which led to half of the seal populations in Skagerrak and Kattegat dying. Despite this, the grey seal population is reported to have a good growth rate (SwAM, 2015a) and the species' range is the largest in the North Baltic Sea and South Gulf of Bothnia (Havet.nu, 20123b).

The marine mammals found in the Gulf of Bothnia are grey seal and ringed seal; in the Baltic Sea, there are grey seal, harbour seal, ringed seal and porpoise, and in Skagerrak and Kattegat, there are grey seal, harbour seal and porpoise. In the Gulf of Bothnia, both the ringed seal and the grey seal are classified as "of least concern". The ringed seal is dependent on the spread of the sea ice as it gives birth to its pup on ice, which the grey seal also prefers to do (Lewander et al., 2011). The ringed seal therefore mainly occurs in the Bothnian Bay during the winter and is thereby very affected by global warming that is at risk of reducing the spread of the ice. For a greater recovery and increased viability of the ringed seal population, further measures are required, especially measures to counteract climate change (SwAM, 2015c). The status of seal species in the Baltic Sea has improved in recent years, and most of them are classified as "of least concern". The harbour seal is, however, classified as "vulnerable" in the Baltic Sea, but as "of least concern" in Skagerrak and Kattegat. The grey seal is the largest of the seal species and is not as common in Skagerrak and Kattegat as the harbour seal, which is the marine spatial planning area's most common seal species. The harbour seal is the only seal species that usually reproduces in Skagerrak and Kattegat.

The porpoise is the only whale species that lives in Swedish waters and it is encountered in all marine areas in the marine spatial planning area. In the Baltic Sea, there are two populations of porpoise, which are called the Baltic Sea population and the Danish Straits population. The Baltic Sea population has been red-listed since 2020 and is classified as “critically endangered”. The porpoise population is mainly affected by injuries from fishing, underwater noise, ecosystem changes and environmental toxins. Today, the species does not have an adequately strong protection system as only a few of the marine protected areas are specifically designed to protect the porpoise. This entails a major risk mainly to the continued existence of the Baltic Sea population as Swedish waters encompass its main range (Carlström & Carlén, 2016). In Skagerrak and Kattegat, there is the Skagerrak population of harbour porpoises that have one large and several small (but important) reproduction areas mainly in Skagerrak (Wijkmark, 2015). An area especially worthy of protection for this population is the area at Jutland’s northern tip, which is part of a large reproduction area. In Kattegat, Fladen and Lilla and Stora Middelgrund are the important areas for the porpoise, which are mainly used by the Danish Straits population. Neither the population in Skagerrak nor the Danish Straits population are endangered today, but are classified as “of least concern”.

Birds

7.3.3 The dominant breeding birds in the Gulf of Bothnia are eider, common scoter and velvet scoter (Green, 2016). Predominant breeding birds in the Baltic Sea’s archipelagos are eider, black-headed gulls and cormorants, and there are also large stocks of several other diving ducks and gulls. On the Karlsöarna islands at the southern boundary of the Central Baltic Sea, there are particularly large colonies of razorbills and guillemots. Razorbills, guillemots and black guillemots are also found further north in the Baltic Sea.

There are many wintering stocks of seabirds in both the Gulf of Bothnia and the Baltic Sea, but they are dominated by diving ducks, such as tufted ducks and long-tailed ducks. Auks also winter in both areas together with various species of gulls (SwAM, 2015a). Many marine bird species, such as long-tailed ducks, eider and velvet scoters, have decreased drastically in the Baltic Sea area in recent decades.

The predominating breeding birds in Skagerrak and Kattegat are eider and gulls such as the herring gull. The majority breed in the archipelagos of Bohuslän, but significant colonies also exist on islands in Kattegat. Among resting and wintering sea birds, eider, velvet scoters and common scoters are the most common, along with a significant number of goldeneyes and mute swans on inland waters. Fulmar and gannets can also be found there, especially in connection with stormy weather in autumn and winter. Other species are also regularly observed, such as black-legged kittiwakes, which breed at Nidingen.

The sea eagle is Sweden’s largest predatory bird and a typical species along the entire Baltic Sea coast. After being exposed to poisoning by the environmental toxins DDT[2] and PCB[3], which prevented reproduction and almost led to the species’ extinction in the late 1970s, a gradual recovery of the population has been observed. This recovery is seen as an example of successful nature conservation, and it is expected that there are currently over 800 breeding sea eagle pairs in Sweden, which is the same level as in the 1950s. Damage to eggs from these environmental

[2] DDT= dichlorodiphenyltrichloroethane

[3] PCB=chlorinated substances polychlorinated biphenyls

toxins, and also elevated levels of lead in tissue, are at times still found, even if most of the deaths are caused by collisions with trains and power lines (Swedish Museum of Natural History, 2015).

7.4. Chemical conditions

Today, marine environments are affected by both historical and contemporary pressures. These consist mainly of emissions of nutrients from activities on land and water and selective withdrawals of species through fishing, but also other human activities. The first monitoring of environmental toxins in Swedish marine areas began in the late 1960s and several measurement series have been added since. Since the first measurements, the levels of early environmental toxins, such as the poorly biodegradable PCB and DDT, as well as lead, have decreased in organisms in the marine environment thanks to successful remediation measures. This has contributed to a significant recovery of several marine species, such as the sea eagle and seal. Even if the levels of most classical environmental toxins have decreased, the Swedish Food Safety Agency still recommends children, young people and women of fertile age to eat fatty fish from the Baltic Sea no more than two to three times a year as a result of dioxins and other environmental toxins in this fish.

Illegal oil emissions from ships in the Baltic Sea and Skagerrak and Kattegat, oil leakage from propeller casings and wrecks in Skagerrak and Kattegat contribute to the pollution of Sweden's seas (Swedish Institute for the Marine Environment, 2014). The Gulf of Bothnia's long tradition of industries has resulted in many polluted areas with high levels of environmental toxins along the coast. The emissions entail concrete environmental challenges when future needs for the dredging of shipping lanes, energy production and energy transmission are to be met.

Altogether, the results from the environmental monitoring show that Sweden is still far from the goal of a toxin-free environment, even if the supply of several environmental toxins has continuously decreased in recent decades and the conditions for achieving this goal have improved in recent years (SwAM, 2018; Swedish Chemicals Agency, 2022). According to the latest initial assessment done within the scope of the EU Marine Strategy Framework Directive, the levels of most hazardous substances are still higher than the thresholds that define good environmental status. Especially worrying are the high levels of mercury and brominated diphenyl ethers, which are exceeded in fish in coastal waters throughout Sweden and which also show no or slow improvement. Dioxins and dioxin-like pollutants continue to be problematic in the Baltic Sea. Since the Baltic Sea's ecosystem is relatively young and poor in species, it is especially sensitive to hazardous substances, particularly if they affect key species. Despite a downward trend in tin pollution, there are still endocrine-disrupting effects on molluscs, especially in the coastal waters of Skagerrak, Kattegat and the Baltic Proper. The cadmium levels in offshore sediment in the water around Gotland are also at an excessively high level, which can partly be attributed to the high levels in the bedrock in the area. A growing problem globally is plastic pollution in the sea, especially when broken down into microscopic particles that can be absorbed by organisms and cause poisoning.

7.5. Maritime activities and pressures

Energy extraction

7.5.1 Offshore energy production can come from wind, waves, currents, tides or salinity gradients. In Sweden, offshore energy production takes place on a small scale and mainly as wind power. In 2022, Swedish wind power produced 33 TWh, of which offshore power accounted for 0.6 TWh (Swedish Energy Agency, 2023c). Today, there are three wind farms at sea in Swedish waters (Bockstigen, Kårehamn and Lillgrund), all of which are located in the territorial sea, but only Lillgrund is included in the marine spatial planning area. Interest in offshore wind power has increased sharply in recent years, partly as a result of increased expectations regarding the role of electrification in the climate transition. Another driving force is the strong technology and market development internationally that has contributed to cost reductions. The offshore wind power being planned today has, for example, significantly larger turbines and can be built at a greater depth than earlier generations (Swedish Energy Agency, 2023a).

In the Gulf of Bothnia's marine spatial planning area, there are today no stations in operation. Here, the conditions for offshore wind power differ to some extent from the other marine spatial planning areas, as conflicts of interest with other uses are generally fewer. One factor unique to the Gulf of Bothnia's marine spatial planning area is the annual ice formation in winter, and there is a need for improved knowledge of how offshore wind power would affect the sea ice, as well as conditions for icebreaking and winter navigation (SwAM, 2022). Wind conditions in the area are generally good, but still somewhat worse compared with the other marine spatial planning areas (Swedish Energy Agency, 2023a). In the Baltic Sea marine spatial planning area, as mentioned above, there is one small wind farm in operation. In May 2022, the Government granted permits for an additional project, in the Swedish part of Kriegers Flak. The conditions for wind power in the Baltic Sea vary, but wind and depth conditions are generally good. In the marine spatial planning area, shipping and national defence have large surface area claims, and there are also high nature values that are at risk of being affected by wind power establishments. In the Skagerrak and Kattegat marine spatial planning area, there are good conditions for wind power, but here, the sector competes for space with commercial fishing and shipping. Since July 2023, there have been two permits granted for the wind farms Kattegatt Syd and Galene off of the Halland coast.

Pressures linked to offshore wind power vary between the construction phase, operational phase and decommissioning phase. The impact during the construction and decommissioning phase is temporary and mainly relates to seabed impact and noise. The footprint is also different depending on the type of foundation. Bottom-fixed foundations are anchored in place with suction cup anchors, or through piling or drilling in the seabed. Today, bottom-fixed foundations are used down to a depth of around 70 metres, but trials are underway in deeper waters. Floating foundations are preferable over bottom-fixed foundations for use at depths of at least around 50 metres, and are anchored to the bottom with lines. The floating wind power has a significantly larger footprint in the water column than the bottom-fixed foundations since lines and electric cables need to be several times longer than the distance between the turbine and the seabed. The different kinds of foundations have roughly the same impact on the seabed (Swedish Energy Agency, 2023a).

During the operating phase, some noise arises, but the effects of this are not clear. Birds and bats are at risk of being affected by collisions, but some species can also suffer habitat loss as they avoid the wind farm to seek food elsewhere. The laying of cables entails physical impact on the benthic environment and turbidity, which can affect fish, benthic fauna and benthic flora. During operation, the cable generates an electromagnetic field, but based on current knowledge, this is not deemed to constitute a threat to fish or fish populations (Öhman, 2023). One potential positive effect of wind power is that the foundations can act as artificial reefs and attract certain invertebrates, fish and marine mammals (Bergström, et al., 2022).

In terms of other energy extraction at sea, the technology is new and largely under development. Research, development and demonstrations within sea-wave power, as well as research and development within tidal stream energy, are being conducted in Sweden. Several private and public actors are preparing new experiments with marine energy in Swedish waters (International Energy Agency, 2023). Today, several wind power projects highlight the possibility of producing hydrogen with the electricity generated by the wind power, either in the actual facility or on land. On-site production entails additional infrastructure at sea, either to be able to receive ships and load hydrogen, or gas pipelines to land. There is currently no hydrogen production in the Swedish marine spatial planning area. Regarding natural gas, there is today a pipeline between Malmö and Denmark that accounts for the supply to the western Swedish natural gas network. Two parallel lines run between Russia and Germany through Sweden’s exclusive economic zone (Nord Stream). Another pipeline is planned between Poland and Denmark, which can also affect the Swedish exclusive economic zone.

7.5.2. Defence

Defence activities in the marine spatial planning area mainly include signals intelligence, surveillance and training activities. The Swedish Armed Forces are currently undergoing the largest growth since the 1950s, based on the Government’s defence decision (Government, 2020), and military activities are conducted in all marine spatial planning areas (**Fel! Hittar inte referenskälla.**). In the Gulf of Bothnia’s marine spatial planning area, there are artillery and aerial training activities in parts of Skellefteå and Luleå Municipality, which, for example, require particular consideration upon energy expansion. In the Baltic Sea’s marine spatial planning area, national defence has large surface area claims, with several artillery and training areas, including those around Gotland and the Blekinge Archipelago. In the Skagerrak and Kattegat marine spatial planning area, there is a large marine exercise area that extends from Sotenäs Municipality in the north to Tjörn Municipality in the south and a smaller area located off of Gothenburg Municipality.

Artillery exercises conducted in appointed areas, both below and above the water, cause pollutants through the introduction of metals to the marine environment. In addition to physical impact, artillery and blasting exercises, and to some extent aviation and ship exercises, cause underwater noise. Effects on marine life vary to some extent with the time of the year, where e.g., spawning periods for fish and breeding and brooding periods for birds are more sensitive. The Swedish Armed Forces, however, need to exercise even at these times and have therefore developed a marine biology calendar to be able to take consideration when the impact risk is large.

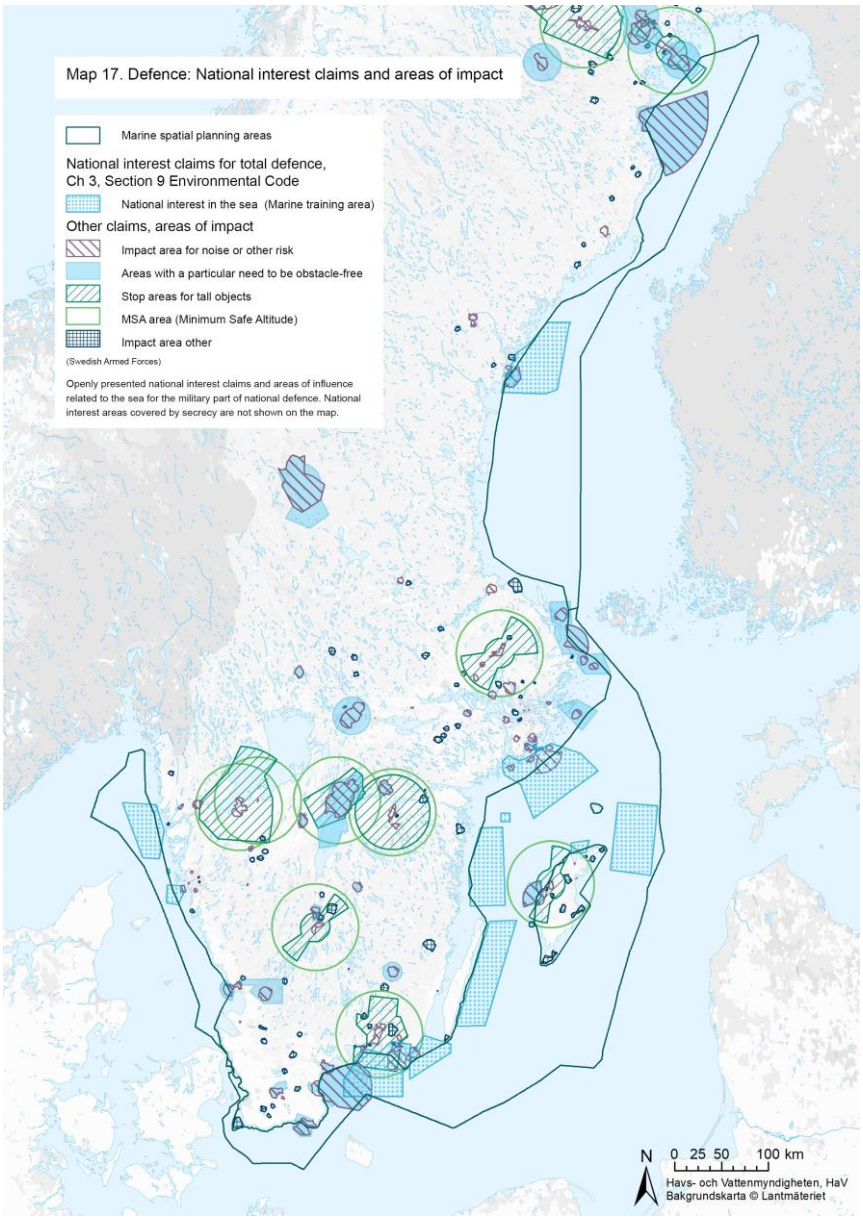


Figure 37. Defence: National interest claims and areas of impact (SwAM, 2023a).

7.5.3. Cultural environment

One of several drivers for marine tourism is access to cultural environments along the coast (**Fel! Hittar inte referenskälla.**). The intensive activities in the coastal and archipelago landscapes over the centuries have resulted in an extensive cultural landscape both on land and at sea. With its low salinity, the Baltic Sea has a unique ability to conserve shipwrecks, which makes it a well-preserved cultural treasure to explore and manage. Today, there are around 300 identified national interests for cultural environment conservation along the coast, but none are in the marine spatial planning area yet. Cultural environments outside the marine spatial planning areas can, however, be indirectly affected by changes in the landscape or changed accessibility in the marine spatial planning areas. At the Swedish National Heritage Board, work is underway to develop guidelines for the identification of national interests for cultural environment preservation in the sea.

Climate change effects, such as an increase in the sea level and an accompanying coastal displacement, can lead to cultural environments being damaged both on land and in the sea. An increase in the sea temperature can also entail the establishment of invasive species that damage wooden structures. Shipwrecks, older port facilities and industrial heritage environments can in turn constitute environmental threats if they contain heavy metals and other environmentally hazardous substances that are released into the sea.

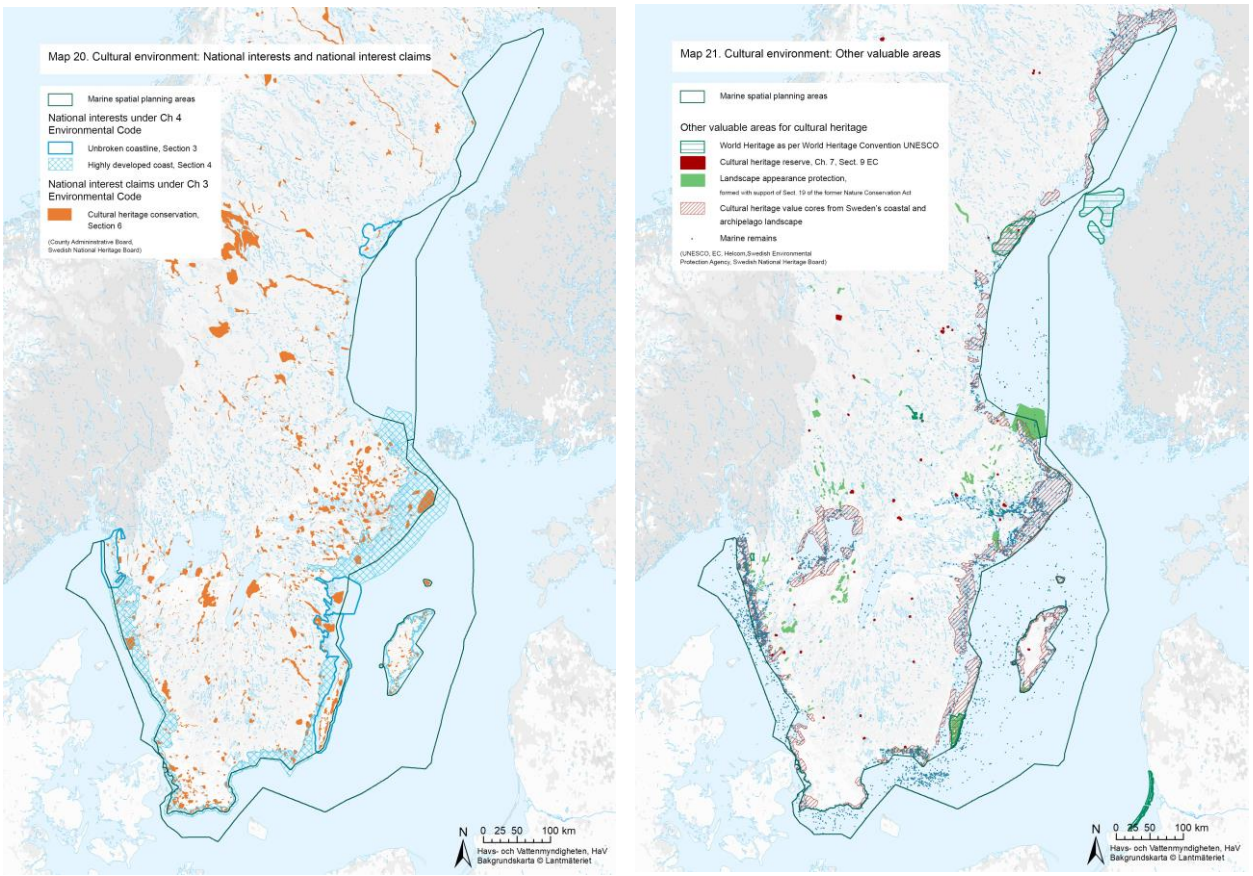


Figure 38. Cultural environment: National interests and national interest claims (Left); Cultural environment: Other valuable environments (Right) (SwAM, 2023a).

Storage and extraction of materials

7.5.4.

Sand and gravel extracted from the seabed are mainly used in the production of building materials and for coastal replenishment. Today, there are no permits for sand, gravel and stone extraction in Sweden, since the earlier permit in the Baltic Sea marine spatial planning area (Ystad Municipality) expired in 2021. A permit for the extraction of sand in Skälderviken is currently being reviewed (August 2023) in Ängelholm and Höganäs municipalities, to counteract coastal erosion in the area. The need for extraction that is intended for material supply is the greatest in Stockholm-Mälardalen, Skåne and Västra Götaland. Here, there are also good possibilities to receive, store, refine and transport marine sand and gravel. Extraction intended for coastal replenishment is mainly of interest in Southern Sweden, which is generally hardest hit by coastal erosion. The extraction of material from the seabed means that sediment and its associated benthic fauna and flora are removed. In addition to the direct impact on the seabed, bird, fish and mammal populations that feed on these resources are negatively impacted. The recovery of benthic flora and fauna varies between different habitat types, from a few months to years.

Today, there is no carbon dioxide storage in Sweden, and at present, there is insufficient data and knowledge to propose areas for storage in the marine spatial plans. Environmental effects of carbon dioxide storage are mainly associated with the risk of leakage from the storage site and potential effects of acidification of the water, in addition to pressures in connection with the construction phase.

Nature

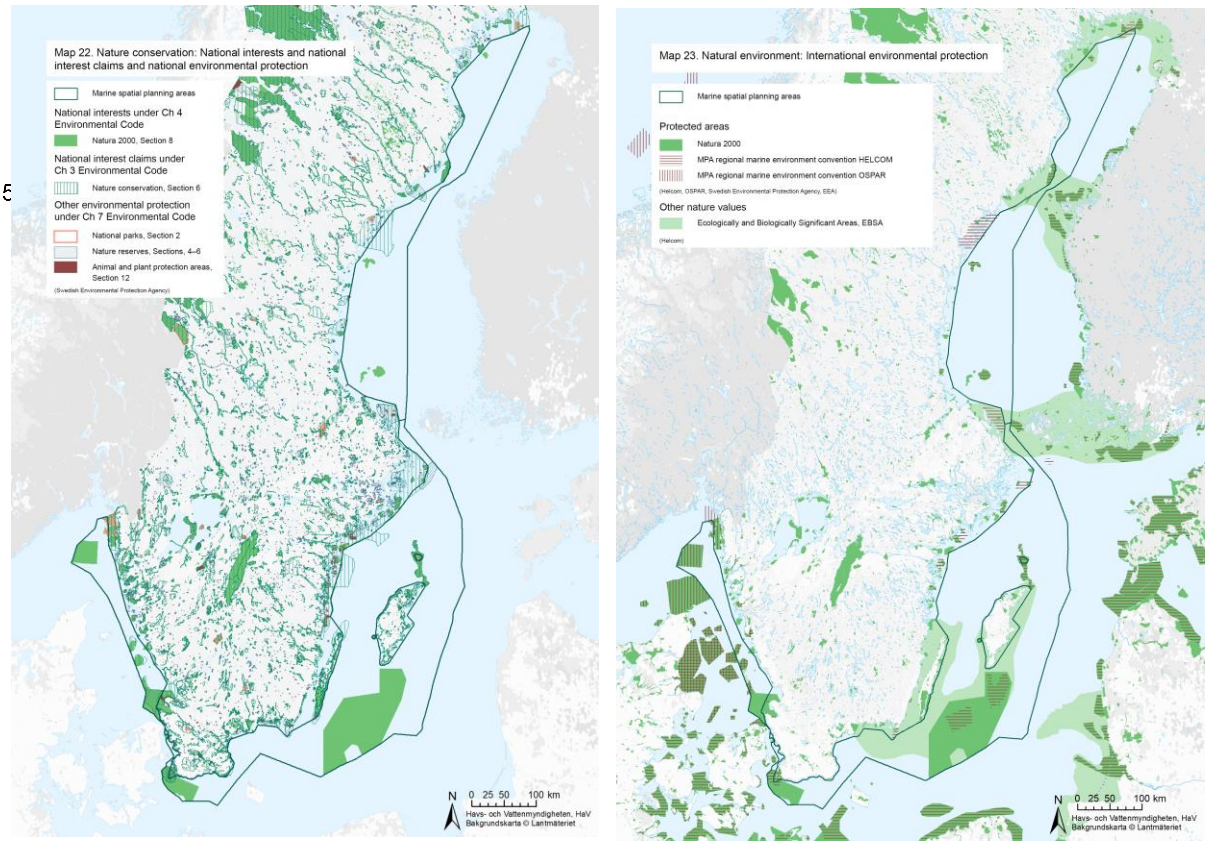


Figure 39. Nature conservation: National interests, national interest claims and national environmental protection (V); International environmental protection (H) (SwAM, 2023a).

The establishment of marine protection areas in the form of Natura 2000 areas, nature reserves and national parks is one way of pointing out and protecting valuable areas (**Fel! Hittar inte referenskälla.**). In 2022, a new international framework was adopted to preserve biodiversity within the scope of the UN Convention on Biological Diversity. The new framework includes an objective of protecting at least 30 per cent of the marine environment by 2030, of which 10 per cent shall be strictly protected. In the Convention, Sweden is represented by the EU, and the European Commission now sets requirements for the Member States to meet the objectives. The existing marine area protection in Sweden in 2022 covered around 14 per cent of Sweden's internal waters, territorial waters and exclusive economic zone. This share varies between the marine spatial planning areas, where Skagerrak and Kattegat have 32 per cent marine area protection, while the corresponding shares in the Baltic Sea and the Gulf of Bothnia are 17 per cent and 5 per cent, respectively.

There are many unique nature environments in the Gulf of Bothnia marine spatial planning area. Norrbotten's archipelago in the North Bothnian Bay is a national interest area since high nature and cultural values are of significance to tourism and recreation. This also includes the Haparanda Archipelago National Park. The marine environment in the offshore area is characterised by stable winter ice that is important for photosynthesising algae and ringed seal pups. The northern parts of the marine spatial planning area become important climate refugia for ringed seals as climate change decreases the spread of the ice (SwAM, 2017b). Further south, the High Coast World Heritage site has been recognised by UNESCO as an area with a unique cultural and natural history environment. Finngrunden in the South Bothnian Sea is the

northernmost location for the wintering of the long-tailed duck, which is an endangered species in Sweden.

In the Baltic Sea marine spatial planning area, there are large areas with high nature values and several of them are protected as nature reserves or through the Natura 2000 network. At the same time, the environment in the Baltic Sea needs to be improved,since there are large areas with dead seabeds due to a lack of oxygen, for example. In the northern parts of the marine spatial planning area, there are, however, unique oxygenated deep areas, viable cod stocks, and passages for migrating birds of prey (Hansson, 2019). In the South-eastern Baltic Sea, there are thethree large offshore banks Hoburgs bank, North Midsea bank and South Midsea bank. This area is relatively unaffected by pollution and contains important habitats for sea birds and the red-listed Baltic Sea population of harbour porpoises (SGU, 2022). The Hanö Bay in the South Baltic Sea is another important area for the porpoise, and there are also high nature values for reef environments, spawning areas, birds and climate refugia for blue mussels, bladderwrack and herring (SwAM, 2017b).

The salty water in Skagerrak and Kattegat makes the marine spatial planning area far more species-rich than the brackish water environments of the Baltic Sea and the Gulf of Bothnia. Here, there are marine mammals, such as harbour porpoises and seals, and spawning and nursery areas for several fish species. The Kosterhavet National Park in the northern part of the Skagerrak and Kattegat marine spatial planning area is Sweden’s only purely marine national park. The aim is to keep a distinctive, species-rich marine and archipelago area and adjacent land areas in an essentially unaltered condition. In Kattegat, there are large Natura 2000 areas and national interest claims for nature conservation. This includes the offshore banks Röde bank, Morups bank, Lilla Middelgrund and Fladen with high nature values for birds, harbour porpoises, spawning areas for fish and valuable benthic environments.

7.5.6. Recreation

The point of departure for the use recreation in the marine spatial plans build on national interest claims for outdoor recreation, according to the Environmental Code. Recreation and tourism occur to a greater extent on the coasts compared with the marine spatial planning areas. Coastal recreation can be affected by the marine spatial planning guidance on use in various ways, such as visible installations like wind turbines. Popular recreation activities at sea and in coastal areas include, for example, boating, angling, coastal hiking, swimming, diving, paragliding, hunting and safaris.

Recreational boats are owned by a total of 16 per cent of Swedish households, and the total number amounts to around 865,000 recreational craft nationally (Swedish Transport Agency, 2021). In 2021, angling was conducted by around 1.5 million Swedish citizens between 16 and 80 years of age, where around 30% of the angling days took place in marine waters (SwAM & Statistics Sweden, 2022). Interest in recreation received a boost during the pandemic years and is expected to have increased significance in the future. The tourism industry is also expected to continue to increase after a decrease during the pandemic, and domestic tourism is an increasingly large part of tourism in Sweden (Tillväxtverket, 2022).

Only a few areas of national interest for outdoor recreation are pointed out in the marine spatial planning areas, mainly in proximity to the coasts and some offshore banks. It should be added

that areas of national interest for cultural environment conservation and nature conservation are also of significance to recreation.

The Gulf of Bothnia has a varied coastal landscape with extensive potential for the development of the tourism industry both in the summer and in the winter. The Bothnian Bay's archipelagos with boat traffic and ice roads, the High Coast World Heritage site and the Haparanda Archipelago National Park are significant tourist destinations.

The Baltic Sea marine spatial planning area, with adjacent coastal areas, includes high nature values that offer opportunities for active recreation close to the metropolitan regions. On the islands of Öland and Gotland, the recreational and tourism sectors are important for regional development, and nearby Hoburgs bank, Salvorev and Gotska sandön are the Baltic Sea's most important bird areas. Angling is a significant activity in the area, with around 2.5 million fishing days in 2021 (SwAM & Statistics Sweden, 2022). Recreation and recreational boating are extensive. Recreational boating traffic often moves both to and from the Gulf of Bothnia in the north and Gryts and Sankt Anna's archipelagos in the south to Gotland and across the Sea of Åland. The coast from Västervik Municipality and south and the coast around Gotland, outside the marine spatial planning area, are covered by national interests for outdoor recreation, and both the coast in the Hanö Bay's western parts and along the coast off of Simrishamn, there is a national interest for outdoor recreation that borders on the planning area. Valuable coastal landscapes extend along Western and Southern Skåne. In Öresund, there are extensive angling and fishing tours. Recreation and recreational boating are important in the entire marine area. Several areas with national interest claim for outdoor recreation is outside the marine spatial planning area, mainly along Skåne's southern and western coasts.

In the Skagerrak and Kattegat marine spatial planning area, there is extensive boating and growing tourism, as well as extensive angling. Recreation and recreational boating are extensive, and recreational boat traffic often moves to and from Norway and Denmark. Kosterhavet National Park possesses unique nature values and is a popular recreation destination. On the coast, there is, among other things, the Bohuskusten Archipelago, which is well-visited with extensive tourism with many natural harbours and marinas. Almost the entire Skagerrak and Kattegat marine spatial planning area borders on a strip closest to the coast with national interests for outdoor recreation. In the marine spatial planning area, there are also national interests for outdoor recreation on the offshore banks, the areas of Lilla Middelgrund, Morups bank, Stora Middelgrund, Röde bank and Fladen.

At the same time that tourism and recreation need access to a healthy sea, the activities also negatively affect the environment. Motorised traffic on the sea contributes to emissions and underwater noise, and various kinds of antifouling paint can contribute to pollutants. Construction
7.5.7 of docks and ports affects valuable shallow ecosystems, and coastal recreation entails littering. Further examples are the supply of nitrogen and phosphorous emissions from the wastewater of holiday homes that contributes to eutrophication. The effects of pressures vary between both place and time (Moksnes et al., 2019; SwAM, 2020).

Shipping

Shipping is a global sector of major significance to Sweden (UNCTAD, 2023). Shipping is also important for the transport of passengers, and in the EU alone, the number of passengers in EU ports exceeded 400 million per year before the COVID-19 pandemic (Eurostat, 2023). In Sweden,

the vessels mainly move in an extensive network of shipping lanes and shipping routes in the sea and major lakes. Swedish industry is dependent on an effective transport system since this system affects the costs of geographic transactions. The freight trend in shipping has been relatively stable since 2015, concerning both imports and exports. The latest freight forecasts show an estimated increase of 4 per cent for imports, while exported goods are expected to increase by 21 per cent until 2030. Shipping is especially significant to raw material-intensive exports, and other industrial sectors that export large volumes. In addition, shipping is of significance to the civil defence need for a functioning provisioning of Sweden with goods and services and by definition constitutes a societally important function (MSB, 2023).

In the Gulf of Bothnia marine spatial planning area, many large industries use shipping for their transport. The freight flows to and from ports in the area are expected to increase markedly in the period 2022-2030, by around 32 per cent for imports and 88 per cent for exports (SwAM, 2023). Today, ferry traffic takes place between Umeå and Vaasa in Finland, and Umeå Municipality has a vision of a future permanent connection over North Kvarken in its comprehensive plan. At the same time, navigability is affected by extensive ice formation in the area in winter, which entails a need for larger areas and alternative shipping lanes. Large surface area claims for permanent installations, such as wind farms, therefore entail a major challenge to winter navigation, especially considering the expected increases in freight volumes. At present, there is a lack of knowledge on the issue of the effects of offshore wind power on winter navigation and icebreaking, and the Swedish Maritime Administration therefore highlights the importance of investigating this further (Swedish Maritime Administration, 2022).

Shipping in the Baltic Sea marine spatial planning area is significant and relates to both goods transport and passenger and cruise traffic. For shipping traffic to and from the Baltic Sea, there are three alternative routes: Öresund, the Kiel Canal and the Great Belt. The most trafficked shipping lane in the area is the Öresund route, which runs through the South Baltic Sea along Sweden’s southern coast. Traffic through the Öresund route is limited, however, by the depth at Flintrännan between Copenhagen and Malmö, which is only around 7.5 metres, is why ships with a larger draft must use one of the alternative routes. In addition, ships with Swedish destinations mainly travel west of Gotland, while international traffic dominates areas south and east of the island.

The Skagerrak and Kattegat marine spatial planning area is home to Sweden’s two largest ports, the Port of Gothenburg and the Port of Brofjorden. Shipping is extensive in the entire area, and several ports are of major significance to Swedish foreign trade. There are also important shipping lanes for transportation to, for example, Oslo, Copenhagen and further into the Baltic Sea. Further information on the significance of shipping and port operations as hubs for regional, national and international transport chains is in this marine spatial plan proposal (SwAM, 2023a).

Shipping traffic is extensive throughout Skagerrak and Kattegat, even close to the coast, and there are several ports of major significance to Swedish foreign trade. A significant part of the traffic to and from the Baltic Sea passes through Kattegat and Öresund. Through Skagerrak, shipping lanes extend further out into the North Sea and the world oceans. In Kattegat, shipping is important and extensive because the area is one of only two ways into the Baltic Sea for large vessels. The shipping lanes are widespread in the entire marine area with several lanes from north to south and into the ports along the coasts, on both the Swedish and Danish sides.

In the south, off of Stora and Lilla Middelgrund, there is the choice of routes of Öresund or Stora Bält, both of which limit the height and depth the vessels can have. The Stora Bält bridge limits the height. To guarantee safe shipping through the shallow waters in Kattegat, new traffic separation regulations were approved in 2018 on both sides of the offshore banks (International Maritime Organization, 2018). These measures entered into force in 2020.

Skagerrak and Kattegat are home to Sweden's two largest ports, the Port of Gothenburg and the Port of Brofjorden. Shipping therefore exists in the entire marine spatial planning area with several shipping lanes from Oslo in the north to Kattegat in the south and in towards the coast and out past Skagen towards the North Sea. For further information regarding the significance of shipping and port activities as hubs for regional, national and international transport chains, see the plan document, Chapter 7.

Shipping is generally deemed to be able to collaborate and coexist with energy areas for wind farms with the right conditions, such as taking shipping safety into account. This means that consideration must be taken to consideration distances so that maritime safety and national and international rules at sea can be complied with. More about legal conditions can be found in the Swedish Energy Agency report 2023:12 (Swedish Energy Agency, 2023a).

The need for consideration distances vary and needs to be adapted based on the nature and use of the shipping lane. Appropriate consideration distances are required to ensure that maritime safety is not negatively affected or entails significant damage to the national interest. The maritime safety aspect is important to avoid accidents at sea and indirect environmental effects with an impact on both the population and animal and plant life and affect conditions for shipping and the working environment at sea. Establishment of operations at sea, such as wind power, requires review and decisions including specification of consideration and consideration distances to enable coexistence with shipping.

Shipping impacts the environment in several different ways. Fuel combustion entails both emissions of pollutants gases and particulates, as well as carbon dioxide and other greenhouse gases. International shipping is a rapidly growing emission source, and the need to reduce its climate impact is currently the strongest driver behind the technical development in the sector (SwAM, 2023). Other consequences of shipping operations are operational oil emissions, as well as waste from kitchens, toilets and cleaning. The use of an emission-cleaning device (a so-called scrubber) has also recently been linked to water pollution (Lunde Hermansson et al., 2023). Marine life is also affected by the underwater noise caused by the ships' engines, propellers and sonar, as it can disrupt communication between organisms. Additionally, through the emptying of ballast water, there is a risk that ships spread invasive species that become established in Swedish waters and out-compete native species with potentially major consequences for the ecosystems. Shipping also affects the seabed adjacent to shipping lanes and ports, where dredging and dumping of dredged materials is underway at places to make shallow areas accessible to larger vessels.

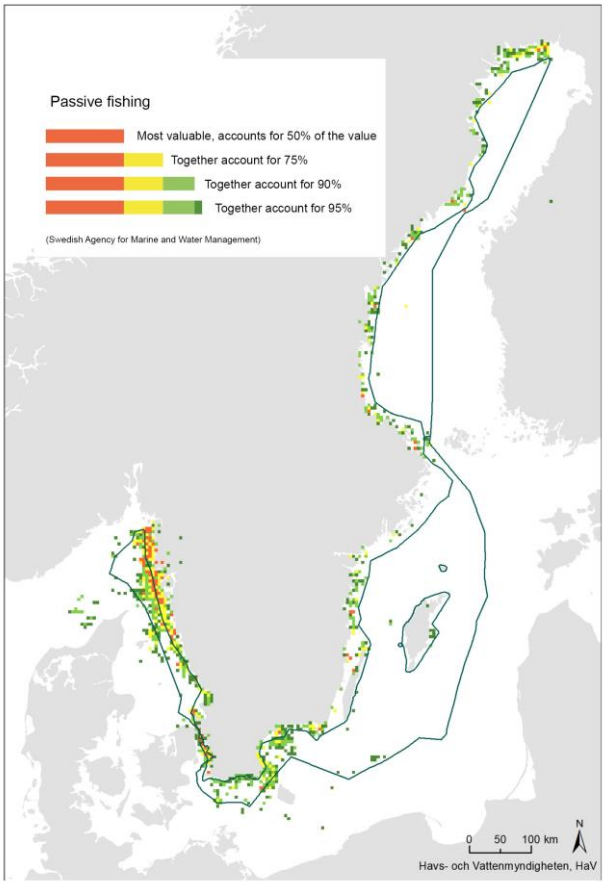
7.5.8. Commercial fishing

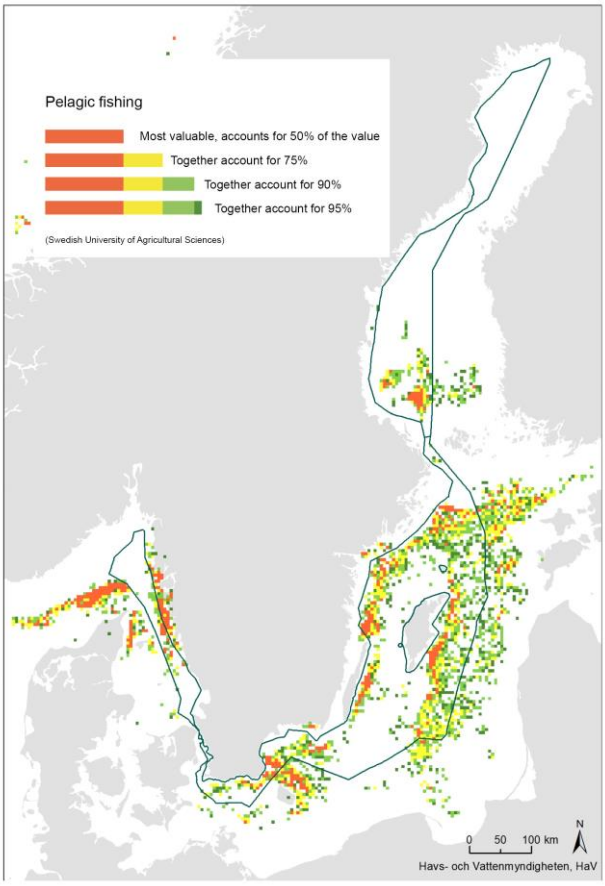
Swedish commercial fishing is varied, with large boats that most often fish with trawl nets and smaller boats with cages, traps and nets (Figure 40). There is a dynamic in fishing that means that the fishing pressure varies both geographically and over time. Small-scale fishing is normally conducted in more limited areas close to the coast, while larger boats move across large areas in

and beyond Swedish territorial waters and the exclusive economic zone. The conditions for fishing are affected by the season, but also by the development of the fish stocks and fishing regulations.

Commercial fishing in the Gulf of Bothnia's marine spatial planning area is mostly small-scale, with the largest concentration close to the coast and in the South Bothnian Sea. Fishing is clearly seasonal, as the area is covered by ice during part of the year. The economically most important species are vendace and herring, where fishing for vendace takes place closer to the coast (outside the marine spatial planning area) (SwAM, 2023b). In the offshore area, Finnish herring fishing is also conducted. Fishing in the Baltic Sea marine spatial planning area is a large part of Swedish commercial fishing both in terms of value and catch amounts. The most important species in recent years (2018-2022) are sprat and herring since the cod stock has weakened (SwAM, 2023b). In the area, both passive and active fishing gear is used, except for Öresund, where fishing is exclusively conducted with passive fishing gear. In the Skagerrak and Kattegat marine spatial planning area, commercial fishing is varied, where the economically most important species are the Northern prawn and Norwegian lobster (Statistics Sweden, 2023). There is also mixed fishing for species such as haddock and coalfish (demersal) and mackerel, herring and sprat (pelagic).

The fishing affects the size and structure of the fish populations both for the species that the fishing is directed at and those that are caught unintentionally. Other species and ecosystems are indirectly affected through interactions in the food chain. Fishing with passive gear affects birds and marine mammals that get stuck in the nets; even fishing gear lost in the sea creates problems as it continues to catch animals long after it is lost. Bottom trawling affects the marine environment through withdrawals of species, by-catch and physical damage to the benthic environment. Pelagic trawling is associated with the same types of pressures as bottom trawling, except for physical seabed impact. Emissions and underwater noise are also among the consequences of fishing.





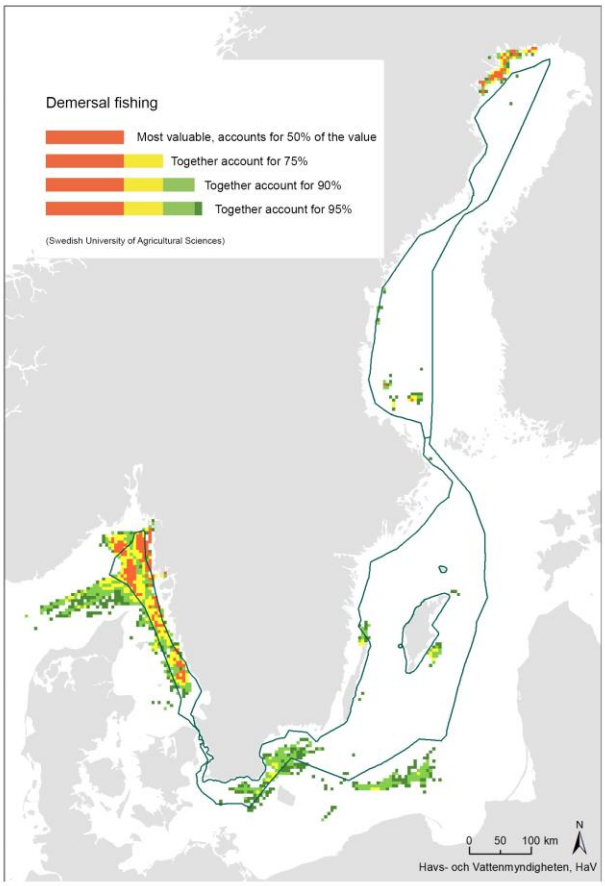


Figure 40. Commercial fishing 2012–2021: Compilation of annual economic landing values for Swedish fisheries during the period 2012-2021: Passive fishing (Upper left); Pelagic trawler fishing (Upper right); Demersal/benthic trawler fishing (bottom trawler fishing) (Lower left) (SwAM, 2023a).

8. Method

The emphasis in the impact assessment is on the estimation of the differences in environmental, social and economic effects between the plan alternatives and the zero alternative (see Section 7.1). In the impact assessment, a mainly semi-quantitative approach was applied, as described below. A quantitative approach is not applicable in terms of the overall level of the marine spatial plans and the impossibility of setting numerical values to every different aspect that the plans impact and the effects they entail. The marine spatial plans' impact is described in relative terms from a changed perspective in relation to the current situation. The impact assessment highlights the relative effects that the various energy areas in the marine spatial plans can entail.

The selection of assessment aspects that are included in the impact assessment was made based on the requirements in Chapter 6, Section 2 of the Environmental Code for the environmental aspects. Social and economic aspects were selected based on the criteria in the sustainability assessment of the approved marine spatial plans (SwAM, 2019b), considering the most likely effects of offshore wind power. In a selection of assessment aspects, consideration was also taken to comments received by SwAM during the delimitation consultation of the impact assessment. In **Fel! Hittar inte referenskälla.**, the assessment aspects used in the impact assessment are shown.

Dimension	Assessment aspect
Environment	Protected animal and plant species and biodiversity.
Environment	Seabed environments
Environment	Water and air
Environment	Climate
Environment	Other parts of the environment
Environment	Management of land, water and the physical environment, as well as materials, raw materials and energy
Social	Population and people's health
Social	Cultural environment
Social	Recreation, including landscape
Economy	Commercial fishing – landing value
Economy	Shipping – accessibility and safety
Economy	Energy extraction – resource efficiency, including production potential

Table 17 - Assessment aspects used in the impact assessment.

Protected animal and plant species and biodiversity, benthic environments, water and air, climate, other parts of the environment and population and human health

Assessment of the aspects *Protected animal and plant species and biodiversity* and *Benthic environments* is based on SwAM's Symphony method for the assessment of cumulative effects (for a detailed description of the Symphony method and its use in an impact assessment, see SwAM, 2019a; for Symphony data, see SwAM and SGU, 2018). Analyses of effects of changed use, in this case energy use, have been done for all energy areas. The results of the effects on ecosystem components marine mammals, wintering birds, coastal birds and benthic environments were then used to show the potential effect of the different areas on a scale from zero to four, where four indicates a large negative effect. The cumulative Symphony results have formed the basis for an expert assessment of the risk of impact in the respective marine spatial planning areas.

The method for assessing effects on migratory birds, bats, fish and spawning fish builds on map data from the Swedish Environmental Protection Agency and SwAM and expert assessment from Lund University and the Swedish Environmental Protection Agency, and SwAM, respectively. Assessment of effects on water and air, climate and population and human health is based on the environmental impact assessment and sustainability assessment of the approved marine spatial plans (SwAM, 2019a, 2019b) and builds on expert assessment.

Management of land, water and the physical environment, as well as materials, raw materials and energy

The assessment of the environmental aspects of *management of land, water and the physical environment, as well as materials, raw materials and energy,* was done qualitatively and is included in the cumulative impact assessment in Chapter 5, particularly Section 5.3.

Cultural environment

The assessment of the effects on the cultural environment is based on the descriptions of the impact on cultural environment interests in Appendix 6 of the Swedish Energy Agency (2023a). In these descriptions, the extent to which the proposed energy extraction areas are at risk of affecting various known types of cultural environments, creating competition or dominance over the cultural environments or affecting specifically appointed cultural environment values or world heritage sites is assessed. These three aspects relate mainly to the visual impact caused by the wind farms, which in turn can affect the perception of the various cultural environment values. The assessment is overall and should be seen as preliminary pending new documentation to be completed in early 2024 within the scope of the county administrative boards' task of preparing planning documents for cultural environments in the national marine spatial planning.

The assessment also takes into account the energy areas' distance to the coast and length parallel to the coast. The distance was measured on the shortest distance between the energy area and the coast including islands. For energy areas that are between two islands or between the mainland and an island, the parallel lengths against both parts of the land were added. Distance to the coast and parallel length were normalised on the scale 0-1 by dividing by the highest measured value for the respective criterion.

For a comparison between energy areas, the following indices were developed:

Impact on cultural environment = $CV \times (D_n + PL_n) + DC + EC$, where

CV – Occurrence of affected cultural environment values (yes/no)
D_n – Distance to coast, normalised
PL_n – Parallel length, normalised
DC – Occurrence of dominance or competition (yes/no)
EC – Impact on especially pointed out cultural environment values (yes/no)

The index can take values between 0 and 4, with the following effect scale:
0 = No effect
0.001 - 1 = Marginal effect,
1.001 - 2 = Small effect
2.001 - 3 = Medium effect
3.001 - 4 = Large effect

Recreation, including landscape

Assessment of the impact on recreation, including landscapes, is based on national interest claims for recreation and the Swedish Energy Agency (2023a), especially Appendix 6. Assessment takes place based on geographic analysis and buffer zones based on potential geographic overlap between national interests for recreation and buffer zones of 20 and 30 km around energy areas. The assessment does not take into account terrain or vegetation on the coast, which has a large effect on visual impact on various areas on land. The assessment is based on the marine spatial plans' energy areas and also includes potential indirect impact on land-based national interests for recreation. The impact relates to conditions for recreation activities and potential impact based on current value descriptions, such as visual impact, experience values and accessibility.

Commercial fishing - landing value

For the assessment of the effects on the *landing values in commercial fishing*, a mapping was first done of the average annual landing value for the fish listed below. The average annual values are based on WMS and logbook data for Swedish commercial fishing for the period 2012-2021. The figures should only be seen as an approximation of the value of catches from different geographic areas as there are uncertainties regarding the estimation of the market value and of the exact geographic origin for certain fisheries. However, the figures are considered to provide a real-life picture of where different fishing is conducted and the relative size in terms of the landing values of the various fishing.

Active fishing:

- Baltic Sea and Gulf of Bothnia:
    - Bottom trawling for cod and demersal species
    - Floating trawling for cod
    - Bottom trawling for vendace
- Skagerrak and Kattegat:
    - Bottom trawling with shrimp trawl
    - Bottom trawling mainly for Norwegian lobster
    - Bottom trawling (including Danish seines) for mainly demersal fish

- Baltic Sea, Gulf of Bothnia and Kattegat:
    - Bottom trawling for pelagic species, mainly herring, sprat and mackerel
    - Floating trawler fishing for pelagic species, mainly herring, sprat and mackerel
    - Purse seine fishing for pelagic species mainly herring and sprat

Passive fishing:

- Cages and pots
- Traps
- Net
- Hooks
- Dredge
- Other passive fishing

Based on this mapping, the value was calculated for each kind of fishing in all energy areas in the marine spatial plans. To estimate the loss in landing value in each energy area caused by wind power establishment, the assumptions below were made. The data on the type of foundations is based on the assumptions in the Swedish Energy Agency (2023a), Appendix 6.

- Within energy extraction areas with floating foundations:
    - No trawler fishing will be conducted
    - All passive fishing may continue to be conducted
- Within energy extraction areas with seabed-attached stations:
    - All trawler fishing decreases by 50%
    - All passive fishing may continue to be conducted

To be able to compare the different energy areas, the share of reduced landing value in each energy area was first calculated in relation to the annual landing value for the respective fishing for the entire country. For each kind of fishing, the percentage was converted in per cent to a five-point index according to the following scale:

0. Shares between 0 and 0.01 per cent
1. Shares between 0.01 and 1 per cent
2. Shares between 1 and 2 per cent
3. Shares between 2 and 3 per cent
4. Shares between 3 and 4 per cent

The average five-degree index for each energy area was calculated by summarising the indices for all types of fishing and dividing them by the number of fish in the area that can be affected by energy extraction.

Assumptions regarding continued fishing operations in energy areas are based on the latest knowledge compilation on coexistence possibilities with offshore wind power (SwAM, Swedish Energy Agency, 2023), which is partly based on exchanges with the fishing industry in Sweden. As there is today a lack of concrete experience of commercial fishing in wind farms, the assumptions should be viewed with caution. Several factors regarding the design of the wind farm and adaptations of both the fishing and wind farm activities are likely to affect the actual coexistence possibilities. In the assessment, consideration was also not taken to the movement

of fishing efforts to nearby alternative fishing areas. The reasons for this are that the possibility of such relocation varies sharply between the types of fishing, that it is not currently possible to predict the changed fishing behaviour and the actual desire to conduct fishing in other areas, and that it is not known if the resource would withstand an increased fishing pressure in the area that the fishing moves to.

The calculation also does not include any possible positive effects for, for example, passive fishing, which can be considered to be possible and in some cases is even promoted in wind farms. Whether this will take place and to what extent is not possible to estimate based on today's knowledge in terms of fishing operations in wind farms.

Shipping – accessibility and safety

The assessment of effects on *accessibility and safety in shipping* takes place based on a relative comparison between energy areas regarding how shipping may be affected and the conditions that exist for coexistence. The point of departure is, among other things, the need for safety zones described in Swedish Energy Agency (2023a), Section 4, Appendix 5 and 6. Section 4 and Appendix 5 of the *Swedish Maritime Administration's memo on the impact of wind power on winter navigation* describe conditions for coexistence, the need for investigation regarding winter navigation and legal conditions. Appendix 6 describes the adaptations to shipping that are relevant to the respective energy area. The assessment that takes place based on the Swedish Energy Agency (2023a) is a preliminary overview of conditions for coexistence with shipping. Further studies regarding conditions for winter navigation and area-specific adaptation for coexistence with shipping and wind power are required in decisions on establishment.

The assessment is accordingly based on the Swedish Energy Agency (2023a) and proposals on energy areas in consultation proposals for marine spatial plans. What is assessed is the relative area and share of safety zones relative to the respective energy areas, the need for changed shipping lanes, the occurrence of winter navigation (icebreaking), if the energy area borders more than one shipping lane, if bordered by shipping lanes in neighbouring countries, and special remarks regarding unsuitability or safety zone presented in Swedish Energy Agency (2023a).

For comparison between energy areas, the following sums and indexing is used:

Impact on shipping = $AZ_n + PA_n + AS + WN_n + MI + NR + BN$

AZ_n – Area, potential area within the safety zone, normalised
PA_n – Proportion of energy area related to safety zone, normalised
AS – Adjusted shipping lane, increased travel distance, per cent in decimal form.
WN_n – winter navigation, energy area as a percentage area of the planning area, normalised
MI – Multidimensional impact. Borders more shipping lanes (No (0) /Yes (1))
NR - Note in report (No (0) /Yes, No acceptance (1), Yes, Remarks requirement of safety distance (0.5))
BN – Borders to neighbouring country (No (0) /Yes (1), 20KM (0.5))

Total impact on shipping is indexed, normalised to 0-1, and distributed according to the following effect scale:

0 = No effect
0.10 - 0.24 = Marginal effect,
0.25 - 0.49 = Small effect
0.50 - 0.74 = Medium effect
0.75 - 1 = Large effect

Energy extraction – resource efficiency, including production potential

Assessment of the various energy extraction areas' economic effects was done indirectly by estimating the areas' *resource efficiency and production potential*. The approach is similar to that used by the Swedish Energy Agency (2023a). As indicators for resource efficiency, distance from the mainland, water depth and average wind speed were used. For the economy, an indicator was used to assess the temporal potential of when a wind farm can be in operation, and the area's potential annual electricity production as an indicator of value added. The motivation for the choice of the indicators is in the Swedish Energy Agency (2023d).

Each area was assigned points for the indicators of distance to the mainland, depth and wind speed according to **Fel! Hittar inte referenskälla.**.

Points	Distance to the coast	Depth	Wind speed
1	More than 80 km	Deeper than -70 m	Less than 8.5 m/s
2	Between 40 km and 80 km	Between -40 and -70 m	Between 8.5 and 9 m/s
3	Less than 40 km	Shallower than -40 m	Higher than 9 m/s

Table 18. Point scale for the indicators' distance to the mainland, depth and wind speed.

The indicator for the assessment of the temporal potential of when a wind farm can be in operation builds on how far in the permit application process each area has come. The points scale in **Fel! Hittar inte referenskälla.** was used.

Criterion	Description	Points
Foundation	The majority of the area is suitable for bottom-fixed foundations (shallower than -70m)	1
Foundation	The majority of the area is suitable for floating foundations (deeper than -70m)	0
Permit	The area overlaps with ongoing projects that have applied for or been awarded permits	1
Permit	The area does not overlap with ongoing projects that have applied for or been awarded permits	0
Consultation	The area overlaps with projects that have submitted consultation documents	0.5
Consultation	The area overlaps with projects that have not begun consultation	0

Table 19. Criteria and point scale for the indicator temporal potential. Information on permits and consultations was downloaded from Vindbrukskollen (https://vbk.lansstyrelsen.se/) at the end of January 2023.

For each energy extraction area, the points for the indicators were summed in **Fel! Hittar inte referenskälla.** and **Fel! Hittar inte referenskälla.** and then divided into quartiles based on the points sum.

There is great uncertainty in estimating the sales value and other economic effects of produced electricity from future offshore wind farms. For this reason, the areas' estimated annual production potential was used as an indicator of value added. The production potential was calculated by multiplying each area's area by a standard value of 5 MW installed capacity per square kilometre and 4,000 full-time hours per year. The interval between the energy extraction areas with the largest and smallest potential production was divided into quartiles, and each area was assigned points between 1 and 4 corresponding to the first to the fourth quartile, respectively.

The index to compare the energy extraction areas was built by summing the quartile corresponding to the point sum of the first six indicators and the quartile corresponding to the production potential. This sum was in turn divided into quartiles to generate a scale between 1 and 4, corresponding to the smallest and largest estimated economic potential.

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List of figures

List of tables

Appendix A Maps of landing values in Swedish commercial fishing

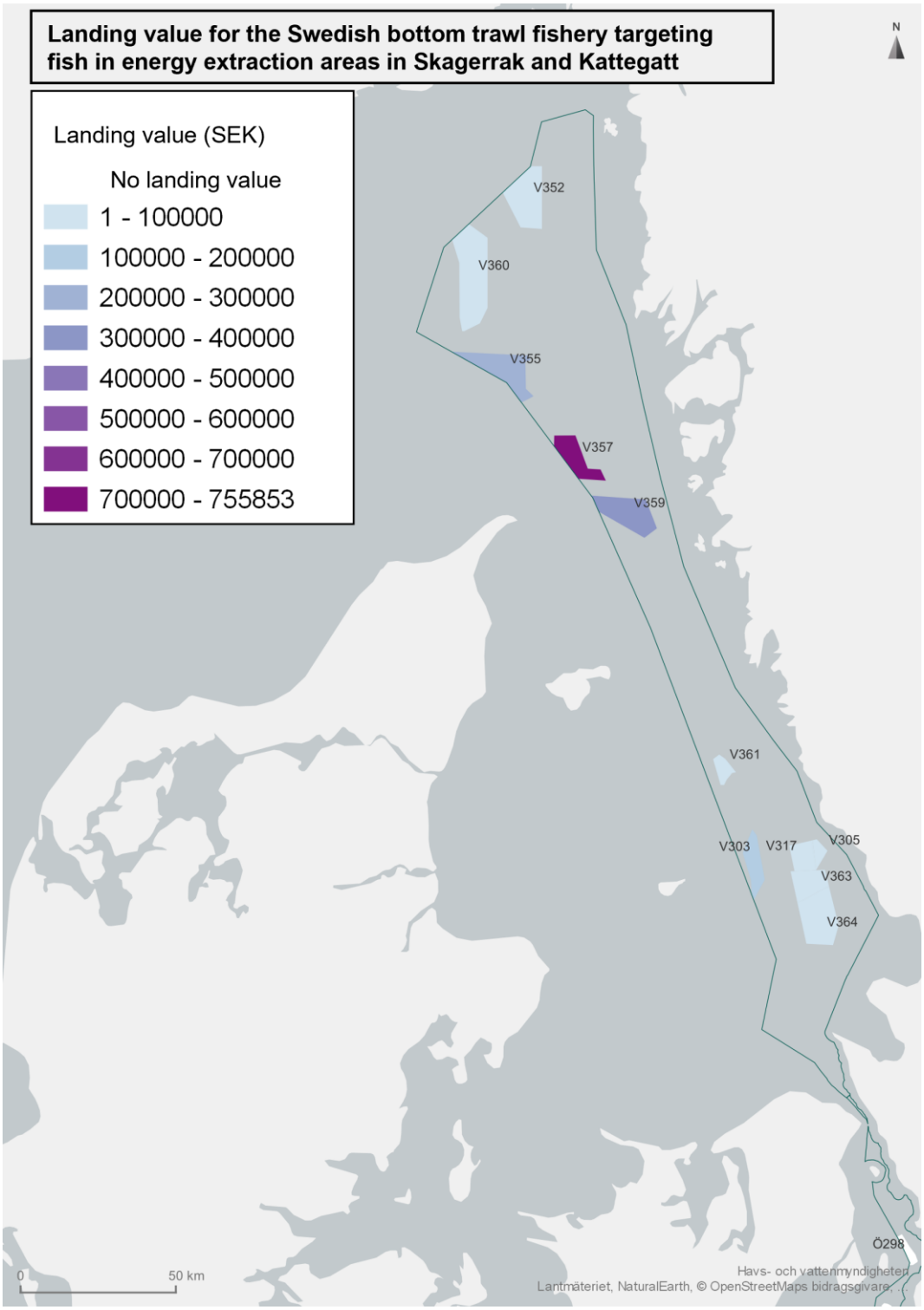

Figure 41 - Map of landing values for bottom trawling for fish in proposed and alternative energy areas in Skagerrak and Kattegat

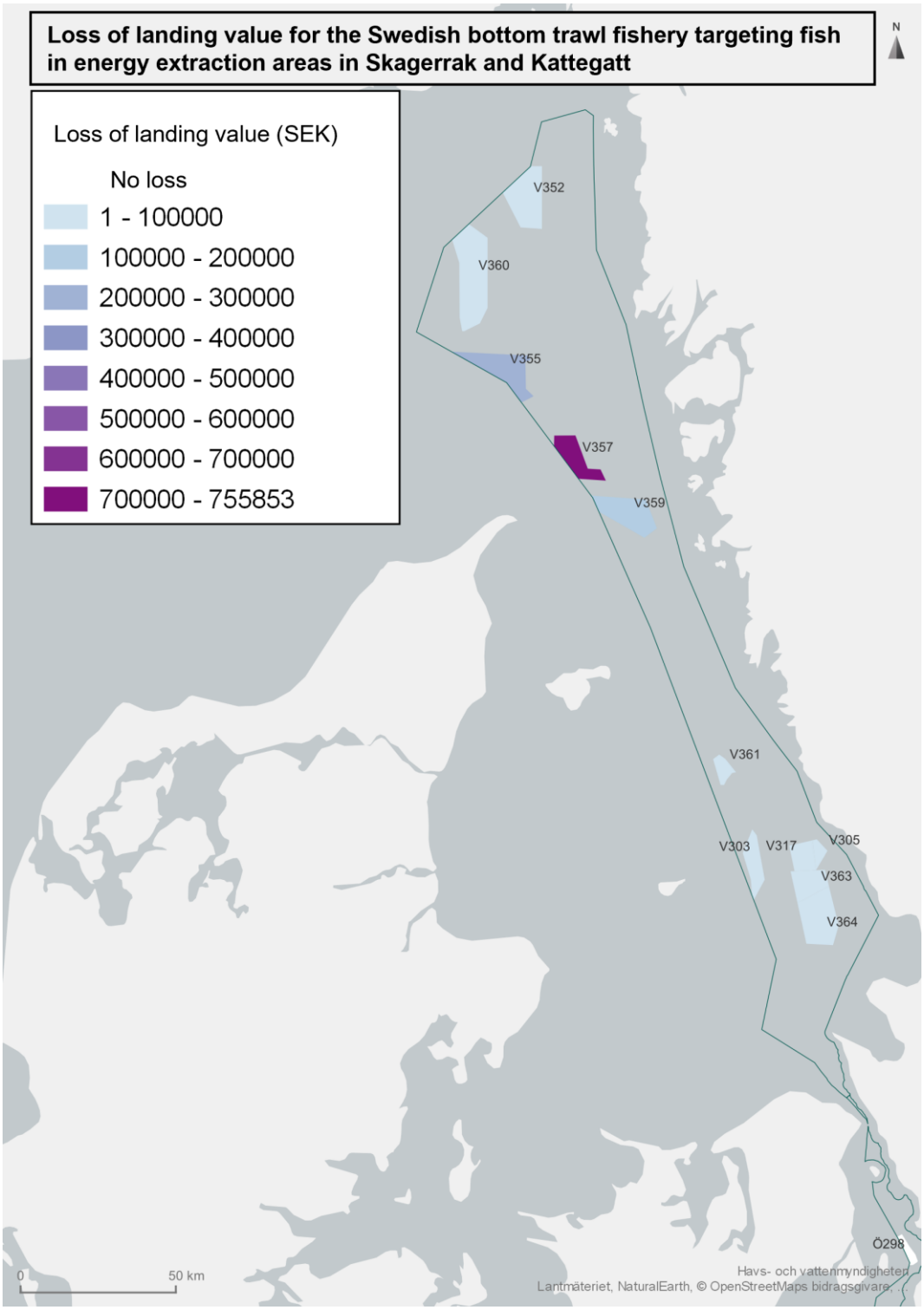

Figure 42. Map of loss in landing values for bottom trawling for fish in proposed and alternative energy areas in Skagerrak and Kattegat.

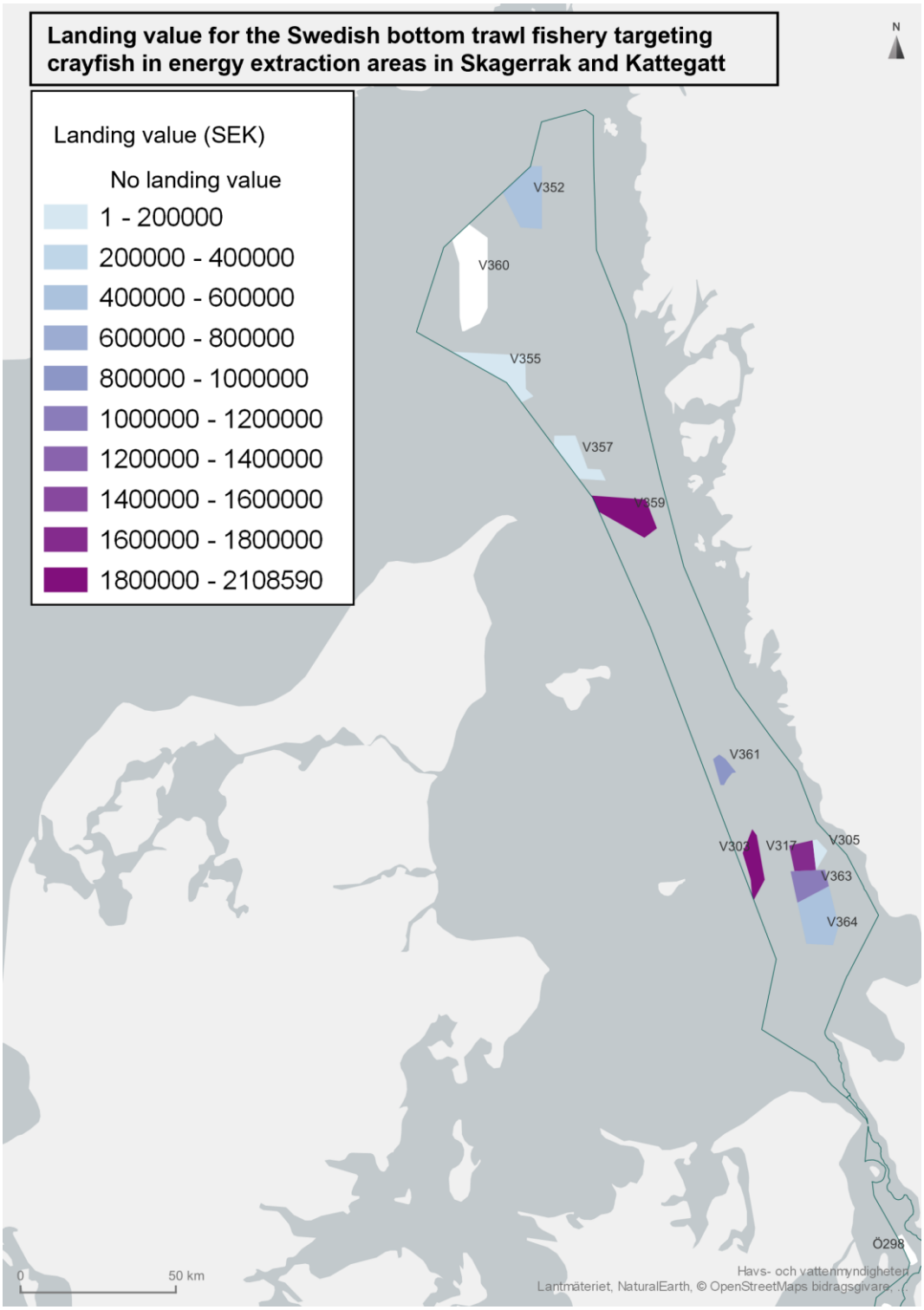

Figure 43. Map of landing values for bottom trawling for crayfish in proposed and alternative energy areas in Skagerrak and Kattegat.

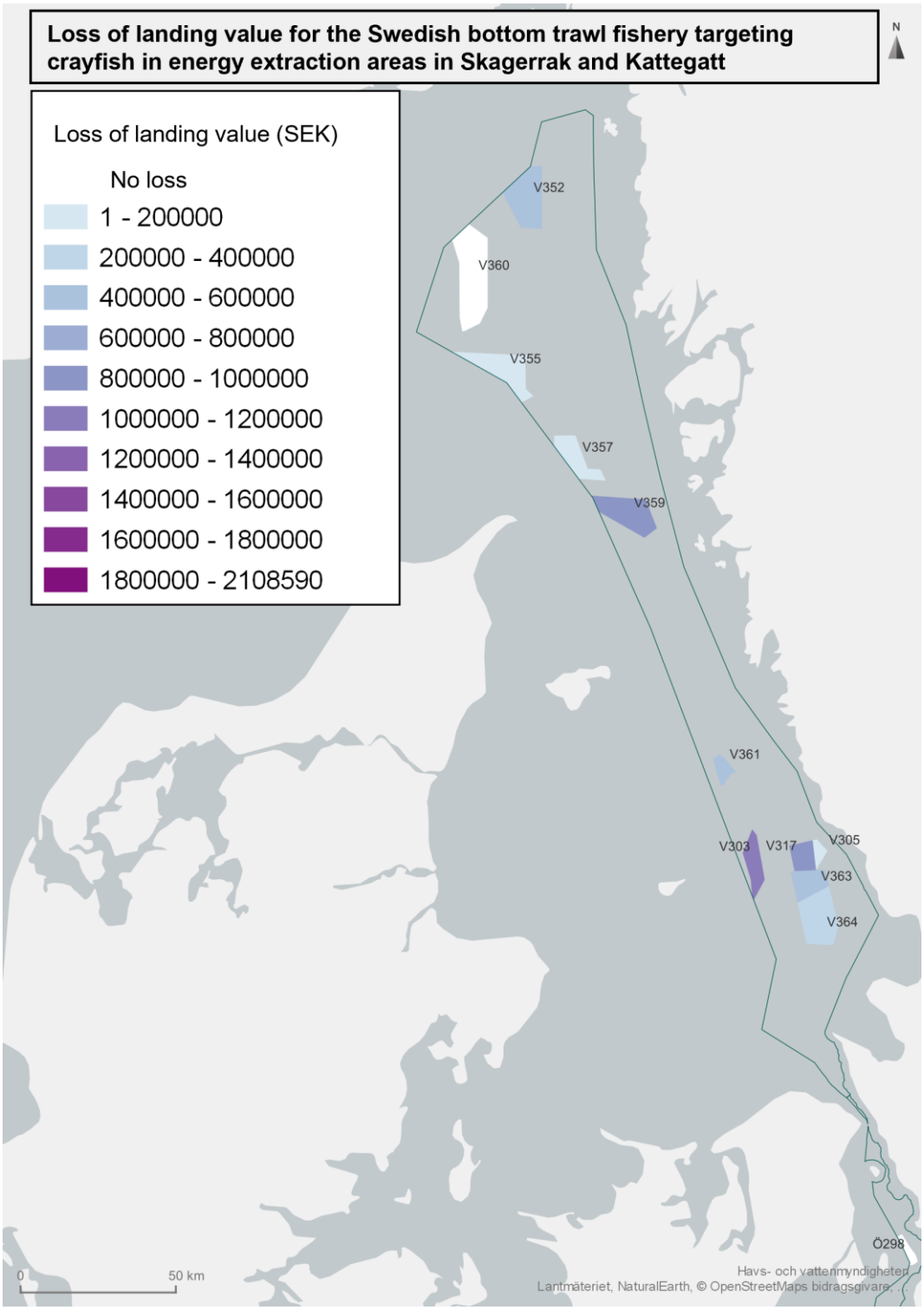

Figure 44. Map of loss in landing values for bottom trawling for crayfish in proposed and alternative energy areas in Skagerrak and Kattegat.

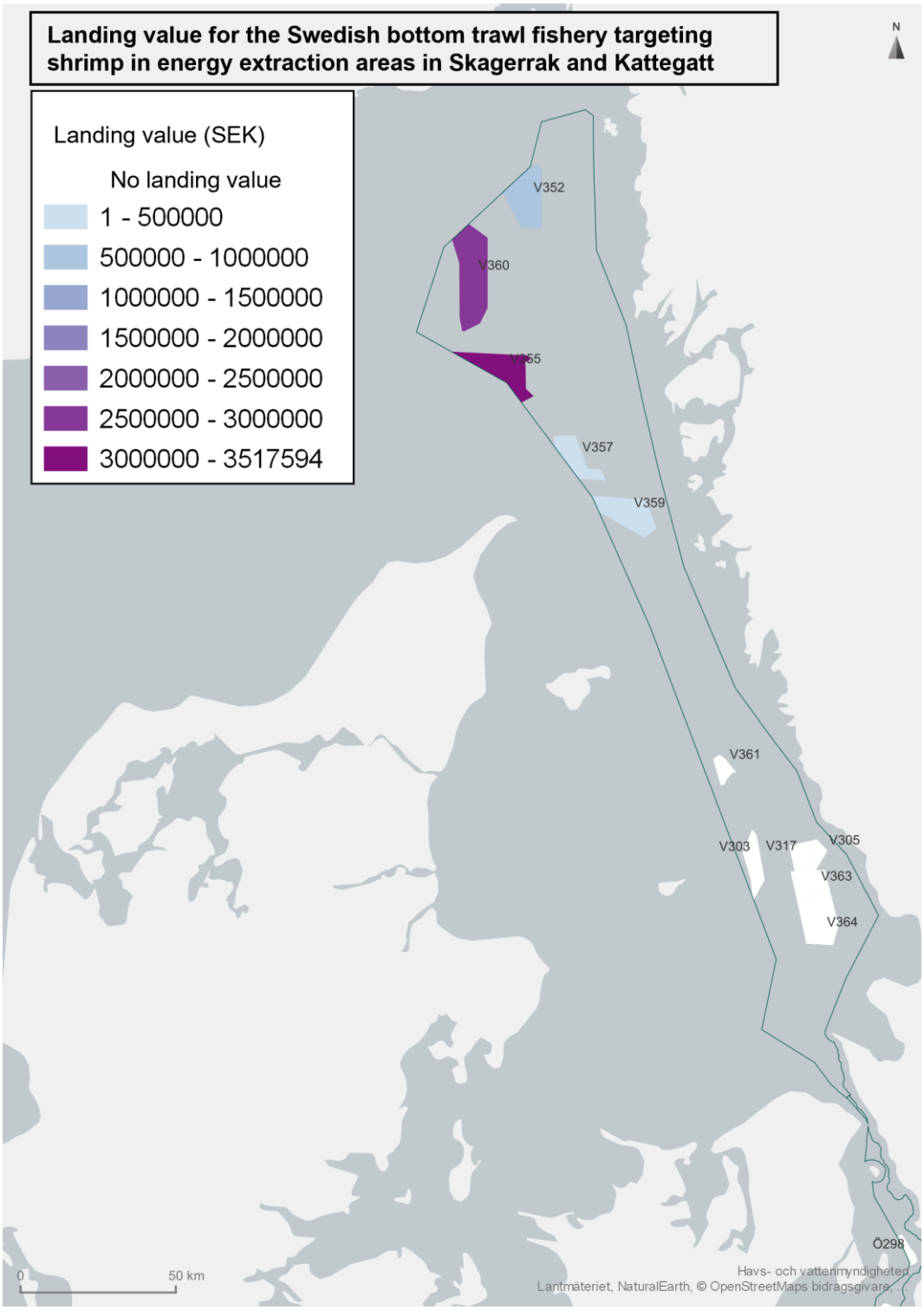

Figure 45. Map of landing values for bottom trawling for shrimp in proposed and alternative energy areas in Skagerrak and Kattegat.

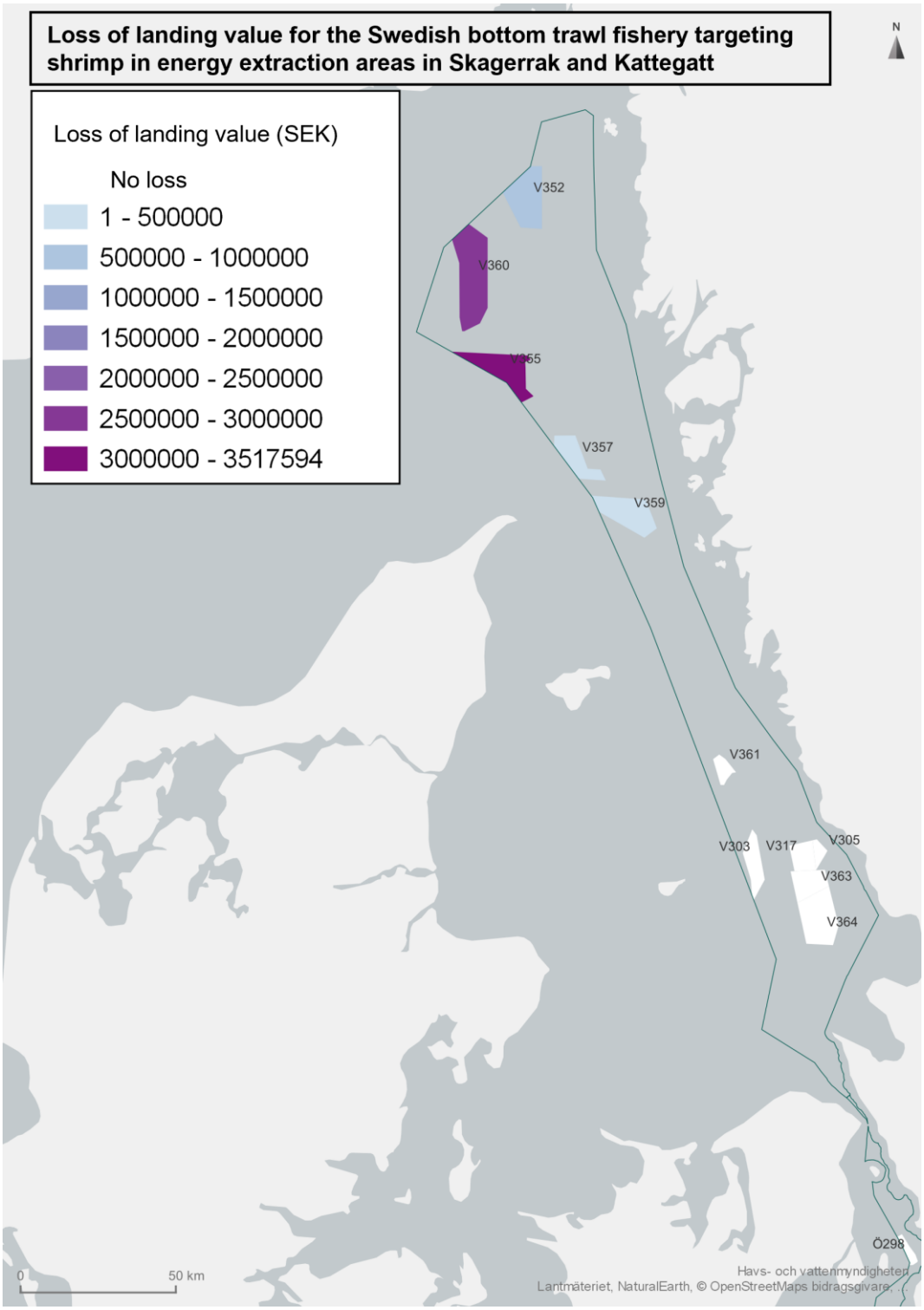

Figure 46. Map of loss in landing values for bottom trawling for shrimp in proposed and alternative energy areas in Skagerrak and Kattegat.

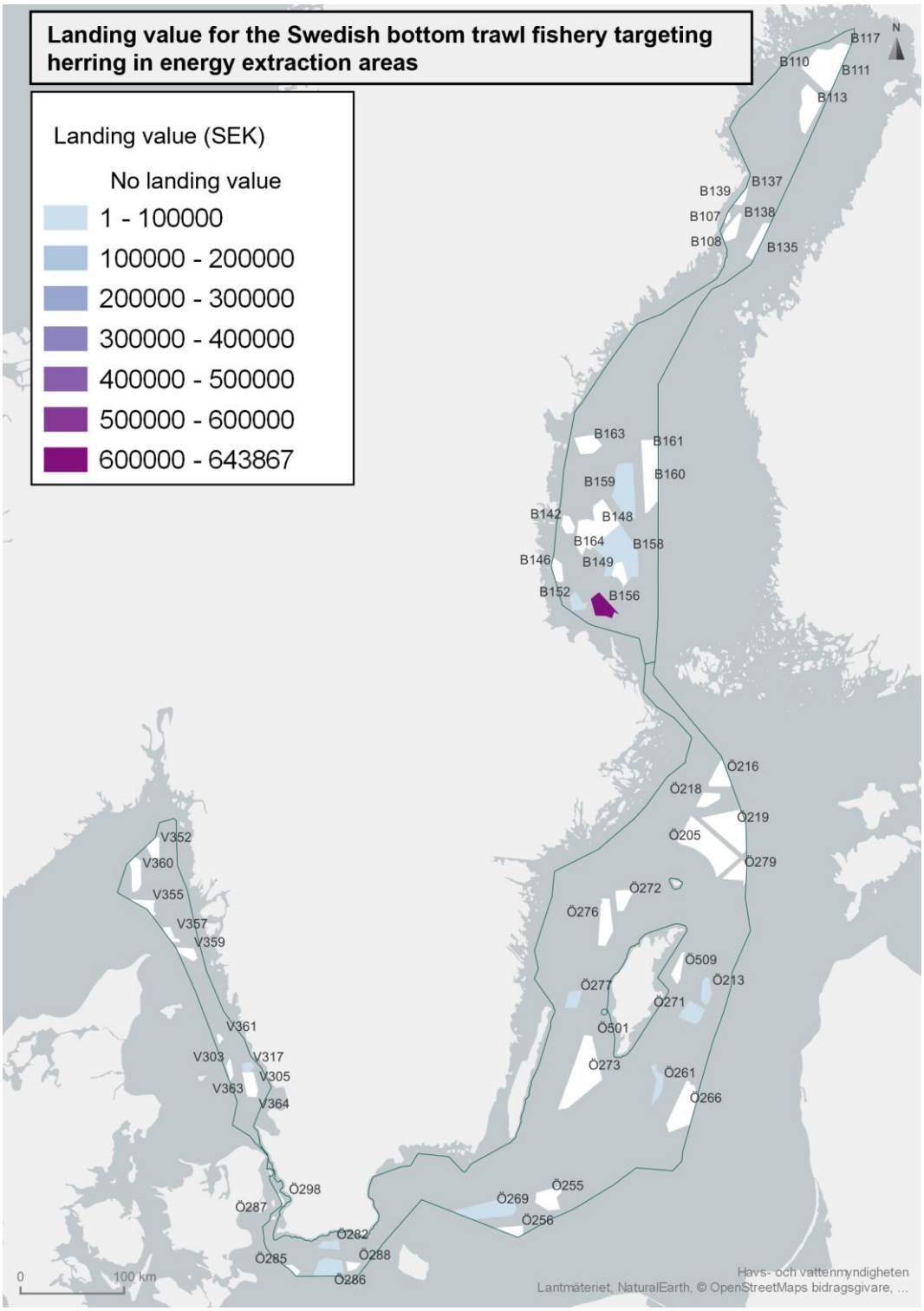

Figure 47. Map of landing values for bottom trawling for herring in proposed and alternative energy areas in all three marine spatial planning areas.

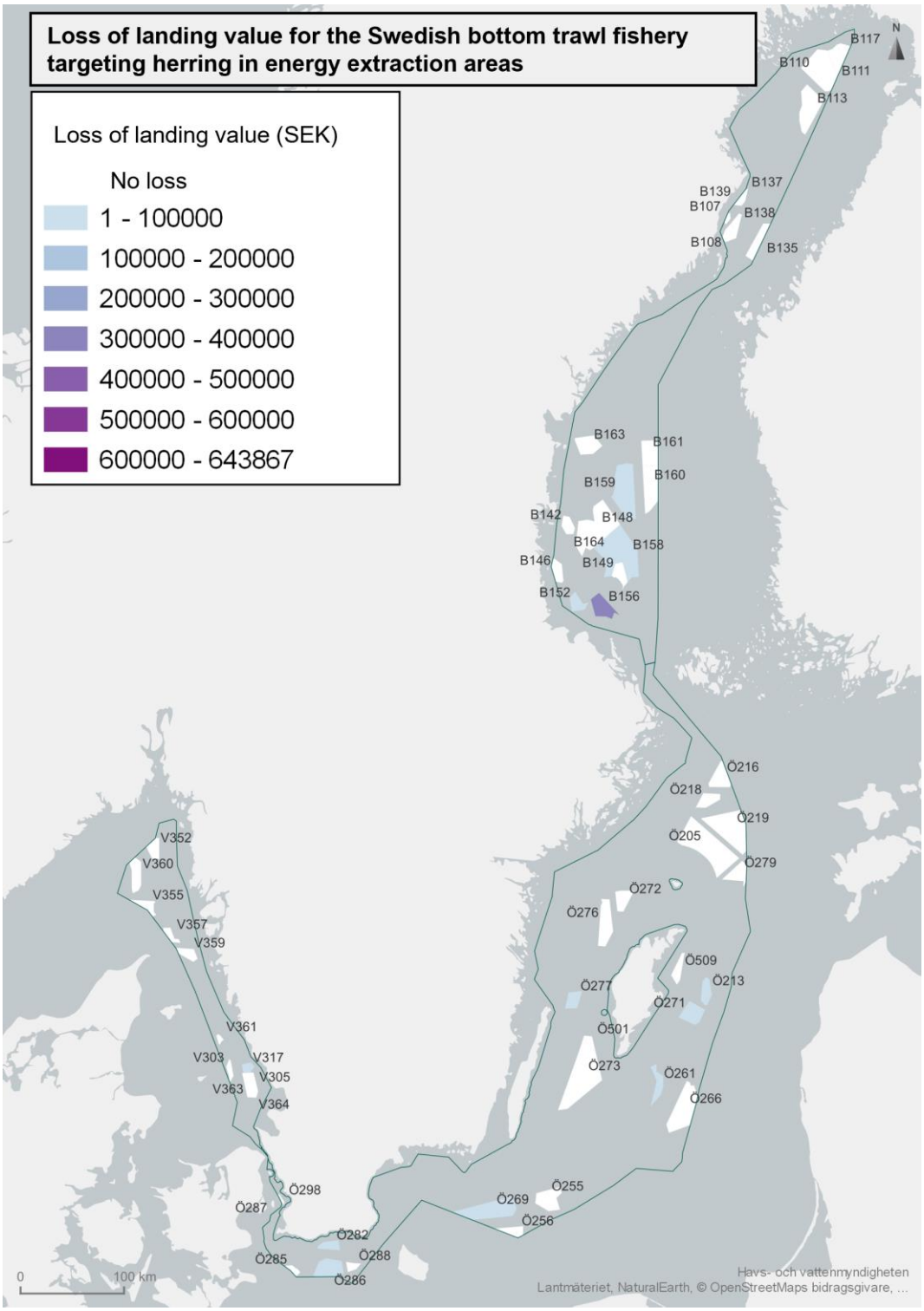

Figure 48. Map of loss in landing values for bottom trawling for herring in proposed and alternative energy areas in all three marine spatial planning areas.

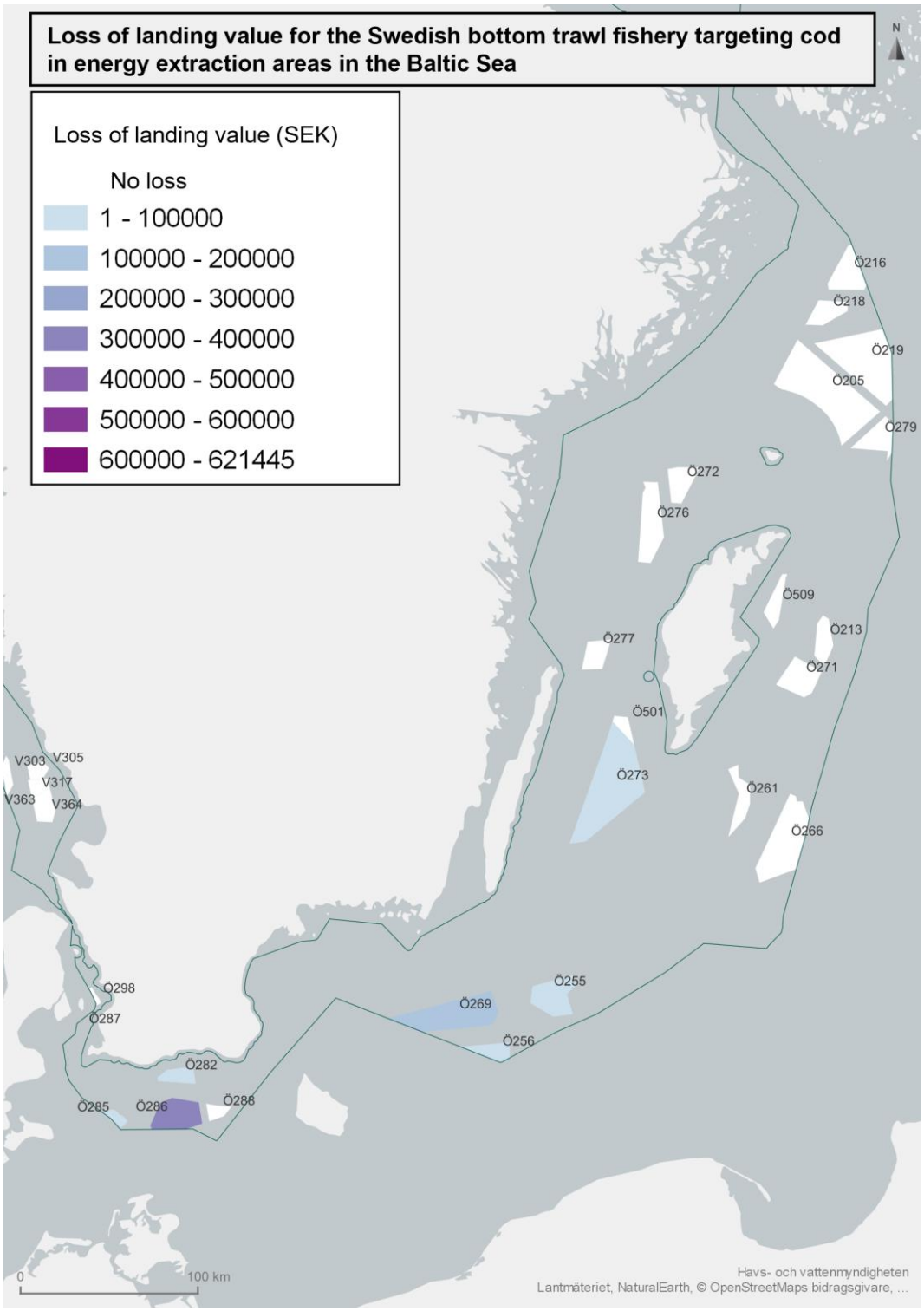

Figure 49. Map of landing values for bottom trawling for cod in proposed and alternative energy areas in the Baltic Sea.

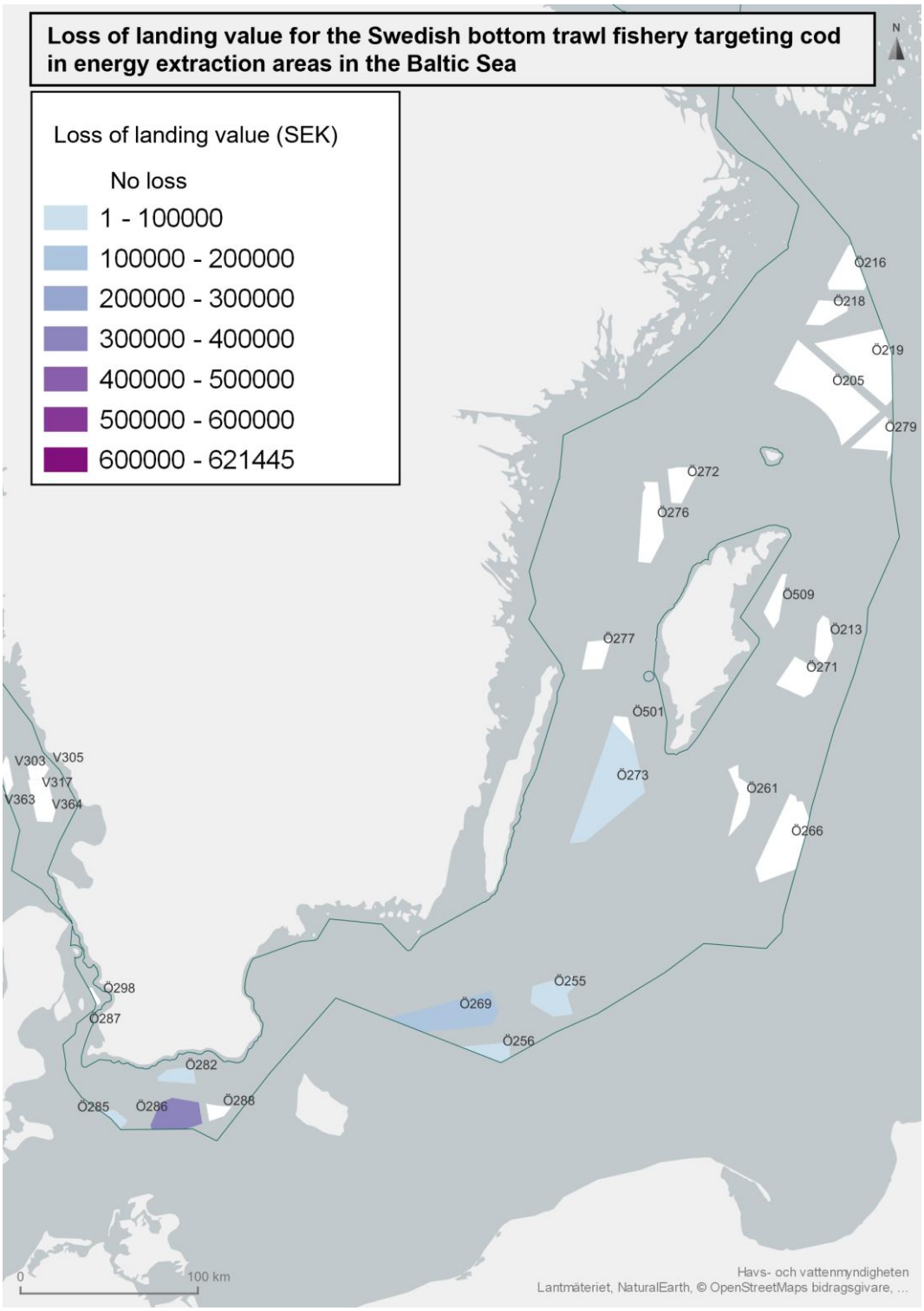

Figure 50. Map of loss in landing values for bottom trawling for cod in proposed and alternative energy areas in the Baltic Sea.

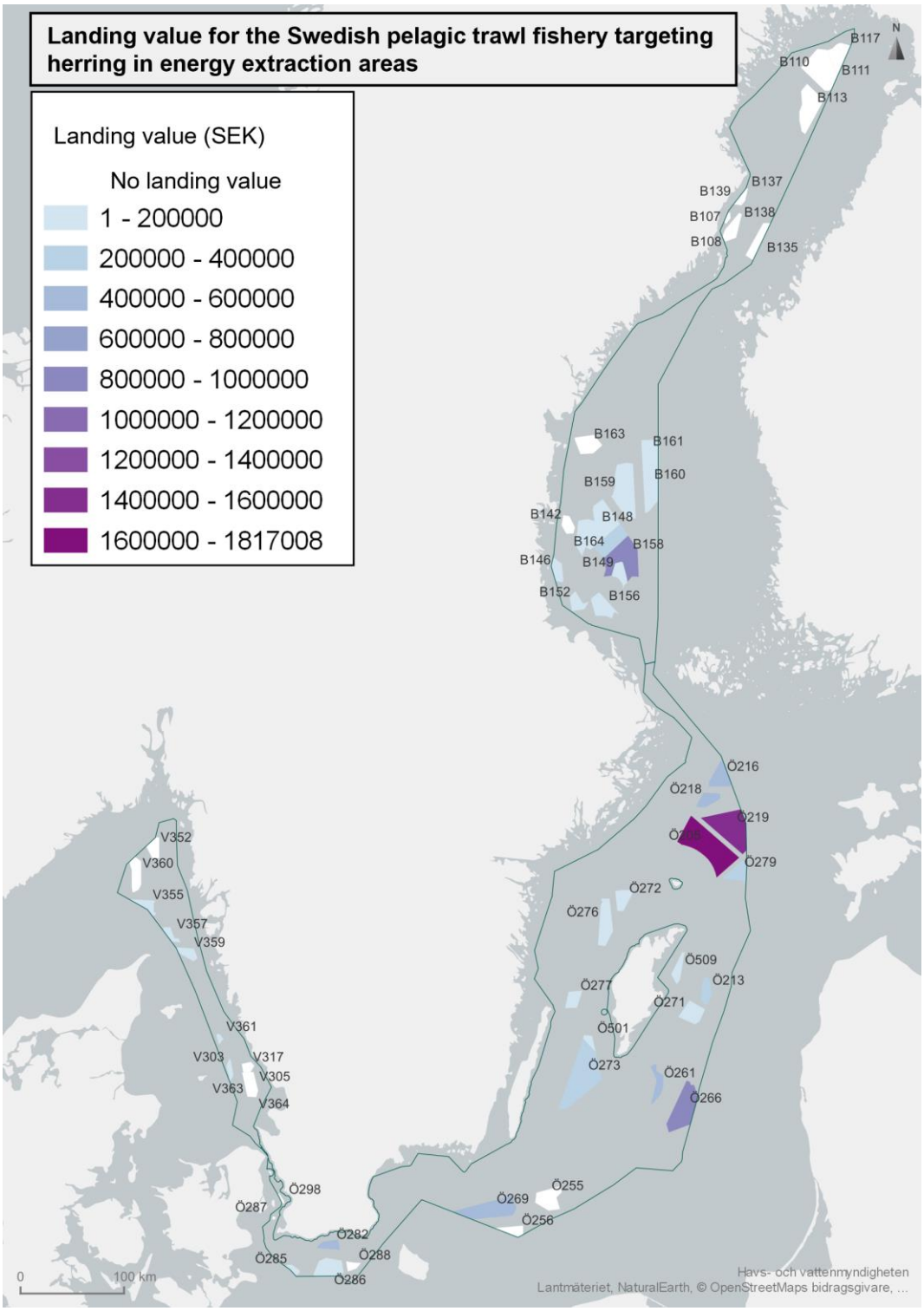

Figure 51. Map of landing values for the pelagic trawl fishery targeting herring in proposed and alternative energy areas in all three marine spatial planning areas.

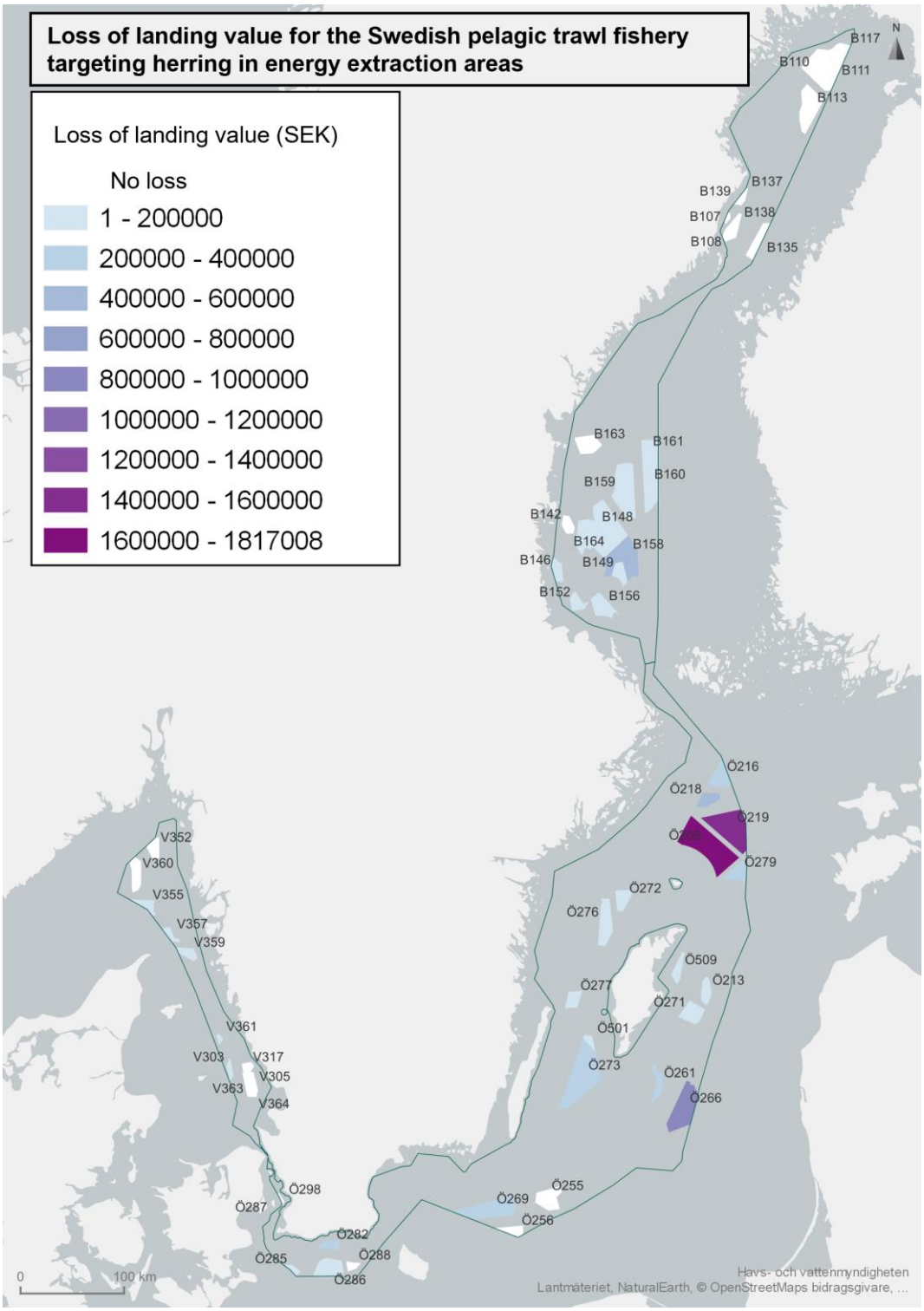

Figure 52. Map of loss in landing values for the pelagic trawl fishery targeting herring in proposed and alternative energy areas in all three marine spatial planning areas.

Appendix B Compilation of measures in the environmental impact assessment of the approved marine spatial plan

Environmental effect	**Habitat loss for marine mammals and sea birds as a result of disturbance in construction and operation of sea-based wind power, and operation of sand extraction activities**
Relevant criteria and indicators	**Descriptor D1 – Biodiversity** *Biodiversity is preserved. The habitats' quality and occurrence and the species' distribution and abundance are consistent with prevailing geomorphological, geographic and climatic conditions.* Criterion D1C2 - Abundance of species of birds, mammals and fish Indicator 1.2A – *Abundance of breeding sea birds* Indicator 1.2B – *Abundance of wintering sea birds* Indicator 1.2C – Abundance and trends for grey seal Indicator 1.2D – Abundance and trends for harbour seal Indicator 1.2E – Abundance and trends for ringed seal Criterion D1C4 – Distribution of species Indicator 1.4A – Distribution of grey seal Indicator 1.4B – Distribution of harbour seal Indicator 1.4C – Distribution of ringed seal Relevant indicators for porpoise are unavailable
Measures to forestall, prevent, counteract or remedy negative environmental effects	Relevant measures are primarily about administrative instruments linked to the regulations for the permit review of water activities according to Chapter 9 and Chapter 11 of the Environmental Code. In connection with this, conditions for the reduction of disturbance to various species can be set. Today, there is a lack of guidance on how sea-based wind power and sand extraction should be designed to minimise the risk of disturbance, and how different solutions should be tested. Among other things, there are no limits for what a reasonable disturbance is for various species or species groups, during construction, as well as during operation and decommissioning. There is also disagreement over the ability of protective measures to minimise pressures to reasonable levels. Knowledge-creating measures within, among other things, the framework for the "Vindval" programme and measure 25 under the Marine Environment Action Programme are relevant in this context. Other relevant existing measures include: - the Species Conservation Ordinance (2007:845), which implements Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, and Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. - Action programme for endangered species. Today, there is a lack of specific programmes for endangered species of sea birds. There is an action programme for porpoise from 2013, which has a focus on minimising by-catch,

Environmental effect	Habitat loss for marine mammals and sea birds as a result of disturbance in construction and operation of sea-based wind power, and operation of sand extraction activities
	counting and mapping populations, underwater noise problems and area protection. The programme is being updated. Within the scope of this environmental assessment, a measure was tested to minimise the risk from wind power establishment at Southern Midsea bank to benthic foraging sea birds, with a special focus on long-tailed duck. The measure entails the relocation of the wind farm to nearby areas deeper than 30 m. Modelling in Symphony shows a significant decrease in the impact on sea birds. At the same time, the measure means that the wind farm is located within the boundaries of the Natura 2000 area.
Monitoring and supervision	**Monitoring programme for sea birds** The monitoring of breeding and wintering birds along the coast and in the open sea aims to follow population development over time, which can be affected by changed conditions in the foodwebs, but also by direct impact that arises from a number of different human activities. Data collected includes: *Wintering sea birds (near to land and in the open sea)* - Number of wintering sea birds within counting units along the coast or along flight transects of the open sea (see methods) - Geographic spread can partly be assessed based on the populations' size *Breeding sea birds* - Abundance and spread of various species of sea birds along the Swedish coast - Number and size of mainly eider young (indirect measure of the young's age) Details about the programme can be found at https://www.havochvatten.se/hav/samordning--fakta/miljoovervakning/remissversion-for-overvakning-i-marin-miljo/marin-miljoovervakning/sjofaglar.html **Monitoring programme for seals** The objective of the monitoring of seals is to study long-term trends in the marine environment as a result of human impact by documenting the development of the seal populations. The following data is collected through test measurements: - population growth rate (in per cent) - population size (number of seals) - spread of grey seal during the fur change period in May - spread of harbour seals during the fur change period in August - spread of ringed seals during the freeze-up in the Gulf of Bothnia in April. Details about the programme can be found at https://www.havochvatten.se/hav/samordning--fakta/miljoovervakning/remissversion-for-overvakning-i-marin-miljo/marin-miljoovervakning/sal.html. **Monitoring programme for porpoises** The objective of the monitoring is to follow up trends in abundance and population growth for porpoises in Swedish waters. Threats to porpoises are mainly elevated mortality through by-catch in fishing, environmental toxins, reduced food supply as

Environmental effect	**Habitat loss for marine mammals and sea birds as a result of disturbance in construction and operation of sea-based wind power, and operation of sand extraction activities**
	a result of overfishing and loss of habitats, which is mainly due to disturbance in the form of noise. The study measures: - Relative density and spread of porpoises in investigated areas - Population growth rate (in per cent) - Population size (number of porpoises per sq. km) - Health and disease monitoring Details about the programme can be found at https://www.havochvatten.se/hav/samordning--fakta/miljoovervakning/remissversion-for-overvakning-i-marin-miljo/marin-miljoovervakning/tumlare.html

Environmental effect	**Physical injury to marine mammals caused by impulsive underwater noise**
Relevant criteria and indicators	**Environmental quality standard E.2** *Human activities shall not cause harmful impulsive noise in marine mammal areas during periods of time when the animals are susceptible to disturbance.* **Descriptor D1 – Biodiversity** *Biodiversity is preserved. The habitats' quality and occurrence and the species' distribution and abundance are consistent with prevailing geomorphological, geographic and climatic conditions.* Criterion D1C4 – Distribution of species Indicator 1.4A – Distribution of grey seal Indicator 1.4B – Distribution of harbour seal Indicator 1.4C – Distribution of ringed seal Relevant indicators for porpoise are unavailable
Measures to forestall, prevent, counteract or remedy negative environmental effects	The environmental effect is strongly associated with the risk of habitat loss for marine mammals described above. The effect is especially important for porpoises due to their sensitivity to underwater noise and dependence on echolocation for survival. The effect is to some extent also relevant to seals. Activities in Swedish waters that mainly cause potentially harmful impulsive noise include: - piling and blasting in construction of wind power at sea - piling for transport infrastructure - blasting in connection with military operations - drawing of electrical and communication lines - seismological surveys of the seabed Water activities that are at risk of negatively affecting people or the environment require a permit according to the Environmental Code and are reviewed by the Land and Environmental Court. The most important effect-minimising measures are established in connection with the permit review in the form of operational conditions, which usually entail provisions on when and where the operations may be done, and the application of protective measures. In this way, the risk of harm is minimised by scaring the animals away from the area, reducing the noise level or

Environmental effect	Physical injury to marine mammals caused by impulsive underwater noise
	avoiding periods where the animals are especially sensitive to disturbance, e.g. the calving period. Examples of risk mitigation measures include. (Nordzell et al., 2019): - choice of the season for construction - gradual increase in piling strength - use of porpoise and seal scares - use of noise suppression methods, namely bubble curtains, various forms of protective mantles, caisson techniques or screens of gas-filled balloons. The effects of the application of noise minimisation measures in the construction of wind farms in Germany have recently been published and form an important input for constructions in Swedish waters, where similar studies do not exist (Brandt et al., 2018; Rose et al., 2019). Within the scope of the Vindval programme, documentation and guidance were prepared on the regulation of underwater noise during piling (Andersson et al., 2016), which among other things sets out proposals on noise levels that can cause hearing damage to porpoises. At SwAM, work is under way to develop uniform guidance on underwater noise that comprises activities other than wind power. Relevant policy measures cover the work within thematic expert groups at the EU level, or under OSPAR and HELCOM for the North Sea and the Baltic Sea, respectively.[4] In Sweden, a national reference group for underwater noise was initiated in 2015 with the task of developing national limits for impact from man-made underwater noise. The objective is for these limits to be used in permit reviews and impact assessments.
Monitoring and supervision	**Monitoring programme for impulsive underwater noise** The programme's objective is to map the scope of noisy activities in time and space to get an image of the accumulated sound environment in the sea and be able to prevent too many high impulsive noises from occurring simultaneously in an area. Information reported in the programme includes: - Type of activity - Position (coordinates or ICES sub-box (*ICES statistical subrectangles*)) - Proxy for source strength (noise level) - Start and end dates - Occurrence of noise-reducing measures Details about the programme can be found at https://www.havochvatten.se/hav/samordning--fakta/miljoovervakning/remissversion-for-overvakning-i-marin-miljo/marin-miljoovervakning/impulsivt-undervattensbuller.html. **Monitoring programme for seals** *See above* **Monitoring programme for porpoises**

[4] MSFD Common Implementation Strategy Technical Group on Underwater Noise (TG-NOISE); OSPAR Intersessional Correspondence Group on Underwater Noise (ICG Noise); HELCOM Expert Network on Underwater Noise (EN-Noise).

Environmental effect	Physical injury to marine mammals caused by impulsive underwater noise
	See above

Environmental effect	Habitat loss and reduced reproduction capacity in fish as a result of physical disturbance in the operation of sand extraction activities
Relevant criteria and indicators	**Environmental quality standard D.3** *Permanent changes in hydrographic conditions resulting from large-scale activities, individually or together, shall not adversely affect biodiversity and ecosystems*. **Descriptor D6 – Seabed integrity** *The seabed's integrity stays on a level that means that the ecosystems' structure and functions can be ensured and that especially the benthic ecosystems are not negatively affected.* Criterion D6C3 – Extent of physical disturbance in benthic habitats Indicator 6.3A – Extent of physical disturbance in benthic habitats Criterion D6C5 – Scope of negative effects of human pressures Indicator 5.8B – Benthic fauna in offshore waters **Descriptor D7 – Lasting changes in hydrographical conditions** *This descriptor currently lacks specific criteria and indicators.* **Environmental quality standard C.3** *Populations of all naturally occurring fish species and shellfish that are affected by fishing have an age and size structure and stock size to ensure their long-term sustainability.* **Descriptor D1 – Biodiversity** *Biodiversity is preserved. The habitats' quality and occurrence and the species' distribution and abundance are consistent with prevailing geomorphological, geographic and climatic conditions.* Criterion D1C2 – Abundance of species of birds, mammals and fish Indicator 1.2H – Spawning biomass for pelagic and demersal fish species **Descriptor D3 – Commercial use of fish and shellfish** *The populations of all commercially used fish and shellfish stay within safe biological limits and show an age and size distribution that indicates a healthy population.* Criterion D3C2 – The spawning stock's biomass in commercially used species Indicator 3.2A – Spawning biomass for commercially used populations
Measures to forestall, prevent, counteract or remedy negative environmental effects	The environmental effect is mainly caused by elevated sediment spread and change of seabed conditions within and near the areas where the MSPs indicate the use sand extraction. Hydrographic conditions that are assumed to be able to change are turbidity and depth conditions, and possibly currents in the immediate area. The risk of such changes can be high in sand extraction, depending on the sediment type and dynamics, and on the scope and duration of the operations. These aspects determine whether the changes become permanent or not. In the construction of wind power at sea, the risk of significant and long-term effects on

Environmental effect	Habitat loss and reduced reproduction capacity in fish as a result of physical disturbance in the operation of sand extraction activities
	biodiversity and ecosystems is usually deemed to be negligible. The risk and possible damage minimisation measures still need to be investigated and reviewed. Changes that arise only during construction or decommissioning phases are usually not counted as permanent, which is, however, the case for the changes that are caused by the actual wind power foundation during the operating phase. The risk of loss of fish habitats has a similar cause as for other marine species, namely porpoises and seals, as described above. Changes in seabed structure and dynamics can make habitats unsuitable for some species, at the same time that greater human presence can scare the animals away. Sediment withdrawals can be directly harmful to species that lay eggs on seabed substrates, at the same time that elevated sediment spread can disrupt reproduction capacity in species with pelagic egg and larval stages. Measures to maintain good environmental status regarding hydrographic conditions mainly fall within the scope of the permit review. These are administrative instruments linked to various laws and the ordinance, namely the Environmental Code. It is important that decision documentation is available for the assessment of activities and measures. An environmental impact assessment is usually required, which should present the activities' impact on hydrographic conditions. Environmental impact assessment in permit review according to Chapter 9 and Chapter 11 of the Environmental Code is considered to be the main control to ensure that infrastructure or other activities in the offshore area do not degrade the status of the environmental quality standard D.3 (SwAM, 2015c). Within the marine environment action programme 2016-2021, a measure (ÅPH 13) was proposed to develop guidance to strengthen the descriptions of hydrographic changes and how they affect marine ecosystems. Within the same action programme, there are a number of other measures to develop guidance or policies regarding various aspects linked to benthic environments' integrity and restoration that are relevant to the fulfilment of the environmental quality standard D.3. Measures against negative effects on fish in terms of habitat loss caused by physical disturbance are largely of the same character as for habitat loss for marine mammals and birds, as described above. It primarily concerns administrative instruments that are set within the scope of the permit review process. The majority of existing measures related specifically to fish are directed at fishing, which is considered to be the main reason for changes to fish stocks and fish communities, despite several other impact factors in the marine environment (SwAM, 2015c). Such measures fall within the scope of the EU Common Fisheries Policy and the national fishing regulation, and are not directly relevant to disruption caused by new constructions or activities. In comparison, measures related to conditions for construction in the water or planning and operation of water activities are generally considered to have a significantly lower potential effect to achieve a good environmental status (SwAM, 2015c). However, in connection with specific projects, such measures can be crucial to minimise the risk of damage, by for instance avoiding disturbance during biologically sensitive periods.

Environmental effect	Habitat loss and reduced reproduction capacity in fish as a result of physical disturbance in the operation of sand extraction activities
Monitoring and supervision	**Monitoring of hydrographic conditions** Monitoring of hydrographic conditions is included in five different monitoring programmes, of which two measure hydrographic characteristics (physical characteristics, such as temperature and salt, and hydrological characteristics, such as currents, waves and water levels), and three follow up on human pressures and their effects, namely: - effects of cooling water; - physical impact - benthic habitats. The latter two programmes are relevant to the effects described above that are deemed to be able to arise as a result of the application of the MSPs. These two programmes are currently under development. Data from both programmes need to be able to be combined to assess the possible impact of physical disturbance on habitats. It is expected that the following data will need to be collected within these two programmes: *Physical impact:* - bottom trawling data - data from Environmental Code reviews, - data from aerial images and satellite data For each activity or construction, the following data is collected: - time - geographic location - area/length - relative impact with regard to hydrological quality factors - general wave regime around the phenomenon and how it is affected - seabed substrate that is affected and affects the surrounding area - depth effect - zoning of intensity - intensity of impact pressure Details about the programme can be found at https://www.havochvatten.se/hav/samordning--fakta/miljoovervakning/marin-miljoovervakning/fysisk-paverkan.html. *Benthic environments* The geographic spread of the nature types and habitats and the areas of occurrences: - Distribution area and area covered by nature types and habitats - Structures (in nature types and habitats) that can be defined spatially Quality of nature types and habitats: - biotic and abiotic structures (e.g. occurrence of vegetation) - ecological functions (e.g. typical species composition, species size and or age structure, etc.) Details about the programme can be found at https://www.havochvatten.se/hav/samordning--fakta/miljoovervakning/marin-miljoovervakning/bentiska-livsmiljoer.html

Environmental effect	Habitat loss and reduced reproduction capacity in fish as a result of physical disturbance in the operation of sand extraction activities
	Monitoring programme for coastal and offshore fish The main objective of these two programmes consists of following up changes in the number and size structure of the most common species that are commercially used. The programmes thereby have a significant focus on fishing and how it affects the populations. Data collected within the programmes is also used to assess the status of the ecosystem. Data from the offshore fish monitoring is coordinated between different countries and is used in the work to prepare documentation for fishing quotas. The programmes have no special focus on how the fish stocks, reproductive capacity in fish or spawning stocks are affected by physical disturbance. Monitoring data is nonetheless the basis for permit assessments, including the assessment of spawning stocks, which are in turn necessary to be able to estimate and compare the effects of new constructions or activities. Where a certain water activity is considered to possibly entail negative effects on fish, spawning habitats and reproductive capacity, a control programme must be prepared that monitors these aspects.

Environmental effect	Loss of benthic environments in construction and operation of sea-based wind power, and operation of sand extraction activities
Relevant criteria and indicators	**Environmental quality standard D.1** *The area of the sea floor unaffected by human activity shall be of a scale which provides the conditions for maintaining the structure and function of the sea floor for each habitat type.* **Environmental quality standard D.2** *The area of biogenic substrates shall be maintained or increased.* **Descriptor D6 – Seabed integrity** *The seabed's integrity stays on a level that means that the ecosystems' structure and functions can be ensured and that especially the benthic ecosystems are not negatively affected.* Criterion D6C3 – Extent of physical disturbance in benthic habitats Indicator 6.3A – Extent of physical disturbance in benthic habitats Criterion D6C5 – Scope of negative effects of human pressures Indicator 5.8B – Benthic fauna in offshore waters
Measures to forestall, prevent, counteract or remedy negative environmental effects	Most existing measures regarding the seabed's integrity are directed at bottom trawler fishing's impact on benthic environments. Despite several other pressures that affect the seabed, bottom trawling for fish is considered to be the dominant activity in the offshore area that causes negative physical impact on the seabed. This is especially true in Skagerrak and Kattegat, while in the Baltic Sea, trawler fishing's impact on the seabed's integrity is not as extensive (SwAM, 2015c). Existing measures comprise area-specific regulations to reduce the impact of trawler fishing in existing protected areas, the relocation of the trawler boundary on the west coast, fishing regulations for the protection of the integrity of the seabed under the Fishing Act and the Ordinance on Fishing, and the establishment of protected areas, including biotope protection areas.

Environmental effect	Loss of benthic environments in construction and operation of sea-based wind power, and operation of sand extraction activities
	The establishment of protected areas can also be relevant as a preventive measure for protection against other pressures that are at risk of affecting the seabed, including wind power establishment and extraction of materials. In this context, the measure can be used to ban or limit human impact with the aim of preserving the seabed, and opens up the possibility of setting requirements for restoration and compensatory measures within protection plans for certain types of protected areas. For specific water activities, such as sea-based wind power and material extraction, the conditions that are set within the scope of permit review according to the Environmental Code are the most important to minimise the risk of negative impact on the integrity of the seabed (see above). An important aspect is the threshold for what is considered to be acceptable disturbance or damage to the seabed's integrity, which is currently not set. This relates to knowledge about the spread of the different nature types and what different degrees and types of human impact mean to the structure and function of the benthic ecosystems. Such knowledge is also necessary to be able to assess the form and scope of possible future restoration and compensation in the event of a loss of natural benthic habitats. Such measures are currently not applied in the open sea. Within the action programme for the marine environment 2016-2020, measure ÅPH 25 was developed, aimed among other things at building up knowledge about mussel banks in the Baltic Sea's offshore areas, physical impact on deep soft seabeds, reef environments and gravel seabed in Skagerrak and Kattegat (SwAM, 2015c).
Monitoring and supervision	**Monitoring programme for physical impact** See above, under Monitoring programme for hydrographic conditions. Today, various kinds of data are gathered that could be used for the estimation of physical impact from various human activities. However, there is a lack of a collective strategy for how data should be used in assessments. Methods for both monitoring and assessment are under development. In individual projects, such methods are usually developed within the scope of the project's control programme. **Monitoring programme for benthic habitats** The monitoring is included in the following six different monitoring programmes, of which the first two are relevant to the environmental effect in question, at the same time that they are currently under development. - benthic habitats - physical impact (see above) - large animals on the seabed - sediment-dwelling macrofauna - vegetation-covered seabeds - the water's chemical characteristics (oxygen and pH) For benthic habitats, see above under *Monitoring programme for hydrographic conditions.* Large-scale national marine mappings of Sweden's marine areas have been implemented since 2016, with the aim of improving the knowledge of benthic marine habitats. Development of monitoring is also under way to continuously be

Environmental effect	Loss of benthic environments in construction and operation of sea-based wind power, and operation of sand extraction activities
	able to monitor the status of the benthic habitats, as well as the scope of human activities and their negative effects on the habitats. Innovative monitoring methods are now being developed, where shallow benthic environments will be monitored by satellite and validated with adapted monitoring locally. A reliable comprehensive monitoring of benthic habitats in deeper areas, however, still requires a comprehensive mapping effort, mainly to create sufficiently accurate data on depth and substrate. In parallel, there is also a development of monitoring of physical impact, using aerial image interpretation and impact models.

Impact assessment of the proposal for amended marine spatial plans for the Gulf of Bothnia, the Baltic Sea and Skagerrak/Kattegat

Espoo consultation document (ref. no. 03746-2022)

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