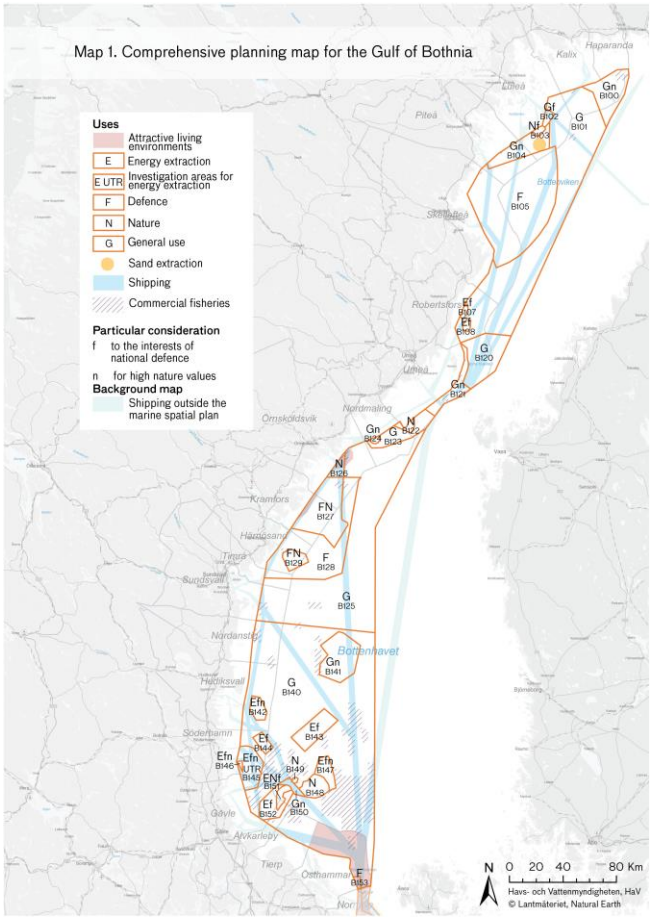
MARINE SPATIAL PLAN PROPOSAL

EARLY STAGE — **CONSUL-TATION** — REVIEW — FINAL PROPOSAL — GOVERNMENT DECISION

Swedish Agency for Marine and Water Management

Strategic Environmental Assessment of the Marine Spatial Plan proposal for the Gulf of Bothnia



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This strategic environmental assessment (SEA) was prepared by the consulting firm COWI AB on behalf of the Swedish Agency for Marine and Water Management (SwAM).

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Strategic Environmental Assessment

Maritime Spatial Plan - Gulf of Bothnia

Preface

In the Marine Spatial Planning Ordinance, the Swedish Agency for Marine and Water Management (SwAM) is given the responsibility for preparing proposals on three marine spatial plans (MSPs) with associated strategic environmental assessments (SEAs) in broad collaboration. The MSPs shall provide guidance to public authorities and municipalities in the planning and review of claims for the use of the marine area. The plans shall contribute to sustainable development and shall be consistent with the objective of a good environmental status in the sea.

In the work on marine spatial planning, SwAM prepared a current situation description (SwAM report 2015:2) and a roadmap (SwAM 2016:21), which includes the scope of the SEA. On 15 February 2018, the Agency published three MSP drafts for the Gulf of Bothnia, the Baltic Sea, and Skagerrak and Kattegat. This associated SEA and sustainability assessment were published on 10 April 2018.

The SEA for the MSP draft for the Gulf of Bothnia in the dialogue phase was prepared by the consulting firm WSP Sverige AB. Comments submitted during the dialogue phase were worked into the MSP drafts prior to the consultation phase between 15 February and 15 August 2018. A revised SEA for the three revised MSPs was prepared by the consulting firm COWI AB. Together with new documentation from the environmental assessment tool Symphony, analysed by the consultants Medins Havs- och Vattenkonsulter, comments submitted during the dialogue phase were worked into the SEA. Symphony contributes to a more detailed spatial analysis of the nature values, their sensitivities, and impacts from plan proposals. The revision was done in collaboration with SwAM, where COWI AB provided the assessment of environmental effects and consequences along with comparisons with environmental objectives.

The results from the SEA will be included in the continued planning work and will constitute input for revision of the plan proposal prior to the review phase in the spring of 2019.

Gothenburg, 10 April 2018

Björn Sjöberg, Director,
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1 Summary

Background, objectives, and purpose
The Swedish Agency for Marine and Water Management (SwAM) was assigned by the Government to prepare marine spatial plans (MSPs) for the Gulf of Bothnia, the Baltic Sea, and Skagerrak and Kattegat.

For each MSP, an environmental assessment and associated environmental impact assessment, the strategic environmental assessment (SEA), are also being prepared. This report is the SEA for the Gulf of Bothnia marine spatial planning area. It constitutes a consultation document together with the proposals on MSPs that were prepared by SwAM for consultation in the spring and summer of 2018. In this SEA, the MSP's three marine sub-regions have been analysed – Bothnian Bay, the Northern Bothnian Sea and Norra Kvarken, and the Southern Bothnian Sea.

The objective of the SEA is to integrate environmental aspects in the planning and decision-making so that sustainable development is promoted (Chapter 6 Section 1 of the Environmental Code). With the help of the planning method Symphony, the cumulative environmental impact within the marine spatial planning area has been estimated and analysed with the aim of assessing the result of the MSP in relation to the zero alternative for 2030.

In parallel with the SEA, a sustainability assessment was also done. The sustainability assessment is based on the three sustainability dimensions of *Economy*, *Ecology*, and *Social aspects*. Through the sustainability assessment, an expanded perspective is added to the SEA by also covering the plan's socio-economic and social impact. The sustainability assessment is presented in a separate report.

Most of the evaluated sectors' operations and development entail an impact on the environment and biological diversity. The results from Symphony indicate that the majority of the environmental impact can be traced to land-based or historical emissions. However, the present MSP proposal entails no or very small changes in the spread of most sectors. Only for energy extraction and sand extraction and to some extent commercial fisheries does the MSP entail a change from the current situation and the development that the sectors are assumed to undergo even without an MSP. It is therefore primarily these sectors' environmental impacts that gives rise to environmental consequences that can be traced to the MSP even if they contribute relatively small environmental effects according to the analysis in Symphony.

Below is a summary of the SEA's collective assessment, Chapter 9.

Environmental impact
The analysis identifies and describes the direct and indirect environmental effects that the MSP might entail for people and the environment, both to the

management of water and the physical environment in general and to other management of materials, raw materials, and energy.

Table 1 Summary of the environmental impact in the Gulf of Bothnia of the MSP on environmental aspects as per the Environmental Code, compared with the zero alternative. Scale: positive, none, small negative, moderate negative, large negative impact.

ENVIRONMENTAL ASPECTS ENVIRONMENTAL CODE / MSP'S THEME	POPULATION AND PEOPLE'S HEALTH	ANIMAL OR PLANT SPECIES AND BIODIVERSITY OTHERWISE	LAND, SOIL, AND WATER	AIR AND CLIMATE	LANDSCAPE, BUILT ENVIRONMENT, AND CULTURAL ENVIRONMENT	MANAGEMENT OF LAND, WATER, AND THE PHYSICAL ENVIRONMENT, AS WELL AS MATERIALS, RAW MATERIALS, AND ENERGY
ATTRACTIVE LIVING ENVIRONMENTS	Positive	None	None	None	None	None
ENERGY	None	Small negative	Small negative	Positive	Small negative	Positive
DEFENCE	None	None	None	None	None	Positive
STORAGE AND EXTRACTION OF MATERIALS	None	Small negative	Small negative	None	Small negative	Positive
NATURE	Positive	Positive	Positive	None	None	Positive
TRANSPORTATION AND COMMUNICATIONSTRANSPORTATION AND COMMUNICATIONS	None	None	None	Small negative	Positive	None
AQUACULTURE AND BLUE BIOTECHNOLOGY	-	-	-	-	-	-
COMMERCIAL FISHERIES	None	None	None	None	None	Positive

Population and people's health

Within the marine spatial planning area of the Gulf of Bothnia, outdoor recreation is mainly comprised of recreational boat traffic and recreational fishing, but also cruise ships and ferry traffic, hunting, safaris, etc. In the future, demand from both national and international tourism to participate in archipelago life and to use the sea for recreation is expected to increase. One of several conditions is that important natural and cultural values are preserved,

which the MSP's guidance for areas with *particular consideration to high nature values (n)* is intended to do. The rerouting of shipping lanes also means that both natural and cultural values are preserved in the shallow areas that are currently impacted by shipping. The MSP entails certain restrictions on outdoor recreation in the areas where energy extraction is pointed out as the most suitable use. In these areas, the appearance of the landscape is also changed. Human health is impacted by the emissions and the littering that takes place in the air and sea. The spatial changes that an adopted MSP has on the Gulf of Bothnia are not deemed to impact these pressures more than marginally. It is rather the sectors' development that has an impact and environmental effects that the plan has no control over. Otherwise, outdoor recreation is not affected in the marine spatial planning area more than marginally. The collective assessment is that the MSP has a positive impact on the environmental aspect *Population and people's health*.

Animals, plants, and biological diversity

The MSP entails a negative environmental effect in the Gulf of Bothnia as a result of energy extraction and sand extraction, and the plan thereby also entails a slightly negative consequence for the environmental aspect of animals, plants, and biological diversity. At the same time, the environmental effect from Commercial fisheries and transports decreases, partly through areas with *particular consideration to high nature values (n)*, which entails a positive consequence on the environmental aspect. The collective assessment is that the MSP in total entails a small negative consequence on the environmental aspect *Animals, plants, and biological diversity* and that extensive consideration needs to be taken to nature values in the area in the planning, permit review, establishment, and operation of various activities.

SwAM's work (2017) on proposals on climate refuges for a number of selected species indicates the possibilities of creating space for especially vulnerable species to successfully adapt and continue to exist in a changed climate. Parts of the northern Gulf of Bothnia have been identified as possible climate refuges for ringed seals, which is further reason to take extensive consideration to nature values.

Sea-based wind power has an impact through *underwater noise* and *physical disturbance* during construction of the facilities, which is a short-term disturbance that is not handled in the Symphony planning method. *Underwater noise* in the operating phase is deemed to constitute a small share compared with shipping noise, but *underwater noise* is a pressure the cumulative effects of which must be taken into consideration. Use of the seabed entails some *physical disturbance* and *physical loss*, i.e. habitat loss, as a result. Energy extraction's use of seabed habitats for wind turbine foundations might create artificial reefs that can benefit biodiversity in general, at the same time that wind power limits access for fishing, shipping, and recreational activities within these areas. In the MSP, the assessment is made that coexistence can be achieved, but in future permit processes regarding wind power establishment in the plan's areas for energy extraction, the negative

environmental effect is taken into account and managed to minimise the cumulative effect and meet the plan's recommendation regarding *particular consideration to high nature values (n)*.

In the MSP, sand extraction is present as the most suitable use in an area in the northern Bothnian Bay. Extraction of sand in the appointed area only takes place on transport bottoms below the photic zone, and natural replacement of sand takes place continuously in the area (SwAM, 2018). Here, the MSP entails a small negative environmental effect on the marine environment (*physical loss* and *physical disturbance*), but the effect is deemed to be of a local significance. *Particular consideration to high nature values (n)* within the same areas is deemed to limit the negative effect from sand extraction.

Within the MSP areas for energy extraction, the use Commercial fisheries will be limited, which entails a reduced pressure from fishing. Through the areas in the MSP where *particular consideration to high nature values (n)* is to be taken, the plan's guidance is expected to result in further regulation of Commercial fisheries.

Alternative for Storage and extraction of materials
The relatively large difference in the cumulative environmental effect between the zero and plan alternative is comprised of the assumption of no sand extraction by 2030 and that the MSP could accelerate sand extraction before 2030 through guiding proposals in the plan, i.e. Svalans and Falkens grund. Within the Bothnian Bay marine sub-region, there are few sectors that contribute to the environmental effect and consequently a new use is a relatively large pressure. Sand extraction has a local impact through *increased turbidity*, *physical disturbance*, and *physical loss* (habitat loss), and within the sand extraction area there are high nature values. The alternative MSP without sand extraction will therefore have a lower environmental effect.

Land, soil, water, air, climate, landscape, built environment, and cultural environment
For the environmental aspect *Land, soil, water, air, climate, landscape, built environment, and cultural environment,* the MSP is deemed to mainly entail local negative environmental effects in the areas where new establishment is proposed, such as material and energy extraction, while a positive effect is expected where *particular consideration to high nature values (n)* shall be taken and through a positive effect from energy extraction on climate. Altogether, the MSP is deemed to not entail any significant change on emissions to air and sea from the sectors shipping and defence compared with the zero alternative except for the longer distance that shipping must take in the Southern Bothnian Sea, which is deemed to have a slightly negative consequence. In addition, the MSP is deemed to entail a small negative consequence to the components *Land, water, and cultural environment* of this environmental aspect, no consequence on *air and climate,* and a slightly negative consequence for the other parts of the environmental aspect – *landscape, built environment, and cultural environment*.

Combustion of fuel from shipping results in emissions to the air that contribute to climate change and acidification and eutrophication problems. The MSP entails certain limitations for shipping in connection with wind power establishment and areas in which *particular consideration to high nature values (n)* and to some extent *to the interests of national defence (f)* shall be taken. In an area in the Southern Bothnian Sea, the plan means that shipping must take a different route as a result of the use energy and *particular consideration to high nature values (n)*. The longer distance that shipping is expected to take entails higher emissions to air (net emissions of carbon dioxide of around 470 tonnes) and thereby a pressure on the marine environment. The relocation of shipping entails a reduced pressure and a positive effect on the cultural environment.

In the Gulf of Bothnia is one of the Defence' marine training areas and associated influence areas for artillery ranges on land that affect the marine environment through emissions of metals from ammunition. Locally, this can cause large concentrations that have effects on the marine environment. The activities of the Defence in that part of the marine area also generate underwater noise. In relation to other human activities, the interests of national defence are expected to have good possibilities for coexistence with Commercial fisheries, outdoor recreation, and shipping. Permanent installations for energy extraction might entail physical obstacles and cause technical disruptions that can compete with defence activities. In the Southern Bothnian Sea, the MSP provides guidance on areas for energy extraction within which *particular consideration to national defence interests (f)* are to be taken in wind power establishment. This might entail limitations in the scope of wind power expansion.

Management of land, water, and the physical environment otherwise and *Other management of materials, raw materials, and energy*.
Altogether, the MSP is deemed to entail a positive consequence for the environmental aspect *Management of land, water, and the physical environmental otherwise* and *Other management of materials, raw materials, and energy* because the plan works for the coexistence between various uses and because sand extraction replaces the extraction of natural gravel on land and energy extraction contributes energy from a renewable source.

At present, there is no need for sand extraction at sea in the Gulf of Bothnia, but within the MSP's horizon year, the need is expected to arise. If extractions are made with good management, material should be able to be removed without resulting in a major impact on the sand and gravel deposits in question. With regard to energy extraction at sea, interest in renewable energy is also expected to increase in pace with technical development, which means that sea-based wind power will likely become more competitive. Both sand extraction and energy extraction are preceded by an environmental permit process in which local impacts and environmental effects are analysed and assessed with the aim of minimising the environmental impact. In the MSP,

some sectors are deemed to be able to coexist, and areas with *particular consideration to high nature values (n)* and *national defence (f)* have been pointed out in co-existence with one or more other uses.

Areas where *particular consideration to high nature values (n)* is to be taken are in most cases spawning grounds and recruiting areas for fish and thus constitute a resource. Through these areas, consideration is shown in the establishment of other activities, and some regulation of fishing can be introduced to benefit the fish stocks.

Goal attainment and sustainability

The proposed MSP for the Gulf of Bothnia has been checked against the work of achieving a good environmental status in the Swedish seas.

Plan proposal and the Swedish environmental objectives

In the evaluation of the plan's contributions to goal attainment of the environmental objective of *A Balanced Marine Environment,Flourishing Coastal Areas and Archipelagos,*, focus is on the specification - *Ecosystem services - important ecosystem services of coasts and seas are preserved*. The plan's combined effect in terms of *maintenance of ecosystem services* is difficult to assess. An overall assessment is that the plan does not entail any negative effect on the possibility of achieving this environmental objective in the Gulf of Bothnia. This is a result of negative effects on cultural ecosystem services and other ecosystem services of significance to *Commercial fisheries* and *Outdoor recreation and tourism* from a potential expansion of wind power.

Good environmental status according to the Marine Strategy Framework Directive

As a result of the environmental pressures, mainly linked to establishment of wind power, a cautious assessment is that the plan proposal potentially contributes negatively to the possibility of achieving the environmental quality standard of *Good environmental status*. The result of the assessment shows that the plan entails both positive and negative effects, but the pressures that are pursuant to the planning proposal's guidance on energy extraction are deemed to be greater than the positive effects, which are assumed to result from the consideration designation (n).

In terms of the possibility of fulfilling the environmental quality standard *D1 – The seabed area unaffected by human activity shall, by substrate type, provide conditions to maintain the structure and function of the seabeds in the North Sea and the Baltic Sea*, the plan proposal is deemed to potentially entail a negative effect due to guidance on energy extraction in an unaffected area (Finngrunden – Västra banken (B151)). Gretas klackar (B142) and the surrounding area (B147) are also potentially affected in the same way.

The sustainability assessment of the proposed MSP for the Gulf of Bothnia indicates a slightly positive result on a general level compared with the zero alternative without an applied MSP (COWI, 2018b):

Economic sustainability
Within economic sustainability, the plan proposal is deemed to not entail any unambiguous result because positive and negative effects are expected to cancel each other out. The positive effects are deemed to come from an extensive establishment of wind power, sand extraction in the Bothnian Bay, and generally stronger ecosystem services in the planning area as a result of more consideration to nature. At the same time, a potential expansion of sea-based wind power is deemed to entail negative economic consequences, partly through the visual disturbance that the sea-based wind turbines give rise to that are of significance to *Recreation and tourism*, and partly through the impact on sensitive natural environments that are of significance to, among other things, *Commercial fisheries*.

Ecological sustainability
Within ecological sustainability, the analysis indicates an altogether positive result as a result of climate effects from the potential expansion of wind power and greater consideration to nature. The plan is also deemed to entail negative environmental effects mainly linked to the construction phase in wind power establishment in the planning area, but also some local environmental pressure from sand extraction. Higher greenhouse gas emissions also arise as a result of the extended route for shipping because the energy areas according to the planning proposal's use constitute physical obstacles to ships.

Social sustainability
The proposed plan is deemed to have small positive contributions in social sustainability as a result of employment effects from a possible expansion of wind power. The plan is not expected to have any effects with regard to *identity-creating activities and factors* in the marine spatial planning area, *gender equality*, or *cultural environments*. However, a potential expansion of wind power entails a degradation in terms of *accessibility* and *coexistence* between various sectors and interests in the marine spatial planning area.

Cross-border cooperation
Sectors that cross borders in the Gulf of Bothnia are mainly Commercial fisheries and Transportation and communicationsTransportation and communications(shipping), but also the possibility of establishing climate refuges for, for example, ringed seals. Because both the spread of the sea ice and the ringed seal population extend across the border to Finland, it is desirable to have cross-border protected areas to increase the area's function as a climate refuge. Commercial fisheries is under way in the border area between Sweden and Finland in the northern Gulf of Bothnia, and this has potential cross-border effects. The MSP provides guidance in the border area between Sweden and Finland regarding the use of Commercial fisheries, but no negative

effects can be seen. In the Northern Bothnian Sea and Norra Kvarken, it is mainly shipping in Norra Kvarken that creates the impact on the environment because shipping is intensive in the marine area and some parts of the area consist of more sensitive environments. Cooperation between Sweden and Finland in the marine area in terms of shipping's impact on the environment is well established.

The analysis carried out with the help of Symphony shows that the areas where the MSP points out shipping and Commercial fisheries in the same areas generally indicates a burden on the environment, which might need to be managed through cross-border cooperation because these sectors are mobile and their environmental impact is cross border. Mobility also provides opportunities of improvements where in particularly pressureed parts of the marine area one can jointly create limitations to fishing and shipping in some areas through cooperation across the borders. In the Southern Bothnian Sea, it is mainly Commercial fisheries in the border area between Sweden and Finland that can create cross-border environmental impacts. The MSP also points out the area as important for shipping, which is why a combination of these sectors can have greater effects. The MSP proposes a relocation of a shipping lane to create space to be able to establish wind power and to keep shipping from passing over shallow banks.

Conclusions and future outlook

In general, areas with *particular consideration to high nature values (n)* contribute to reduced negative environmental effects The good effect of consideration recommendations for these areas is weighed up to some extent by the impact from wind power establishment and sand extraction in an analysis of the cumulative environmental effect with the help of the Symphony assessment method. One recommendation is, however, that more areas be identified where some form of special environmental consideration should be taken and to find possible coexistence with various sectors within these areas.

As of 2050, several areas are expected to be protected by marine area protection. Within the Convention on Biological Diversity, there is a target that 10% of coastal and marine areas shall be protected by marine area protection by 2020. In connection with the Government decision on new Natura 2000 areas in December 2016, Sweden has achieved the objective on a national level. However, measures must still be implemented for the marine area protection to become representative and functional. In the Gulf of Bothnia, 5% of the area is covered by marine area protection (SwAM, 2016b).

SwAM can propose regulations for areas if it is considered necessary to achieve the objective of the MSP. These can contain binding limits and could be a stronger alternative to areas with *particular consideration to high nature values (n).*

The results from the sustainability assessment have identified a number of adjustments to the MSP that could mitigate the negative effects of wind power establishment. An expanded use of the indication *particular consideration to high nature values (n)* combined with *General use* and *Energy extraction* could potentially strengthen access to the ecosystem services that Commercial fisheries and a significant part of Attractive living environments are dependent on. The effect would partly or entirely be able to offset the local negative effect from the wind power expansion. Another proposal on adjustment is to not indicate sea-based wind power closer than around 10 km from land in order to minimise the negative visual effect.

These changes would probably also provide a more positive outcome in the assessment of the plan's effect on goal attainment for the Swedish environmental objectives.

2 Introduction

2.1 Background: National marine spatial planning with associated environmental assessment

On 1 September 2014, a new regulation was introduced in the Environmental Code (Chapter 4 Section 10) regarding national marine spatial planning in Sweden. According to this regulation, there shall be an MSP for each of the areas of the Gulf of Bothnia, the Baltic Sea, and Skagerrak and Kattegat that provides guidance to authorities and municipalities in the planning and review of claims. The Marine Spatial Planning Ordinance (2015:400) regulates the implementation of the marine spatial planning. It contains provisions on geographic boundaries; the content of the MSPs; the responsibility for preparation, consultation, and cooperation in the proposal process; and monitoring and review.

According to the Ordinance, SwAM shall develop proposals for MSPs with the help of relevant county administrative boards and with support from national authorities, which will assist with supporting data for the planning. The municipalities, regional planning bodies, regional coordination bodies, and county councils that might be affected must be given the opportunity to participate in the proposal process so that consideration can be given to local and regional conditions and needs. SwAM shall promote cooperation with other countries and the coordination of the Swedish MSPs with those of other countries. Each MSP shall be environmentally assessed and a strategic environmental assessment (SEA) shall be prepared.

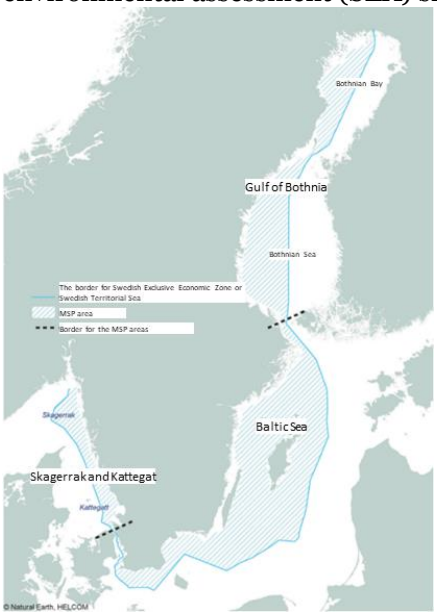


Figure 1 The three marine spatial planning areas. The municipal boundary between Östhammar and Norrtjälje forms the boundary between the Gulf of Bothnia's and the Baltic Sea's marine spatial planning areas. The municipal boundary between Helsingborg and Höganäs represents the boundary between the Baltic Sea and the Skagerrak/Kattegat marine spatial planning areas.

The MSPs cover Sweden's exclusive economic zone and Swedish territorial sea from one nautical mile (1,852 metres) outside the Swedish baseline. Privately owned water is excluded. The MSPs accordingly do not comprise the coastal area, which extends out one nautical mile from the baseline.

The municipalities have planning responsibilities for the marine area that is within the municipal boundaries, meaning internal waters and the territorial sea. The municipalities' and the state's planning responsibilities thereby overlap in most of the territorial sea since 2015 in connection with the Marine Spatial Planning Ordinance. The overlap means that municipal and national planning meet within a geographic zone in the territorial sea. Within this zone, differences in planning interests might exist and entail a challenge regarding collaboration and dialogue in future planning. Through good collaboration between the state and municipality, possible future conflicting objectives between the planning levels can be minimised.

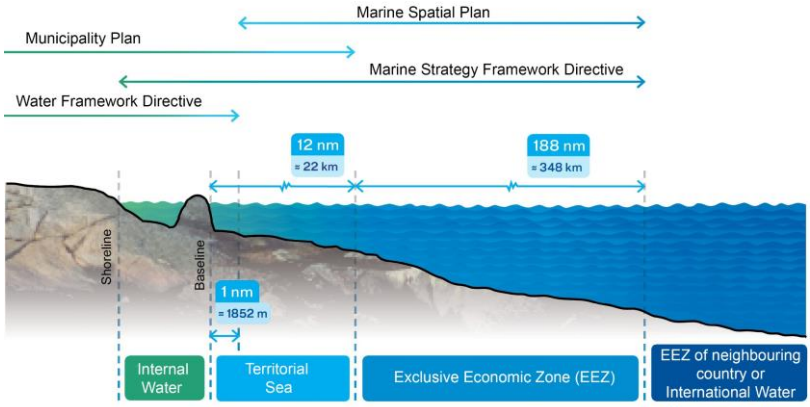


Figure 2 Illustration of the MSP's physical scope. This figure also indicates planning responsibility and environmental legislation for the sea.

2.2 MSP's purpose and objective

Planning of the sea comprises the areas in the water, on and above the surface, and on and in the seabed. The purpose of the MSPs is to integrate economic policy objectives, social objectives, and environmental objectives. The MSP shall contribute to:

- achieving and maintaining good environmental status
- the resources of the sea being used sustainably so that maritime industries can develop
- promoting coexistence between various activities and areas of use

An MSP should also provide the guidance necessary to be able to use the areas for the purposes that they are best suited for considering their character,

situation, and needs[1]. The MSPs shall provide guidance to public authorities and municipalities in the planning and review of claims for the use of the area. This includes a presentation of which areas are of national interest according to Chapter 3 of the Environmental Code and other public interests of material significance. When necessary, the plan shall provide proposals on considerations between interests with claims in the same geographic area through standpoints. A point of departure for the marine spatial planning is consideration of the conditions of the ecosystems in order to secure the values that form the basis of industries such as tourism or Commercial fisheries. SwAM therefore applies an ecosystem approach in marine spatial planning. Marine spatial planning is a process that is carried out over several years and can be described in cycles where one goes from information gathering and present situation analysis where the MSPs are the results of the planning processes. The plans are subsequently implemented and monitored continuously.

2.3 MSP's relation to other plans and programmes

The MSPs are not legally binding, but serve as guides. The planning should interact with both the international planning perspective and the regional and municipal perspectives, which is why the MSPs must relate to both a large geographic area and a small one. The reasoning and analysis behind the plan's standpoints will therefore be larger, both internally and externally, than the actual marine spatial planning areas. The planning processes for Skagerrak and Kattegat, the Baltic Sea, and the Gulf of Bothnia also need to be coordinated with each other (SwAM, 2015b).
The planning of the marine areas must relate to the Law of the Sea, other international law, and EU law, which provides both opportunities and limitations in planning. An MSP cannot restrict an activity or an interest beyond what is made possible by the Law of the Sea, for example (SwAM, 2018b).

2.3.1 International plans

From the international perspective, common solutions must be sought with neighbouring countries, and efforts should be made to establish coordinated forms of presentation of the MSPs.
In July 2014, the EU adopted the Framework Directive on Maritime Spatial Planning. The official name is Directive 2014/89/EU of the European Parliament and the Council of 23 July 2014, establishing a framework for maritime spatial planning. Within the Baltic Marine Environment Protection Commission (HELCOM), there is a joint roadmap in the Baltic Sea region with the goal of MSPs functioning together across borders and applying an ecosystem approach to 2020. The Marine Spatial Planning Directive indicates March 2021 as the latest time when national MSPs are to be adopted.

[1]Section 4 of the Marine Spatial Planning Ordinance (2015:400).

2.3.2 National plans

The MSPs cover Sweden's exclusive economic zone and Swedish territorial seas, but not the coastal area, which extends from the baseline out to one nautical mile.
The MSPs shall provide guidance to public authorities and municipalities in the planning and review of claims for the use of the area. The MSPs shall also serve as a complement to the existing national sector planning and contribute to a holistic perspective there.

2.3.3 Municipality plans

In accordance with the Planning and Building Act, the planning of the municipalities extends out over all the territorial waters, i.e. 12 nautical miles from the baseline. Through the introduction of the marine spatial planning in Sweden, there are 65 municipalities where the planning responsibility overlaps between the municipality and the state in the territorial sea. Some 20 additional municipalities border the sea, but not waters that are included in the national marine spatial plan areas (SwAM, 2018b).
As long as the purpose of the marine spatial planning is fulfilled, the marine spatial planning needs to take into account the existing municipal comprehensive plans where they present planning issues and development intentions in the national marine spatial planning area. Data produced during the planning process that might facilitate municipal comprehensive planning should be made available to the municipalities. The three national MSPs shall support municipal planning of the coastal zone and territorial sea.

2.3.4 Interaction between land and sea

Developments in the sea are dependent on and governed by activities on land, and the MSPs must therefore be placed in this context in the MSP proposal, the SEA, and the sustainability assessment. Populations and industries on the coast, transportation systems and ports, etc., are important reference points for marine spatial planning. Urban and rural development is another important factor as well as regional development strategies linked to the land. Emission sources on land also impact the sea to a significant degree, which is an additional factor that marine spatial planning needs to relate to. The Symphony method that was used in this report also provides analysis results that include land-based emission sources. The municipalities are responsible for the spatial coastal zone management and like the state have planning responsibility in the territorial sea. Good collaboration between the state, regions, and municipalities is necessary in order to coordinate local and regional conditions and perspectives with the national issues in the national marine spatial planning.

2.4 Strategic environmental assessment

At present, the marine spatial planning is in the consultation phase. Comments submitted during the dialogue phase in 2017 have generated an MSP proposal for the Gulf of Bothnia, the environmental impact of which is being assessed in this (SEA). The objective of the SEA is to integrate environmental aspects in the

planning and decision-making so that sustainable development is promoted[2]. With regard to the preparation of plans and programmes, the environmental assessment process is called an SEA. An SEA shall be carried out when the implementation of a plan is assumed to entail a significant environmental impact, which is the assumption for the preparation of an MSP in accordance with the Marine Spatial Planning Ordinance. The work on the strategic environmental assessment is compiled in an SEA-document, the contents of which is listed in Chapter 6 of the Environmental Code. One of the main tasks for the environmental assessment of the MSPs is to indicate the marine spatial planning's possibilities of contributing to a good environmental status and to assess what significant impact different uses of the sea might entail.

The MSP proposal for the Gulf of Bothnia (plan map and plan description) was published on 15 February 2018, and the SEA and the sustainability assessment were added to the consultation on 10 April 2018. Consultations will take place with concerned authorities, organisations, etc., at the national, regional, and municipal level and will be under way until 15 August 2018. During the consultation period, consultations will also be held for the SEA with Sweden's neighbouring countries, which is required in cross-border contexts within the scope of the Espoo Convention.

2.5 Guiding objectives

SwAM has prepared a *Marine Spatial Planning Roadmap* with the aim of supporting and guiding the work of developing the MSPs and to create clarity and support for the continued planning process (SwAM, 2016b). The Roadmap establishes the planning objectives and planning strategies that shall serve as guides in the work of developing the MSPs. This also includes a scope for the environmental assessment and focus in the SEA. In the Roadmap, ten planning objectives are presented, see Figure 3. The overall objective for marine spatial planning is Good marine environment and sustainable growth. The other nine planning objectives support this overall objective. Towards the end of this SEA, the plan will be evaluated with regard to environmental objective fulfilment.

[2]Act (2017:955).

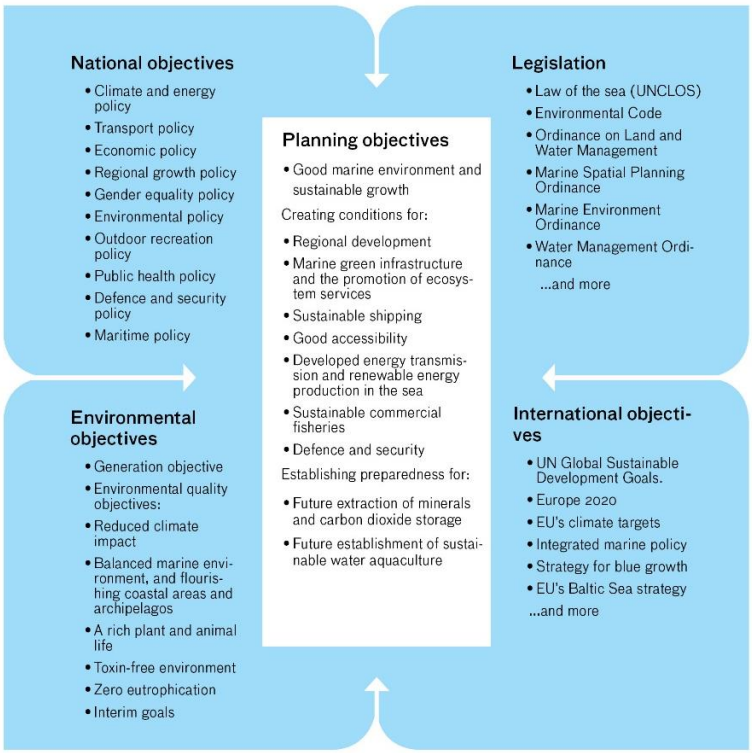


Figure 3 Identified planning objectives for the marine spatial planning, Marine Spatial Planning Roadmap, SwAM report 2016:21.

2.6 Sustainability assessment

In parallel with the SEA, a sustainability assessment is being done of the MSP for the Gulf of Bothnia. The sustainability assessment is based on the three sustainability dimensions of *Economy*, *Ecology*, and *Social aspects*. Through the sustainability assessment, an expanded perspective on the ecological sustainability dimension is added to the SEA by also covering the plan's socio-economic and social impact.

- Economy – within the economic dimension, the MSP's socio-economic impact is investigated for the sectors the conditions of which are affected by the planning.
- Ecology takes into account the plan's impact on nature and environmental aspects that cover both the marine environment and the relationship to climate change more generally. Marine ecosystem services and their fundamental role for the ecosystem's function are important points of departure because these are a prerequisite for several of the maritime industries.
- The Social aspect investigates the plan's consequences with regard to employment and gender equality, as well as public access in the marine spatial planning area. Within this aspect, possibilities of coexistence are also investigated between various interests and the areas' natural and cultural values.

The sustainability assessment is coordinated with the environmental assessment under Chapter 9 Collective assessment.

3 Maritime Spatial Plan - Gulf of Bothnia

The Marine Spatial Plan - Gulf of Bothnia (SwAM, 2018b) contains guidance in text and a plan map that shows the most suitable use of an area, such as conducting Commercial fisheries or shipping, extracting energy, or managing and protecting nature.

The MSP also indicates the areas where particular consideration shall be shown to nature values and the interests of national defence, which are marked in the plan map with "n" and "f", respectively. *Particular consideration to high nature values (n)* can, for example, be areas that have valuable or sensitive nature values or animal and plant species worthy of protection, but which today do not have statutory protection and where particular consideration shall be shown in coexistence. *Particular consideration to high nature values (n)* is not a use in the plan, but is a guide regarding consideration. *Particular consideration to national defence interests (f)* means that particular consideration shall be shown in all use of the area.

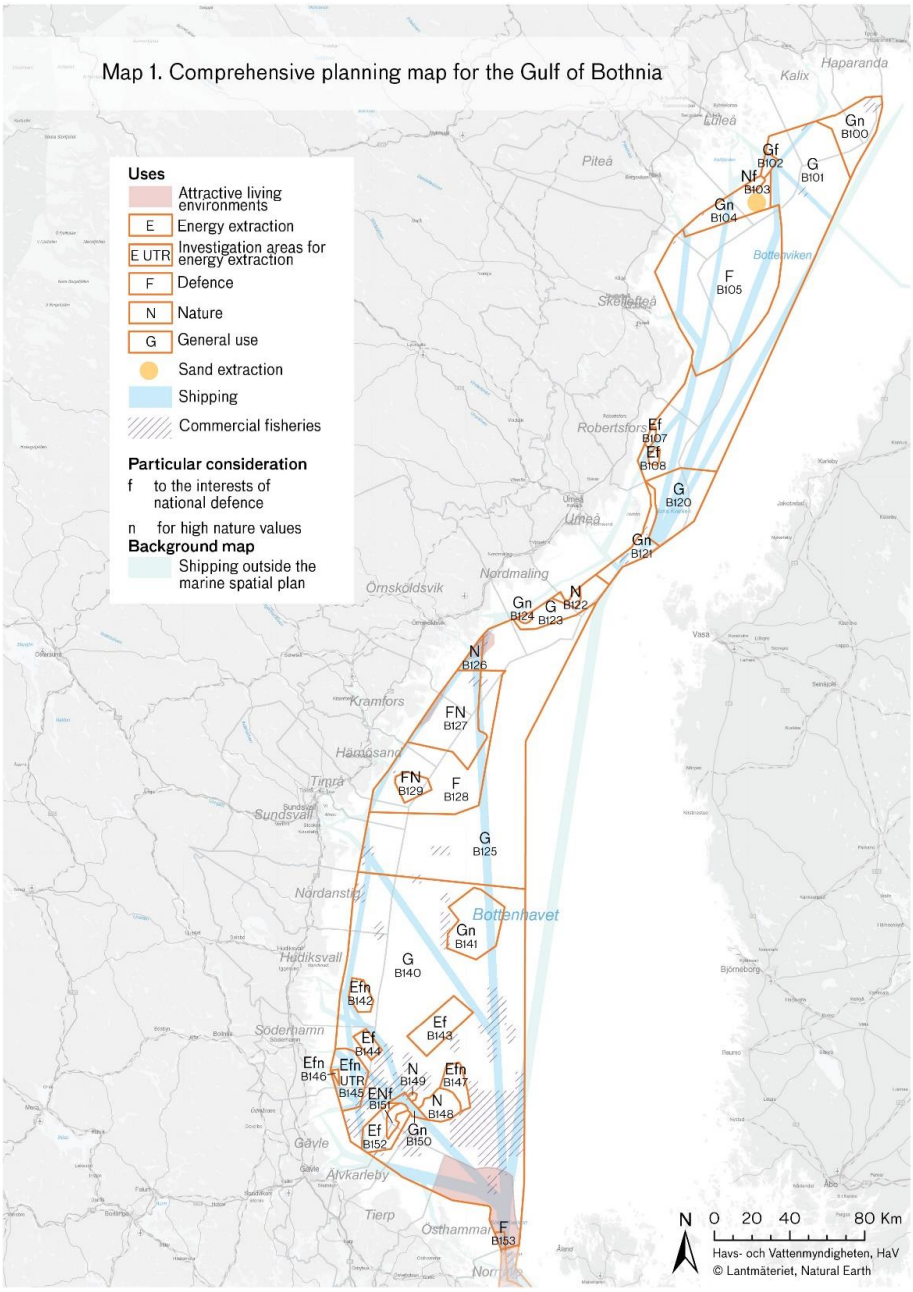


Figure 4 Comprehensive planning map for the Gulf of Bothnia (SwAM, 2018b)

3.1 Summary of the Maritime Spatial Plan - Gulf of Bothnia

Shipping is crucial to many industries, and ice conditions in the Gulf of Bothnia mean that shipping generally needs large areas in order to ensure navigability. In the marine spatial planning area, the Swedish Defence has one of Sweden's largest artillery ranges and one of the world's largest flight exercise areas. Commercial fisheries is sparse in offshore waters and is mainly conducted outside the marine spatial planning area. Several offshore banks with untouched and valuable nature are spread throughout the area.

The Gulf of Bothnia consists of three marine sub-regions – the Bothnian Bay, the Northern Bothnian Sea and Norra Kvarken, and the Southern Bothnian Sea.

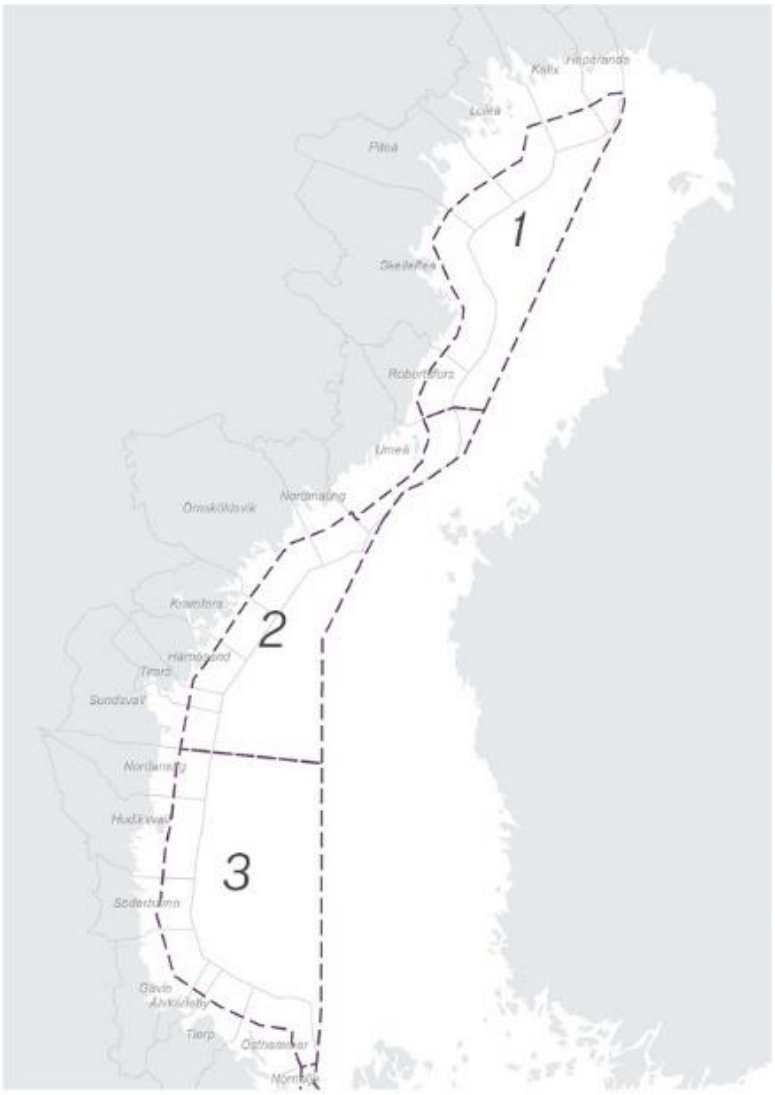


Figure 5 Comprehensive map over the marine sub-regions in the Gulf of Bothnia: 1. Bothnian Bay Northern, 2. Bothnian Sea and North Kvarken and 3. Southern Bothnian Sea.

3.2 Bothnian Bay

Thick and extensive sea ice in the winter affects the conditions for shipping, which needs large areas to ensure navigability. Shipping is important for industry in this part of the country. Permanent constructions, such as wind turbines, can be exposed to extremely severe strain from sea ice. Wind power is deemed to be a public interest of material significance in these areas. Within this marine sub-region, there is a military training area and an influence area from one of Sweden's largest artillery ranges.

The MSP points out areas where *particular consideration to high nature values (n)* is to be taken, areas for use for wind power (Energy), and areas for

sand extraction (Storage and extraction of materials), with the latter two most often in combination with *particular consideration to high nature values (n)* or *defence (f)*.

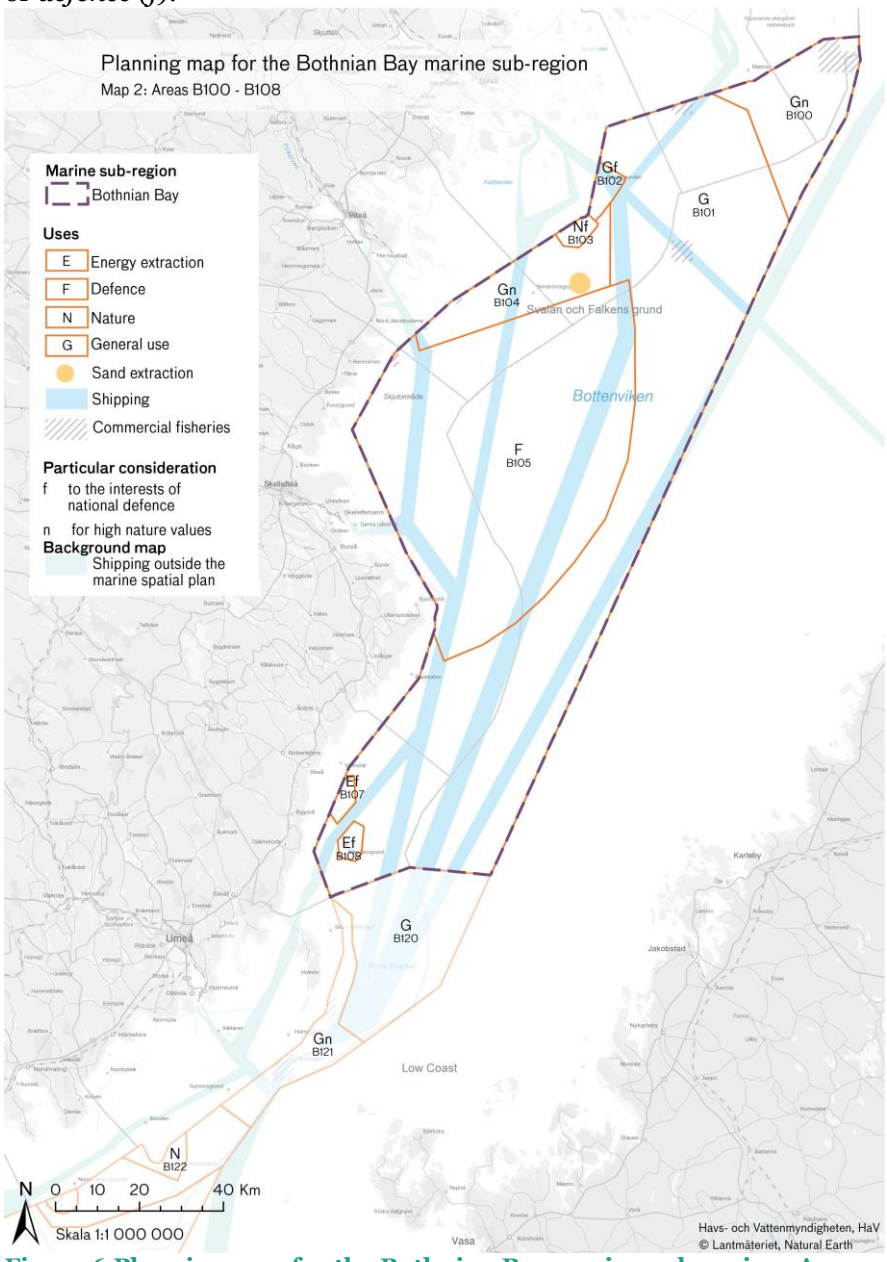


Figure 6 Planning map for the Bothnian Bay marine sub-region. Area numbers are on the map (SwAM, 2018b).

3.3 Northern Bothnian Sea and Norra Kvarken

Norra Kvarken is very important to shipping, and in this area shipping has limited room to manoeuvre and is divided into a traffic separation system (TSS) due to the shallow depth conditions and the narrow passage between Sweden and Finland. The southern parts of the marine area's deep sea host shipping and general use. Höga kusten's World Heritage site extends out into the sea with both natural and cultural environments under water. On the Finnish side, there is an area pointed out as a World Heritage site. The associated national interest for nature and outdoor recreation extends far out

in the MSP and is safeguarded, similarly to the marine area's nature reserves and Natura 2000 areas, through the use Nature. The MSP points out areas where *particular consideration to high nature values (n)* is to be taken.

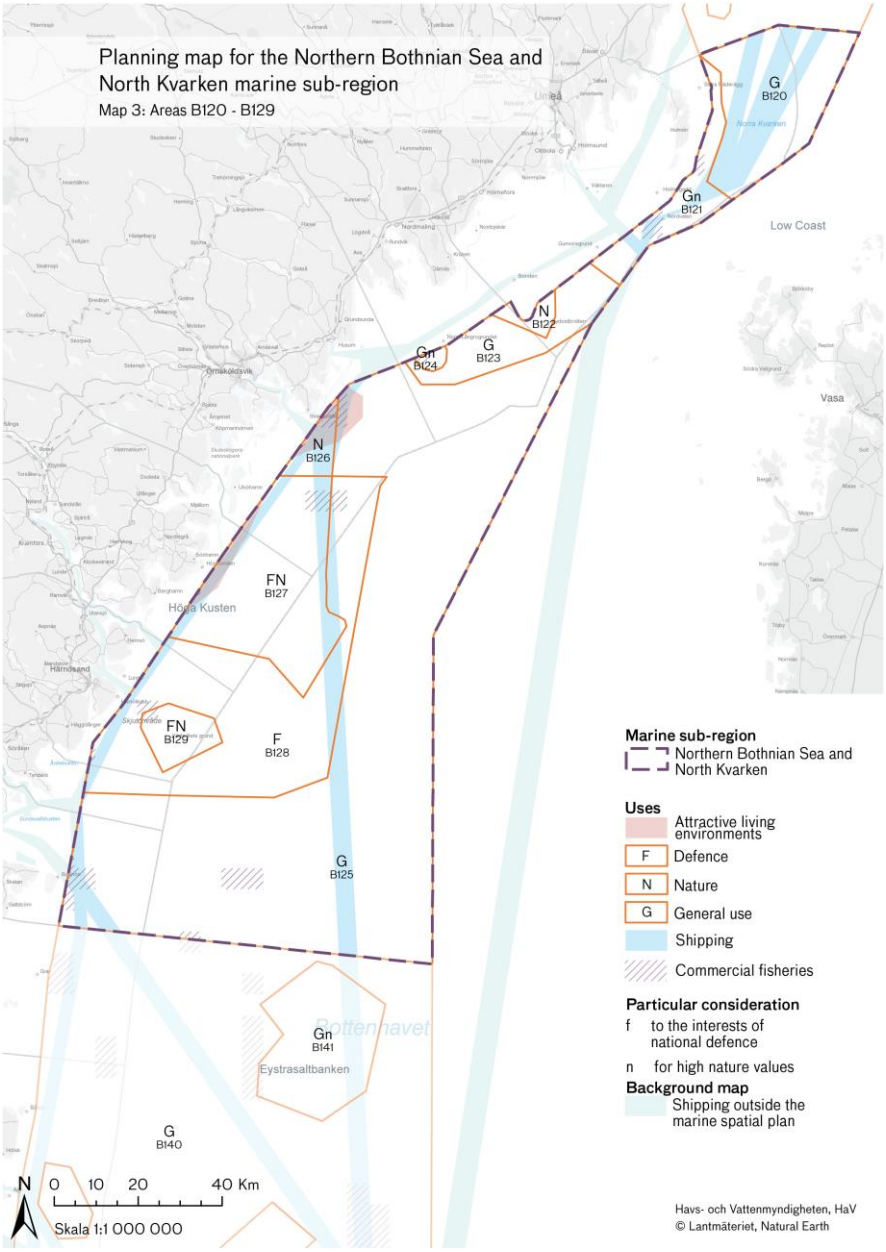


Figure 7 Planning map of the Northern Bothnian Sea and the North Kvarken marine sub-region. Area numbers are on the map (SwAM, 2018b).

3.4 Southern Bothnian Sea

The areas that are almost untouched by mankind are the offshore banks of which the shallowest are characterised by ecologically valuable seabeds with algae-covered reefs. The wind conditions, shallow areas, and proximity to good connection points make the conditions favourable for wind farms from Gretas Klackar to Gävlebukten. In this marine sub-region, shipping is crucial to many industries and several important ports are located along the coast in the Southern Bothnian Sea. Commercial fisheries is spread throughout the

Southern Bothnian Sea, mainly close to the coast although there is some pelagic fishing.

The MSP points out areas where *particular consideration to high nature values (n)* is to be taken and areas for energy extraction where *particular consideration to high nature values (n)* or *defence* (*f*) is to be taken. Thus the wind power that can be established on parts of Finngrunden is considered to be able to coexist with the areas' nature values. The many areas for energy extraction that the MSP indicates within the marine area entail a risk for cumulative impact on national defence interests.

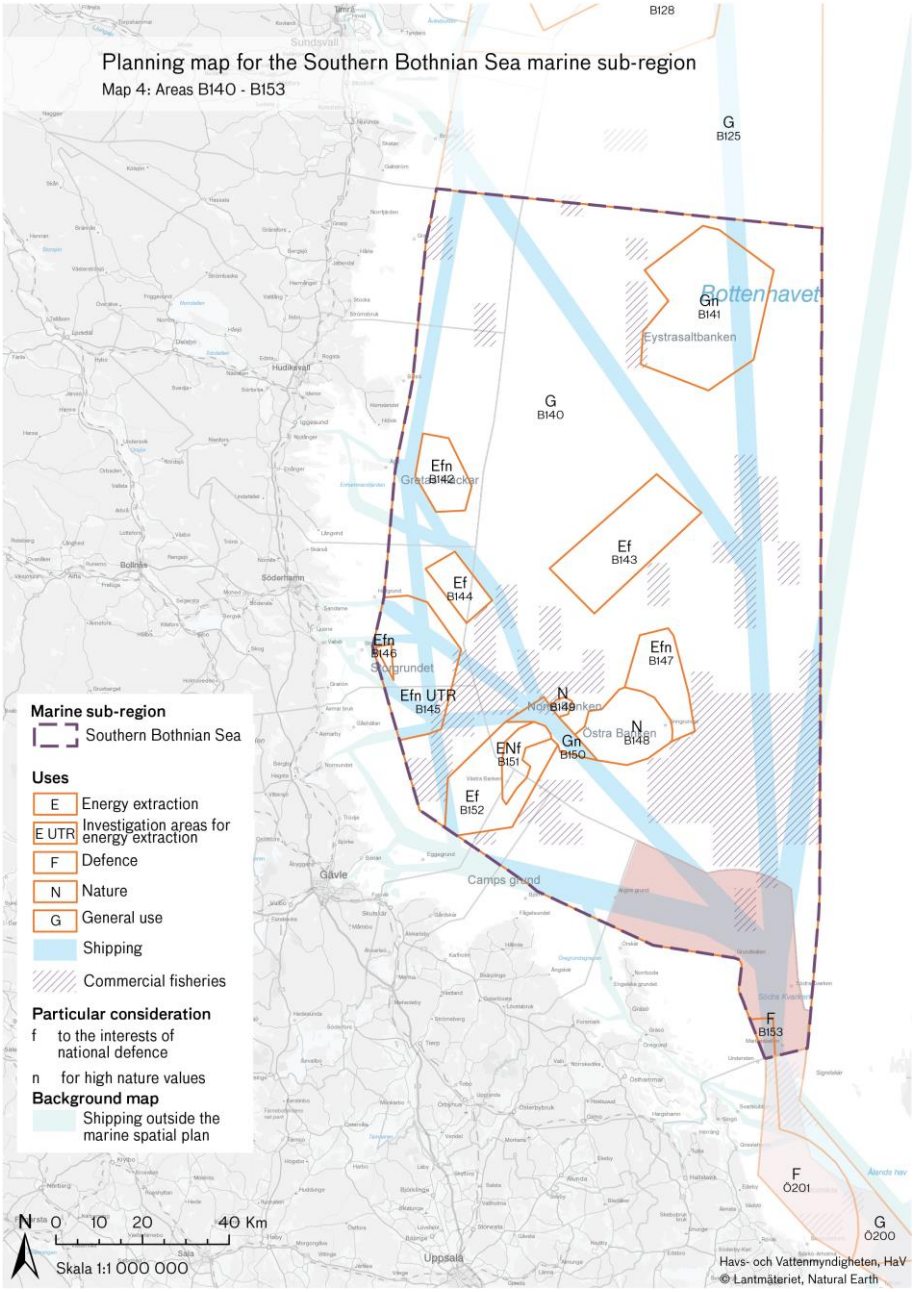


Figure 8 Planning map for the Southern Bothnian Sea marine sub-region. Area numbers are on the map, and areas with particular consideration to high nature values are marked with an "n" (SwAM, 2018b).

Investigation area for energy extraction

In this marine sub-region, there are good conditions for energy production at sea. The majority of shallow areas constitute suitable locations with good wind conditions to establish wind power, and several wind power projects are active in the marine sub-region. Today, there are no plants in operation in the marine sub-region. However, there are four appointed areas for national interests for wind power, including Finngrunden's western bank, Storgrundet, Utposten II (part of Storgrundet), and Utknallen (part of Finngrunden's eastern bank). For Utposten II, there is currently a permit for the construction and operation of a wind farm. There are on-going permit processes for wind power at an early stage for Gretas klackar and Utknallen (the number of turbines is unspecified). Natura 2000 areas have also been introduced on Finngrunden's banks to protect appointed types of nature. The permit application for a wind farm on Finngrunden's eastern bank was rejected in 2014 considering the impact on the long-tailed duck. The possibility of wind power should be investigated further, mainly based on the interest of national defence, nature values, and shipping.

4 Environmental assessment method

4.1 Purpose of the environmental assessment

The environmental assessment of plans and programmes is regulated according to Chapter 6 of the Environmental Code. The objective of the environmental assessment is to integrate environmental aspects into the plan or programme so that sustainable development is promoted. This means that the environmental assessment needs to be an integral part of the planning process so that the environmental impact of the plan receives adequate treatment in the planning work and is allowed to influence the plan's direction and standpoints.

An SEA is the written account that an environmental assessment leads to. The purpose of an SEA is to identify and describe a plan's significant effects and consequences on human health and the environment and on the management of the physical environment and natural resources. The significant environmental effects that the implementation of the plan, the programme, or the change can be assumed to entail shall be identified, described, and assessed. Reasonable alternatives with regard to the plan's or programme's purpose and geographic range shall also be identified, described, and assessed.

4.2 Scope

Geographic scope
The environmental assessment shall describe the significant environmental impact that might arise as a result of the MSPs. The line between the marine areas and the coastal zone is important from an environmental perspective, and the cross-border environmental impact in relation to our neighbouring countries is also included in the assessment. This SEA primarily comprises the marine spatial planning area even if the influence area for certain environmental aspects (Chapter 6 of the Environmental Code) is larger. The marine spatial planning area has been divided into marine sub-regions, which in turn are divided into areas. The environmental assessment is carried out for every marine sub-region. When the analysis shows major changes in the cumulative effect as a result of the application of the MSP, a more detailed assessment is done at the area level. A collective assessment is then done for the marine spatial planning area. This means that the environmental assessment's smallest geographic unit is on an area level.

Time perspective
In the environmental assessment, the zero alternative (development without the plan) and the MSP are primarily assessed for the reference year 2030. To some extent, this is also related to the planning's horizon year of 2050.
The planning's horizon contributes to capturing the ecosystems' large-scale processes that require a long-term perspective in directions and measures. In

addition, it is important to try to include a generation perspective in planning and environmental assessment. Another factor regarding the chosen scope is the UN's new global sustainable development goals with the target year of 2030 (UN, 2015). Good environmental status in the seas shall be achieved by 2020 according to the Marine Strategy Framework Directive, but several of the environmental quality norms for good environmental status in the seas are deemed to be difficult to achieve by then and are therefore also relevant as points of departure for the marine spatial planning with the time perspective 2030/2050.

Actual scope

In the SEA, the long-term sustainability and environmental effects are the main focus. The MSPs will be assessed according to Chapter 6 of the Environmental Code with regard to the following environmental aspects:

1. population and people's health
2. animal or plant species that are protected under the Environmental Code Chapter 8, and biological diversity otherwise
3. land, soil, water, air, climate, landscape, built environment, and cultural environment
4. management of land, water, and the physical environment otherwise
5. other management of materials, raw materials, and energy
6. other parts of the environment

The environmental assessment aims to identify and assess the MSP's overall environmental impact compared with the zero alternative in 2030, i.e. if the plan were not applied. The environmental assessment was based on Symphony and expert investigations, and Symphony is described in the following section. Investigations and analyses have been done for the themes defined in the MSP:

- attractive living environments (cultural environment, tourism, outdoor recreation, angling)
- energy
- defence
- storage and extraction of materials (carbon dioxide, sand)
- nature
- transportation and communications (shipping, communication cables)
- aquaculture and blue biotechnology
- Commercial fisheries

The methodology for this SEA is presented in further detail in Section 4.4.

Terms used in this environmental assessment:

Themes are defined in the MSP, e.g. attractive living environments, nature, transportation and communications, commercial fishing, etc.

Sectors describe actors that can directly affect the environment with their activities, i.e. tourism, transportation and communications, commercial fishing, defence, energy, aquaculture and blue biotechnology, and storage and extraction of materials.

Environmental aspects are the aspects described in Chapter 6 Section 2 of the Environmental Code, with regard to which the environmental assessment is done.

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

Effect is the change in the environment that the impact entails on an ecosystem component (i.e. ecosystems or individual flora and fauna). Effects can be direct or indirect, cumulative, positive or negative, long or short term (in Symphony, the collective cumulative environmental effect is given when the ecosystem components' sensitivity is linked to the pressure). Ecosystem components in Symphony are living environments, species, or groups of animals and plants that constitute a part of the marine ecosystems.

Consequence is the impact that effects have on the environmental aspects.

4.3 Symphony

Symphony is an assessment method that has been developed as an aid for national marine spatial planning that is based on the ecosystem approach. The objective is to show on a general level how environmental effects differ between different areas and how the planning affects this distribution.

Symphony calculates the cumulative environmental effect from a spatial perspective, which means that every area in the sea (spatial resolution: 250 m × 250 m) is given a value that describes how much we humans affect a representation of the marine environment. The value is based on the current knowledge, and uncertainty is large in many cases. The value is provided in order to be compared between areas rather than to be related to absolute limits. Symphony consists of three main components – maps of pressures, maps of ecosystem components, and a matrix that shows how sensitive every ecosystem component is to every pressure. The result is illustrated through a map of the environmental effects (SwAM, 2018a). Pressures are things that we humans cause that can affect and harm the marine environment.

Ecosystem components are living environments, species, or groups of species that constitute parts of the marine ecosystems. To calculate the environmental

effect, the values for ecosystem components are multiplied by the values for pressures and the values for the sensitivity in each area (pixel). The result is an estimate of the combined environmental impact (here called the cumulative environmental effect).
In this way, Symphony contributes a quantitative input to the environmental assessment. Cumulative environmental effect is calculated among other things for a description of the present situation, the zero alternative for 2030, and the MSP for 2030 (SwAM, 2018a).

1. The present situation is an assessment of the effect of individual pressures on the marine environment at present. Input for this is prepared in different ways for pressures and ecosystem components. The resulting data show the cumulative effects of the sectors' impacts on the environment as they are today.
2. The zero alternative 2030 is an extension of the present situation where the results from a sector analysis until the reference year 2030 are added to the present situation. The results show the cumulative effect in 2030 without the MSP.
3. MSP 2030 provides a further development where, besides results from sector analysis to the reference year 2030, changes regarding the use of the marine area according to the MSP have also been added. The results show the cumulative effect in 2030 with an application of the MSP.

The planning support Symphony includes a large amount of information where all components contain uncertainties. The results are a comprehensive aggregation of uncertainties where certain geographic areas have a higher uncertainty than others, see Figure 9. The areas in red are areas where knowledge of nature values is low. The number of measurements in the offshore areas is much lower than closer to the coast and where a larger amount of data is available (SwAM, 2018a).

Interpretation of the results from Symphony must generally be made with caution because the results are a gross assessment of a complex reality. Within Symphony, consideration is not taken to interactions between parts of the ecosystem, e.g. if an ecosystem component is affected, what effects this entails on other directly related ecosystem components. Symphony provides an illustration of the long-term environmental impact, and individual short-term disruptive elements are not included because they would have an overrepresented impact on the results. The geographic resolution in Symphony is high, but measurement data do not exist in all pixels and the result is therefore closer to the truth on a rough geographic scale compared with a detailed scale. The uncertainties in Symphony also indicate the need for an overall qualitative analysis and supplementation of environmental aspects that are not analysed within Symphony.

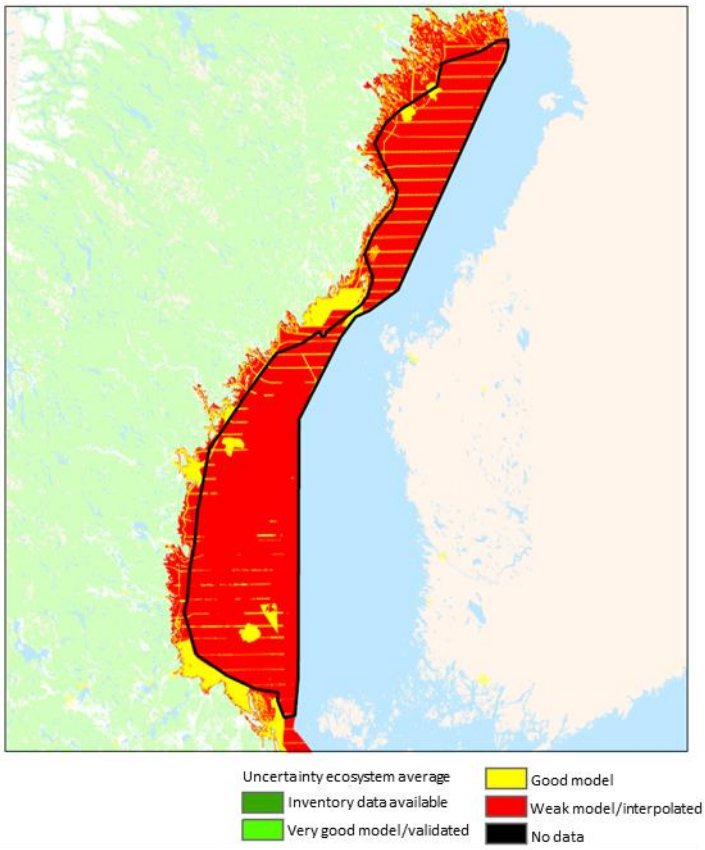


Figure 9 Aggregated uncertainty for the Gulf of Bothnia based on data on ecosystem components. In the red areas, knowledge of nature values is low and the model is thereby weaker compared with e.g. coastal areas.

Further information on the planning support Symphony can be found in the SwAM report 2018:1.

4.4 Environmental assessment method

Environmental assessment of the plan proposal in 2030 is made against the zero alternative in 2030. This way, the MSP's environmental effect and benefit is estimated and put in relation to the environmental conditions without implementation of the MSP. The environmental assessment is done according to the following three steps.

Step 1. Identification of connections between sectors and pressures
The environmental assessment is based on the sectors defined in the MSPs within the themes. The sectors' impacts are linked to the type of potential impact (pressures) as defined in the Marine Strategy Framework Directive. The purpose of this is to achieve a suitable structure in the environmental assessment.

The environmental assessment is largely based on an analysis of data from Symphony, which provides a quantitative assessment of the cumulative environmental effect. The type of impact as defined in Symphony is linked to the impact according to the Marine Strategy Framework Directive, see Table 2. Today, some of the Marine Strategy Framework Directive's pressures are not

handled in Symphony, and for these pressures input has been used from the environmental assessment in the discussion phase (WSP Sverige AB, 2017) and the environmental effect has been assessed qualitatively.

Table 2 Connections between Themes/Sectors and the Marine Strategy Framework Directive.

MSP (Theme/Sectors)		Marine Strategy Framework Directive (Pressures)	Input data
Attractive living environments	**Recreation and tourism** Angling Recreational craft Cruise ship service Ferry traffic	*Selective withdrawal of species* *Physical disruption* *Underwater noise* *Introduction of pollutants* *Introduction of nutrients and organic material* *Introduction of microbial pathogens* *Introduction and relocation of invasive species* *Marine litter*	***Symphony*** *Recreational craft noise* *Recreational craft pollution* *Bird hunting* *Infrastructure in the sea* *Coastal development* *Water treatment plant pollution* ***Environmental assessment discussion phase*** *Air quality* *Greenhouse gases* *Marine litter* *Invasive species*
Energy	Wind power Power from: waves, currents, tides and salinity gradients	*Biological disruption of species* *Physical loss* *Physical disruption* *Underwater noise*	***Symphony*** *Electromagnetic fields* *Wind power noise 125 Hz* *Wind power bird impact*
Defence	Artillery range/training areas Dumped ammunition (existing)	*Underwater noise* *Introduction of pollutants*	***Symphony*** *Explosions overpressure* *Explosions sound pressure* *Artillery ranges pollution*
Storage and extraction of materials	**Extraction** Sand, gravel, shells **Storage** CO_2	*Physical loss* *Physical disruption*	***Symphony*** *Sand extraction water clouding* *Sand extraction habitat loss*
Transportation and communications	**Shipping** Maritime transports Dredging and dumping dredged materials **Linear infrastructure** Pipelines Cables	*Biological disruption* *Physical disruption* *Underwater noise* *Introduction of pollutants* *Introduction of nutrients and organic material* *Introduction of other forms of energy* *Introduction and relocation of invasive species* *Marine litter*	***Symphony*** *Shipping noise 125 Hz* *Shipping noise 2000 Hz* *Shipping oil spills* *Shipping erosion* *Dredging water clouding* *Dredging habitat loss* ***Environmental assessment discussion phase*** *Air quality* *Greenhouse gases* *Marine litter* *Invasive species*

Aquaculture and blue biotechnology	Fish farming Mussel farming	*Introduction of pollutants* *Introduction of nutrients and organic material* *Introduction and relocation of invasive species*	***Symphony*** *Fish farming nutrient emissions* *Fish farming habitat loss* *Clam farming habitat loss*
Commercial fisheries	Bottom trawling Pelagic trawling Other fishing	*Selective withdrawal of species* *Physical disruption* *Underwater noise* *Introduction of pollutants* *Introduction of nutrients and organic material* *Marine litter*	***Symphony*** *Net-fishing catch* *Pelagic trawling catch* *Bottom trawling catch* *Bottom trawling habitat loss* *Bottom trawling water clouding* ***Environmental assessment discussion phase*** *Air quality* *Greenhouse gases* *Marine litter*

Neither Symphony nor data from the environmental assessment from the discussion phase provide a complete basis to fully cover all of the pressures of the Marine Strategy Framework Directive. Accessibility to input is, however, deemed to be so comprehensive that a good general illustration of the MSP's effects and environmental impact can be provided.

Step 2. Description of the values, environmental impacts, and environmental effects

The MSP proposal is set up based on various themes that describe marine sectors for which the plan states conditions for future development. It is thereby mainly activities in these sectors that entail an impact that is to be assessed in this SEA. In this step, the sectors' environmental impact and environmental effects are identified. Basic conditions in the marine area are described in this step. Symphony is used to describe the present situation, the zero alternative in 2030, and the MSP proposal in 2030. Each sector's contribution to the environmental impact in Symphony and to the total cumulative environmental effect is stated as a percentage.

In addition, the areas are identified in the marine sub-regions in which the plan entails significant change in the cumulative environmental effect compared with the zero alternative. These areas are described in more detail with regard to changes in activities from the sectors in question and the impacts they entail. The sectors also entail some impacts, the environmental effect of which is not calculated in Symphony. For these, qualitative assessments will be done based on the SEA from the discussion phase. The assessments are relative and are based on the affected aspect's or the affected object's value and on the size of the impact/pressure as per Table 3.

Table 3 Assessment of effects for pressures not handled in Symphony.

	PRESSURE/IMPACT		
OBJECT'S VALUE/SENSITIVITY	**Large pressure**	**Moderate pressure**	**Small pressure**
HIGH VALUE	Large effects	Moderate-large effects	Moderate effects
MODERATE VALUE	Moderate-large effects	Moderate effects	Small-moderate effects
LOW VALUE	Moderate effects	Small-moderate effects	Small effects

Step 3 Assessment of environmental consequences

In this step, the scope is assessed of the environmental effects that arise as a result of the marine sectors' impact.

The following scale has been applied in the impact assessment:

- Positive consequences
- Small negative consequences
- Moderate negative consequences
- Large negative consequences

5 Basic conditions

5.1 General

The Gulf of Bothnia's marine spatial planning areas comprise the counties of Uppsala, Gävleborg, Västernorrland, Västerbotten, and Norrbotten. The County Administrative Board of Västernorrland leads and coordinates the regional work on the MSP. In the area, there are 20 coastal municipalities with a total of 780,000 residents. The marine spatial planning area borders on Finland to the east. The border runs from Haparanda in the north to Södra Kvarken at Åland in the south.

5.2 Physical and chemical conditions

5.2.1 Hydrographic conditions

The Baltic Sea including the Gulf of Bothnia has estuary circulation due to the large amounts of fresh water that run out into the Baltic Sea area and constitute surface water layers and inflows of heavier salt water. The difference in the salt content between the surface and deep water creates a layer, a halocline, the depth and strength of which affects how the water can be mixed between the water layers. This together with the supply/loss of nutrients affects the basins' water quality. The deep mixing during cold winters means that the Bothnian Bay does not demonstrate a shortage of oxygen in the deep water.

During a normal winter, the maximal spread of ice reaches 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 and 190 days a year. The ice cover affects, among other things, the water's turnover, and permanent constructions can be subjected to very severe strains by sea ice, which affects wind farms and other constructions. Wave power is not relevant due to the ice, and shipping is affected because the ships must follow the routes of icebreakers. In the marine spatial planning, it is important to note that summer and winter conditions might entail two entirely different environments and circumstances.

The stable winter ice in the Bothnian Bay characterises the marine environment in the deep sea. The ice forms a basis for photosynthesising algae, and the ringed seal needs the ice in order 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).

The Gulf of Bothnia is divided by two shallow thresholds, Södra Kvarken and Norra Kvarken, which means that it takes around five years for the water to be replaced. The turnover period for the water in the Bothnian Sea is estimated at four years and in the Bothnian Bay at three years, which is a large difference from the Baltic Sea's roughly 30 years. The closed-in location means that the water quality here is almost entirely characterised by water from rivers and

bodies of fresh water, which makes the salinity low in the area. Surface water circulation in the Gulf of Bothnia goes anti-clockwise as saltier water comes from the east and fresher water flows out from the rivers along Sweden's coast.

In the Bothnian Bay, the land uplift is 8.5 millimetres per year, and the largest depth in Norra Kvarken is 25 metres. If the land uplift continues at the same pace, a land bridge between Sweden and Finland will form in about 2,000 years. In such a case, the Bothnian Bay would become Europe's largest lake.

5.2.2 Physiochemical composition

One of the largest impact factors for the physiochemical composition of the water is climate change. The problems of global warming lie in the higher input of carbon dioxide into the air, which affects the climate by increasing air and water temperatures. These problems are also visible in Bothnian Bay where the greenhouse effect from the elevated carbon dioxide level has caused the water temperature to increase since the beginning of the 1990s. An elevated carbon dioxide content in the air also entails the addition of carbon dioxide to the water, which reduces its pH. The reduction of pH in the Baltic Sea has also taken place as a result of sulphur dioxide emissions, even if the impact of the sulphur is greater on lakes than in the sea. The water temperatures vary by year and by season, which also affects pH. At higher temperatures, primary production that consumes carbon dioxide increases, thereby raising pH. The temperature itself also affects pH because carbon dioxide is less soluble in warmer water and is thereby emitted into the air. In the summer, the surface water is around 13°C in the Gulf of Bothnia, while in the winter and spring it is around 0°C. Cold water is heavier than warm water, and sharp differences in temperature across the depth form temperature layers known as *thermoclines*. A thermocline can make it difficult, or completely impossible, for surface water to mix with water from greater depths.

The salinity varies between 2 and 4 psu (practical salinity units) in the Bothnian Bay. The sea's salinity sets limits on the ecosystems and affects species' ranges in the sea. 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. An important factor that affects the conditions for life in the sea is the halocline, which prevents a remixing of the entire water mass and thereby oxygen transport down to the bottom (Swedish Environmental Protection Agency, 2013). Precipitation has an impact on salinity, and more ample precipitation than normal periodically causes the salinity to drop (SwAM, 2009). This has been the case for the Gulf of Bothnia since the 1970s (Swedish Institute for the Marine Environment, 2016b). During the summer, the halocline coincides with the thermocline, and a layering is created at a depth of around 15 m in the area.

5.2.3 Nutrient levels and microbiological water quality

The amount of nutrients in the seawater controls biological life in the seas because the nutrients are the main food for primary producers that build up the

entire sea's food chain. When the nutrient level increases, the production of the primary producers also increases, which in a naturally nutrient-poor sea can be positive, but in an already nutrient-rich sea can lead to eutrophication and cause problems such as algal blooms.

The amount of bio-accessible nutrients in the surface water varies in the different marine sub-regions, and the amount of inorganic phosphorous is generally lower in the Bothnian Bay than in the Northern and Southern Bothnian Sea, while the amount of inorganic nitrogen is higher (SMHI, 2014). HELCOM has classified the eutrophication level on the scale of good, moderate, poor, and substandard. According to this classification, the status for the Bothnian Bay is assessed as good and for the Northern Bothnian Sea as moderate to poor with the general part of the offshore area as poor, while the status for the Southern Bothnian Sea is classified throughout as poor (HELCOM, 2010a).

5.2.4 Pollution level in the sea

The Gulf of Bothnia's long tradition of industries has resulted in many polluted areas with high levels of environmental toxins along the coast. On-going and historical emissions from industry, sewage, farming, and forestry affect the marine environment and illustrate the connection between land and sea (SwAM, 2015b). The emissions entail concrete environmental challenges when future needs for the dredging of shipping lanes, energy production, and energy transmission are to be addressed.

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 chlorinated substances polychlorinated biphenyl (PCB) and dichlorodiphenyltrichloroethane (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 we succeed in reducing the levels of most classical environmental toxins, some are still too high, such as dioxins, mercury, and lead. Moreover, the concentrations of a number of environmental toxins are high in the sediments, such as PCB and DDT. Levels of mercury, which originate from old emissions and natural leaching, have decreased in guillemot eggs, but at the same time increased in cod from both the Baltic Sea and Skagerrak and Kattegat (Swedish Environmental Protection Agency, 2014a). The level of dioxin (tetrachlorodibenzo-p-dioxin equivalents) in herring is higher in the Bothnian Sea than in the other sea basins, and the Swedish National Food Agency recommends children and women of fertile age to eat fatty fish from the Baltic Sea a maximum of three times a year due to dioxins and other environmental toxins in this fish.

Altogether, the results from the environmental control show that we are still far from the goal of a toxin-free environment. Lead, cadmium, mercury, and organic tin compounds have been pointed out as especially dangerous because

they can cause illness in humans by affecting the nervous system, reproduction, kidneys, and bones. Herring from the Gulf of Bothnia contains significantly higher levels of cadmium than herring in Skagerrak and Kattegat (Swedish Environmental Protection Agency, 2014a).

The sea's ecosystem is also affected by several new foreign substances that are increasing in the marine environment. For example, perfluorinated substances have increased substantially since the 1980s. These substances can disrupt hormones and have proven to negatively impact human and animal reproduction. Pesticides from agriculture also make their way to the sea, which can mainly affect important underwater plants and microorganisms.

The preliminary assessments done by the county administrative boards for all offshore areas (112 nautical miles from land) within the marine spatial planning area (and also for all marine spatial planning areas) show that all areas achieve good chemical status "without pervasively exceeding substances" (mercury and brominated flame retardants), but that none of the MSP's areas achieve a good status if pervasively exceeding substances are included in the assessment (County Administrative Board VISS, 2016). HELCOM (2010b) classifies the pollution situation in the Baltic Sea in the water on the scale of high, good, moderate, poor, and substandard. The situation is deemed to be moderate for all marine sub-regions with regard to the level of harmful substances in the water.

With regard to the pollution situation in the sediments, there is some variation between the marine sub-regions. The largest coherent area of high levels of mercury in the sediments for all marine sub-regions is located in the Bothnian Bay, while the levels in the Southern Bothnian Sea are mostly low and are low to moderate in the Northern Bothnian Sea. The surface sediments in the Bothnian Bay generally have high levels of cadmium, while levels are low in the Southern Bothnian Sea and vary between low and high in the Northern Bothnian Sea. The levels of trybuteltin (TBT) and DDT are generally low except in the Bothnian Bay where moderate levels of TBT are indicated. The levels of HCHs (Hexachlorocyclohexanes) are low in all sediment sample points where continuous monitoring is done except in the Southern Bothnian Sea's test point where the levels are moderate (HELCOM, 2010b).

5.3 Biological conditions

5.3.1 Biodiversity and green infrastructure

Even if the Gulf of Bothnia does not contain as many species as other areas in the Baltic Sea, most populations are thriving. HELCOM (2010a) classifies the status for biodiversity for the entire Northern and Southern Bothnian Seas as high, while the offshore areas are classified as low to moderate (although high for the coastal areas).

The physical and chemical conditions in the Gulf of Bothnia affect the ecosystems and what species are found here. In the southernmost, saltiest

areas, there are marine species to a larger extent than in the northern areas. The number of marine species decreases the further north one goes. Besides brackish-water species in the form of vascular plants and Charales, various fresh water species, such as angiosperm vascular plants and mosses and ferns, also contribute to species-rich environments in the northern part of the area. Future changes of salinity levels might therefore be assumed to have a major impact on the composition of sensitive species. The land uplift in itself contributes to a diversity of biotopes and species in the marine environment.

The Northern and Southern Bothnian Sea are the only marine areas in all three of the marine spatial planning areas that, according to HELCOM's classification, have acceptable levels of biodiversity status; the remaining areas receive unacceptable rankings. Among the marine species, there are the most red-listed species in hard and soft seabeds in deep water areas, although the status has been good for the bottom fauna in the marine spatial planning area of the Gulf of Bothnia since 2014 (Swedish Species Information Centre, 2015) where a typical bottom fauna society consists of around 10 species (Havet.nu, 2016).
The green infrastructure in marine environments is related to the spread of certain species of a high significance to the ecosystems, so-called key species. The impact of these key species has especially significant consequences because there are no similar species that can replace them. Examples of key species are sea mussels and bladder wrack, which are two important biotype-building species. The range of the sea mussel is limited by salinity and therefore it does not extend beyond the Bothnian Sea. The range of bladder wrack extends up to the middle of the Bothnian Bay. North of this boundary live exclusively fresh water species, and an example of a biotope-creating species here is the freshwater mussel.

Because the Gulf of Bothnia contains much lower biological diversity than, for example, Skagerrak and Kattegat, the system can be assumed to be more sensitive (to have lower resilience) to external disruptions. Many species in the Gulf of Bothnia have recovered well in recent years, which indicates a relatively good resilience in the area. Examples of such species are the ringed seal and *Monoporeia affinis*, which is an indicator species because it is especially sensitive to external environmental factors. Another example is the Baltic mussel, which has increased in number and biomass in the Northern Bothnian Sea, but decreased in the Southern Bothnian Sea, although other species with a high sensitivity value have increased in the Southern Bothnian Sea (Swedish Institute for the Marine Environment, 2016a). The health of the ecosystems is classified as moderate according to HELCOM (2010a) in the whole of the Gulf of Bothnia, but somewhat lower in the Northern and Southern Bothnian Sea.

The Gulf of Bothnia's offshore banks are mostly comprised of swelling moraine, which makes them very unique environments that provide good conditions for many plant and animal species that are not found in other parts of the marine spatial planning area. However, the offshore banks are naturally poor in species, mainly due to the low salinity and the harsh ice conditions that exist

during the winter. The vegetation is almost solely annual plants because few plants survive the harsh conditions during the winter and thus there is a lack of cohesive and structure-forming multi-year vegetation. Few red-listed species occur, except for some birds and the eelpout (Swedish Environmental Protection Agency, 2006). Several of the areas have been affected by bottom trawling and defence activities and the dumping of weapons and chemicals. In the Bothnian Bay, there are the offshore areas of Marakallen, Klockgrundet/Tärnans Grund, and Rata Storgrund, in the Bothnian Sea there are Väktaren/Petland and Vänta Litets Grund, and in the Southern Bothnian Sea there is Finngrunden/Östra Banken and Storgrundet (SwAM, 2015c).

5.3.2 Pelagic habitats

The pelagic zone in the marine spatial planning area is strongly affected by nutrients emitted from various sources.

The occurrence of plankton is the greatest in the Northern and Southern Bothnian Sea, but plankton are also amply occurring in the Bothnian Bay. The proportion of plankton decreases closer to the coast and is also lower off of Umeå's coast, which is in the southernmost part of the Bothnian Bay. The presence of plankton decreases to the north in the Bothnian Bay and increases somewhat in all areas during the summer. During the winter, the amount of plankton decreases to very low levels in the Bothnian Bay. Also in the Northern Bothnian Sea, we see a decrease in the amount of plankton during the winter while the decline in the Southern Bothnian Sea is limited to the northernmost parts.

For plant plankton, the ecological status is good for the Bothnian Bay's offshore areas and moderate in the Southern and Northern Bothnian Sea. Chlorophyll levels have increased in the Bothnian Sea in both coastal and offshore areas since 2000 (the summer period June–August), but the follow-up of biomass does not show any clear trend. In the Bothnian Bay, the chlorophyll levels have increased since 1991, but the biomass has been relatively constant. In the Bothnian Bay's offshore areas, no significant trend is seen in the total biomass of animal plankton, but the cyclops has increased in the past 15 years, although not the total biomass. In the Southern Bothnian Sea and the Bothnian Sea's offshore areas, the amount of animal plankton is decreasing. In the past 15 years, there has been increased bacterial growth within the entire marine spatial planning area (Swedish Institute for the Marine Environment, 2016b).

5.3.3 Oxygen-free bottoms

The oxygen level in the bottom water has been higher in the Bothnian Bay than in the Bothnian Sea since the 1970s, and the Bothnian Sea's oxygen levels have dropped somewhat in recent years. The oxygen levels of the Bothnian Bay have been between 7 and 9 ml/l, and the Bothnian Sea generally has levels between 4 and 7 ml/l (Swedish Institute for the Marine Environment, 2016a). The reduction in oxygen level in the Southern and Northern Bothnian Sea can be partially explained by deteriorated oxygen conditions in the Baltic Sea's intermediate layer, which forms the deep water in the Bothnian Sea. The

inflowing phosphate-rich water from the Baltic Sea might also be part of the explanation of the higher production and higher oxygen expenditure in the bottom water in the Bothnian Sea.

5.3.4 Marine plants

Seabeds lined with plants are among the most productive and species-rich seabeds. There is a great variety of species along all coastlines in Swedish waters, and also on the offshore banks. The dominant plant groups change as one moves from the Skagerrak to the Bothnian Bay, but generally speaking the occurrence of macroalgae, or seaweed, is of major significance to local biodiversity because it creates biotopes. Charophyte green algae together with angiosperms fill the same function as macroalgae in terms of diversity and biotopes (SwAM, 2015c). Many angiosperms, such as sago pondweed (*Potamogeton pectinatus*) and eel grass (*Zostera marina*) have root systems that can form beds and bind sediment, which in turn reduces the effects on the seabed from erosion at the same time that they introduce oxygen. Healthy eelgrass beds also bind a large amount of nutrients that can counteract algal blooms and carbon, which can reduce the carbon dioxide level and raise the pH in the water.

In the Gulf of Bothnia, the number of marine species decreases the farther north one goes. The majority of the Gulf of Bothnia consists of shallow soft bottoms with various species of angiosperm vascular plants and charophyte green algae, while bladder wrack and *Fucus radicans* perform a significant ecological function on the hard bottoms (SwAM, 2015c).

Along Höga kusten, the vegetation-covered seabed continues to have a good status as the vegetation's depth range has been high every year (Swedish Institute for the Marine Environment, 2016a).

5.3.5 Marine animals

Marine mammals

The marine mammals encountered in the Gulf of Bothnia are grey seals and ringed seals. The status for the seal species varies and is classed as nearly threatened. The grey seal is, however, not listed on the Swedish red list, but rather is classed as viable. The situation for the seal species has improved since the 1970s when they were severely threatened due to hunting and low fertility. Since 1988, a number of disease epidemics have occurred that have reduced the seal populations. In spite of this, the grey seal population is reported to have a good growth rate (SwAM, 2015c) and the species' range is the largest in the Northern Baltic Sea and Southern Gulf of Bothnia (Havet.nu, 2016). The grey seal's range areas are thereby counted as satisfactory, while the ringed seal's is still counted as unsatisfactory (Swedish Species Information Centre, 2015).

The ringed seal is dependent on the spread of the sea ice because it gives birth to its pups on the ice. In connection with this, the ringed seal occurs mainly in the Bothnian Bay during the winter and is strongly affected by global warming that is reducing the spread of the ice. There are around 8,000–11,000 ringed

seals in the Bothnian Bay (including the Finnish bay and Rigabukten). After the seal species' tough period in the 1970s, all seal species have succeeded in recovering except for the ringed seal, and the lack of sea ice during the reproduction season is the most likely explanation for this. For a greater recovery and increased viability of the ringed seal population, further measures are required, especially measures to counteract climate change (SwAM, 2015c).

Invertebrates

Marine invertebrates represent a large part of the ocean's biodiversity, while a limited number of species predominate over larger areas. Of the red-listed species from the 2015 list (Swedish Species Information Centre, 2015), 70 per cent are invertebrates, but many species are missing from the list because there is a lack of knowledge about this particular group. Blue (common) mussel banks constitute a substrate for other organisms and therefore indicate high biodiversity. These mussel banks also contribute a regulatory ecosystem service in the form of filtration of particles in the water, which contributes to lower turbidity in the water column. The banks are therefore of high protective value, but soft seabeds that are also relatively unaffected by trawling can have a high protective value because they are often home to digging organisms and various species of sea pen. Live sponges are also effective filterers and can take up plankton and other organic materials, and these are mainly found on hard moraine bottoms.

The distribution and composition of invertebrate bottom dwellers has undergone a considerable change over the last hundred years. The Bothnian Bay's bottom-dwelling fauna is, however, generally undeveloped and species poor, which also holds for the invertebrates. The species that dominate are various *Gammarus locusta*, snails such as river nerites and pond snails, flat freshwater sponges, and brackish water hydroids (Swedish Environmental Protection Agency, 2006). The most common bottom-dwelling animals are, however, *Saduria entomon*, *Monoporeia affinis*, and the Baltic clam, where *S. entomon* is an important food for many fish species in the Gulf of Bothnia (Havet.nu, 2016). Otherwise, the range of crustaceans is low in all marine areas. The sea mussel's range is greatest in the Southern Bothnian Sea and low in the other marine areas. Most species threatened by fishing by bottom trawling are soft-bottom dwelling species, but emissions from sewage, agriculture, and other operations also affect the invertebrates' conditions (SwAM, 2015c).

Fish

The composition of fish fauna in the Gulf of Bothnia mainly consists 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 whitefish stock is decreasing in the Northern and Southern Bothnian Sea but is stable in the Bothnian Bay.

The situation for wild salmon in the Bothnian Bay has improved for 15 consecutive years due to successful fishing regulations. Now, the natural

regrowth is good in several unregulated rivers, and the migration upriver is extensive. The sea trout stocks are, however, weak due in part to by-catch in nets at the coast and some migration obstacles in rivers for regular spawning areas. Vendace, which is the financially most important species in the Bothnian Bay, has strong stocks (Swedish Institute for the Marine Environment, 2016a), and the red-listed eelpout is commonly occurring in this marine sub-region (Swedish Environmental Protection Agency, 2006).

The stocks of whitefish in the Northern and Southern Bothnian Sea have decreased over the past 20-year period at the same time that there is a shortage of older individuals. The herring's situation looks better in all areas with a large stock, increasing regrowth of young fish, and long-term sustainable fishing pressure. The catches of perch in sample fishing are declining in the Northern Bothnian Sea, but are stable or increasing in the Southern Bothnian Sea (Swedish Institute for the Marine Environment, 2016a).

The main human impact on the fish population is of course fishing, but the population is also affected by the supply of nutrients, exploitation, and physical impact on habitats, such as salinity and environmental toxins. An uncertainty factor is how climate change and the growing spread of seabeds with oxygen shortages in the Baltic Sea also affect the fish's habitat and food base in the Gulf of Bothnia. Further studies of how pH affects the fish stock are needed, but an effect in, among others, cod and herring larvae is already documented. Regulation of rivers and clean-ups in both large and small bodies of water affect fish stocks and fishing by limiting the access to suitable spawning areas for marine fish (SwAM, 2015c). The fish resource is affected by a number of physical disruptions in the ecosystem, which might be due to dredging, installations, lost fishing equipment, and noise.

Birds

In 2015, 157 bird species were registered in the Baltic Sea and the Gulf of Bothnia in different sea bird assessment routes for the Swedish Environmental Protection Agency, and the dominant brooding birds in the Gulf of Bothnia are eider, common scoters, and velvet scoters (Green, 2016). There are many wintering stocks of sea birds, and they are dominated by diving ducks such as tufted ducks and long-tailed ducks. Auks also winter in the Gulf of Bothnia together with various species of gulls (SwAM, 2015c).

Many marine bird species, such as long-tailed ducks, eider, and velvet scoters, are decreasing drastically in Swedish marine areas. A decrease in the velvet scoter began as early as the 1950s, and the eider has decreased drastically since the mid-1990s. At the same time, the pressure on the birds' habitat might increase, in part by the many wind farms being planned mainly in German, Danish, Polish, and Swedish waters. A species that overwinters, such as the long-tailed duck, is entirely dependent on shallow offshore banks with a rich occurrence of sea mussels. These important habitats are also relevant for the establishment of wind farms, which risks the birds disappearing from these

areas. Research indicates that some species, including long-tailed duck, often do not return to an area that has been developed (SwAM, 2015c).

The sea eagle is a typical species for the Baltic Sea and Gulf of Bothnia and has become a representative for the environmental problems in the region (SwAM, 2015c). One sees some increase in the population compared with earlier, and its activity has increased in the milder winters of recent years (Green, 2016). It is estimated that there are more than 700 sea eagles in Sweden, which is the same level as the level of the 1950s, and it is thereby assessed that the species has generally recovered from poisoning by the environmental toxins DDT and PCB, which obstructed reproduction and nearly led to the species' extinction. Damage to eggs from these environmental toxins, and also elevated levels of lead in tissue, are still occasionally found. In the vast majority of cases, the development for sea eagles in the Northern and Southern Bothnian Sea has been positive and the populations are growing. However, some ambiguities have appeared in recent years as sea eagle mates have been found with fewer young in their brood than in the other parts of the Baltic Sea area. Damage to egg shells has been discovered again in the past ten years that matches the same kind of change that nearly wiped out the entire sea eagle population from the 1960s to the 1980s. In the Northern Bothnian Sea, an analysis of eggs has indicated sharply increased levels of environmental toxins, such as DDT and PCB, even though the use of these substances has ended. The increased levels have not had an effect on population growth. The cause of the high level of toxins in the eggs is still unknown (Swedish Environmental Protection Agency website).

5.4 Protected areas

The establishment of marine protection areas in the form of Natura 2000 areas, nature reserves, biotope protection, and national parks is one way of pointing out and protecting valuable areas. Within the Convention on Biological Diversity, there is a target that 10% of coastal and marine areas shall be protected by marine area protection by 2020. Existing nature reserves, Natura 2000 areas, and marine national parks comprise just over 13.6% of Swedish internal waters, territorial waters, and the exclusive economic zone today. Sweden's interim target in the environmental targets was to increase the share to at least 10% by 2020, which was achieved in December 2016. However, much of the area protection is coastal and is outside the marine spatial planning areas. In the Gulf of Bothnia, 5% of the marine areas are covered by marine area protection.

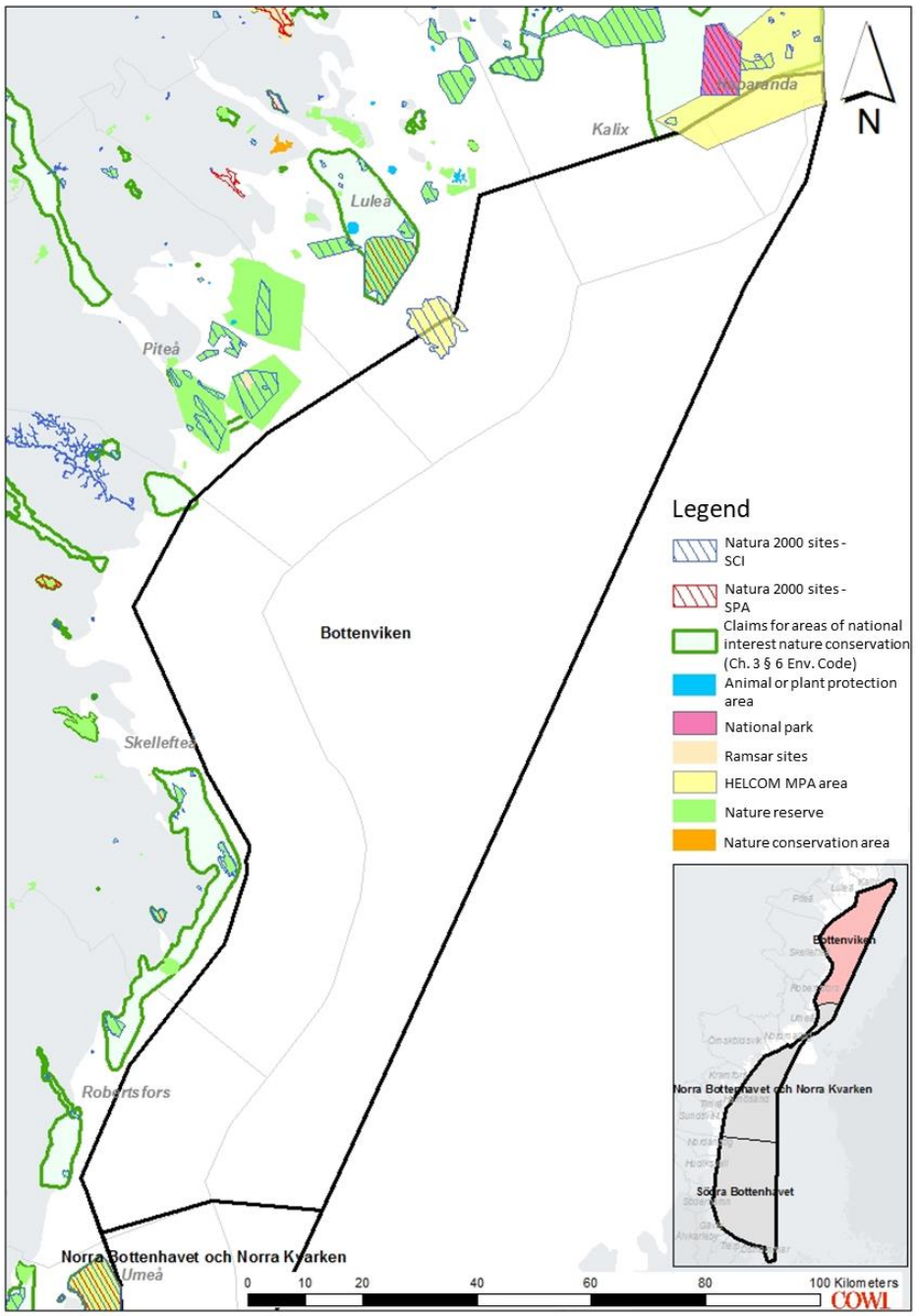
The protected areas shall at the same time be geographically representative and ecologically connected, which they currently are not. Bird and seal protection areas, Natura 2000 sites under the EU Birds Directive, and some other categories of areas are not included in the area target, but they are still important in marine spatial planning.

In the Gulf of Bothnia, there are two national parks, around seven marine nature reserves, and more than 100 Natura 2000 areas. Finngrundet's banks

make up Natura 2000 areas and are mostly within the exclusive economic zone. There are also two HELCOM MPA areas, Höga kusten and the Haparanda archipelago, within the marine spatial planning area that are not comprised of nature reserves or Natura 2000, but are of national interest for nature conservation. Höga kusten is a World Heritage site appointed by UNESCO as an area with a unique cultural and natural history environment that bears witness to the history of mankind and the Earth. Norrbotten's archipelago in the Bothnian Bay's northernmost area is a national interest area because high natural and cultural values are of significance to tourism and outdoor recreation. The Haparanda archipelago is included in this protection, but it is also a national park. The Holmöarna and the Örefjärden-Snöanskärgården archipelago are two nature reserve areas that border on the marine spatial planning area, and the impact from these should be taken into consideration. There are a number of conservation areas for fish in the marine spatial planning area (SwAM, 2015c).

5.4.1 Bothnian Bay

Marakallen is a Natura 2000 area that is a large, flat shallow area off of Luleå's coast in the Bothnian Bay. The seabed consists of hard moraine bottoms and sandy sediments in a mosaic-like pattern, which contributes to a high habitat variation. The bank is an important colony area for the ringed seal and the grey seal and also an important spawning and nursery area for several fish species. Virtually the entire area is overlapped by an area of national interest for wind farms (County Administrative Board of Norrbotten, 2010).



Natura 2000 areas, national interests for nature conservation, and other potential protected areas for the Bothnian Bay.

5.4.2 Northern Bothnian Sea and Norra Kvarken

Vänta Litets Grund is a relatively deep shallow area off of Härnön in Härnösand. It is a Natura 2000 area dominated by the nature type sublittoral sandbank. From the Bothnian Sea perspective, the rich occurrence of sea mussels is characteristic for Vänta Litets Grund, which is otherwise generally expected to decrease to the north with declining salinity. No new studies seem to have been performed since the introduction of nature protection in 2009 (County Administrative Board of Västernorrland, 2009).

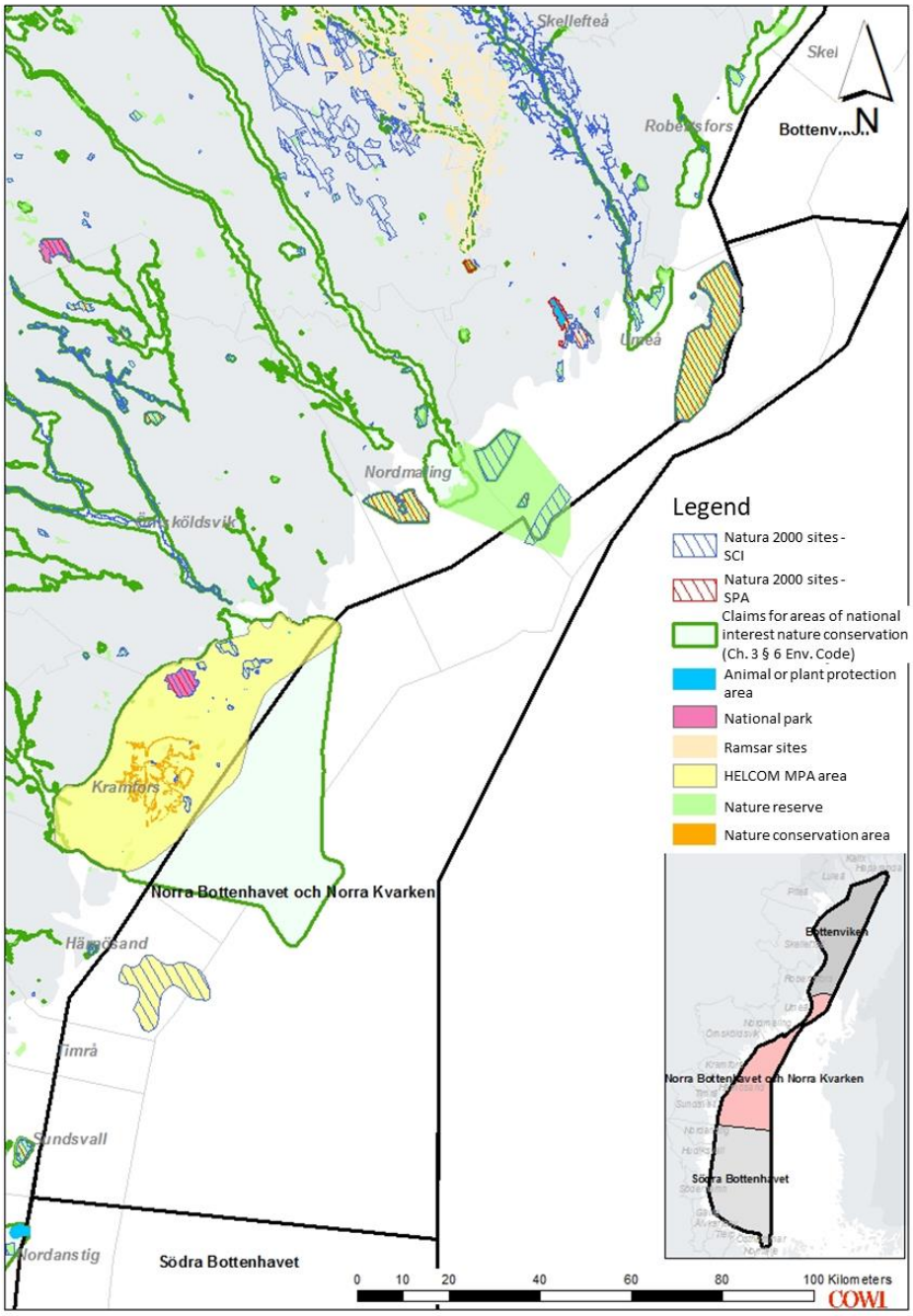


Figure 10 Natura 2000 areas, national interests for nature conservation, and other potential protected areas for the Northern Bothnian Sea.

5.4.3 Southern Bothnian Sea

Östra banken/Finngrunden is a Natura 2000 area located east of Gävle that is characterised by a large and relatively shallow section, which provides favourable conditions for vegetation attached to the seabed. In Finngrunden, plans have existed for Sweden's largest wind power installation, the permit of which was rejected in 2013 by the Land and Environmental Court due to the site's significance to the red-listed long-tailed duck (Swedish Environmental Protection Agency, 2006).

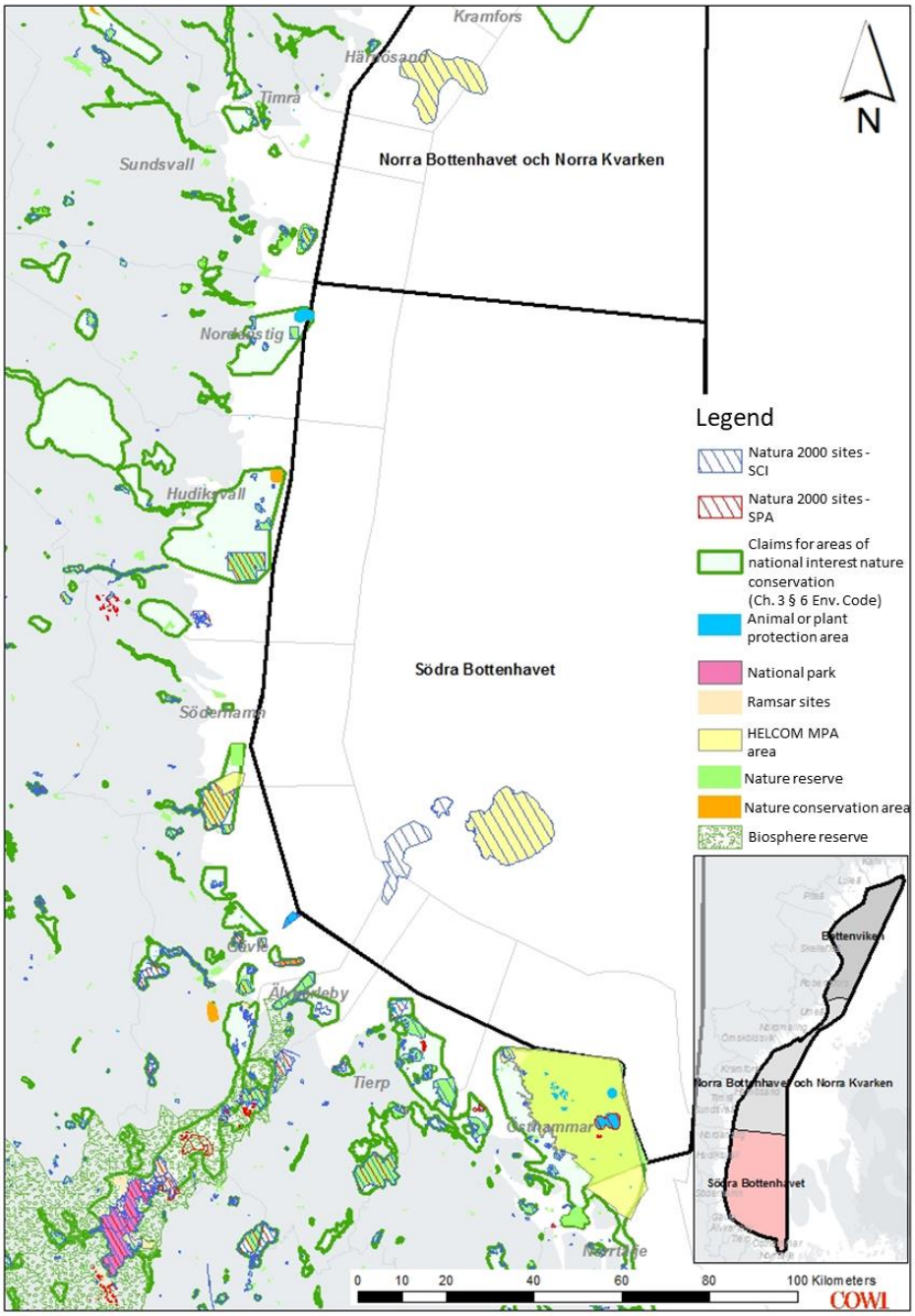


Figure 11 Natura 2000 areas, national interests for nature conservation, and other potential protected areas for the Southern Bothnian Sea.

5.4.4 Green Map

In addition to analyses of cumulative environmental effects, SwAM has prepared a map within the work on the planning support Symphony that describes aggregated ecological values. This product is called the Green Map (or Green Map 3 because it is the third generation green map for marine nature values that the agency is preparing), and it shows which areas are valuable for many different ecosystem components (SwAM, 2018a). If an area is of major significance for many different ecosystem components, the area receives a high value in the Green Map.

In the Green Map, a normalisation has been done with the aim of creating comparability and representativeness. In the version of the Green Map that is mainly used in marine spatial planning, normalisation has been done based on both the MSP and ecosystem components (Figure 12). Normalisation according to MSPs means that the areas in the Gulf of Bothnia do not automatically receive lower values than areas in Skagerrak and Kattegat only because there are fewer species in the Gulf of Bothnia. Instead, the analysis is based on the regional conditions, and areas that for the Gulf of Bothnia have uncommonly high nature values receive the same value in the Green Map as an especially rich area in Skagerrak and Kattegat. The aggregated ecological values for the Gulf of Bothnia are presented in Figure 13.

Together with other input on nature values, the Green Map is used in the marine spatial planning work to identify areas where *particular consideration to high nature values (n)* might need to be observed (see Chapter 3 and the MSP).

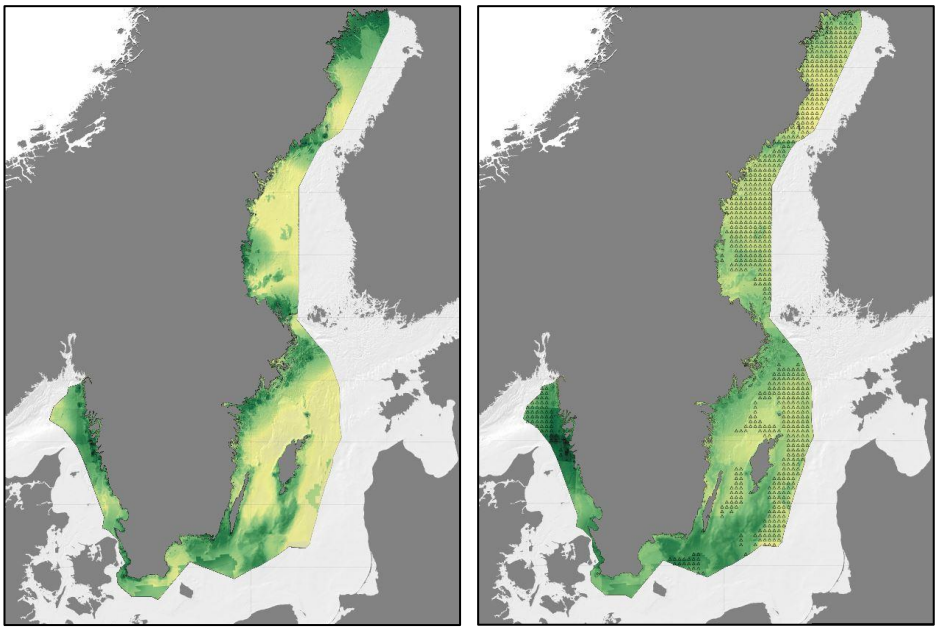


Figure 12 The Green Map. The picture on the left shows the version of the Green Map used in the marine spatial planning, where normalisation has been done both according to the MSP and to groups of ecosystem components (habitats, fish, mammals, and sea birds). The picture on the right shows a simple aggregation of ecosystem components without normalisation or weighting, and this version represents what is included in the calculations of the cumulative environmental impact within Symphony. The grid that is visible on top of the map in the picture on the right shows areas with especially high uncertainty in the data. Here, the knowledge of the nature values is low.

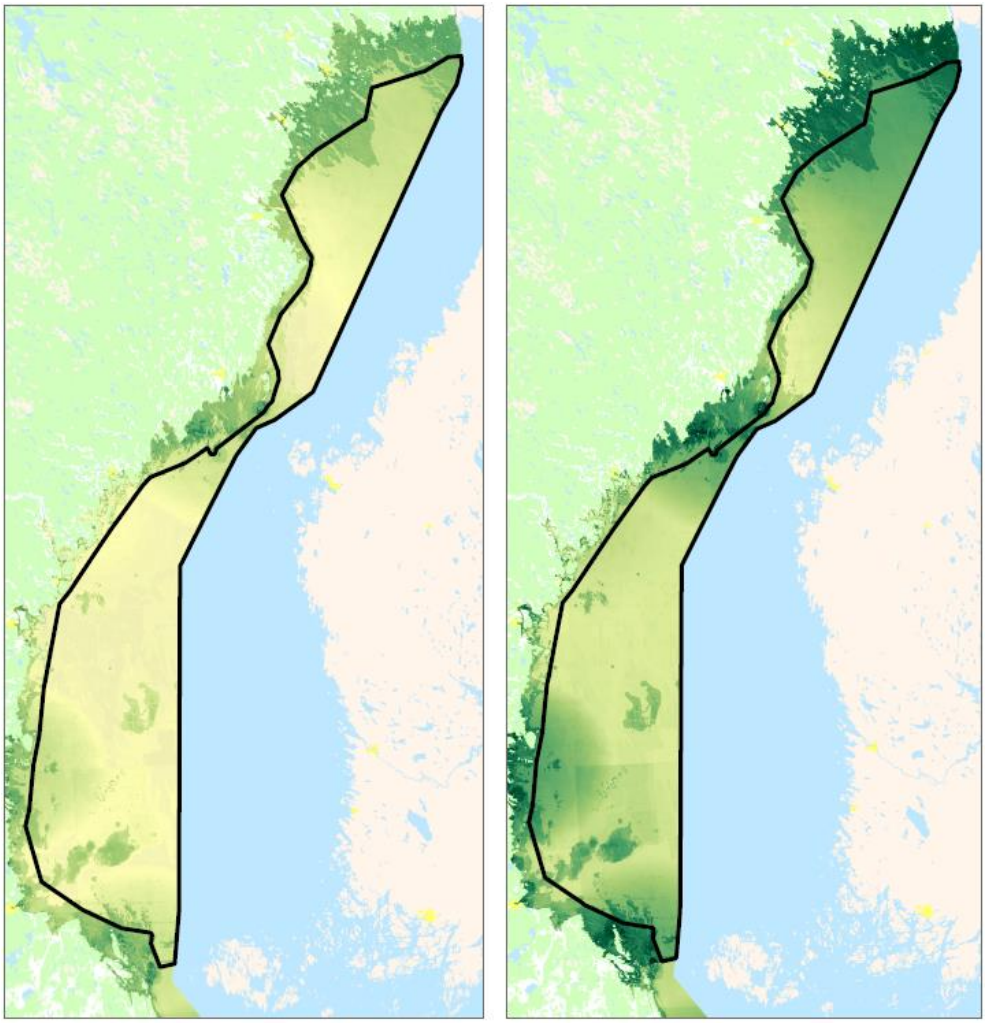


Figure 13 Aggregated ecological values for the Gulf of Bothnia. The picture on the left shows averages without weighting, and the picture on the right shows four equally weighted groups of ecosystem components (bottom environment, fish, mammals, and birds) and normalisation of the values. (Dark green – high value, light green – low value).

6 Current situation

6.1 Sectors and themes

6.1.4 Defence

The activities of the Defence in the marine spatial planning area mainly involve conducting signal surveillance and monitoring and training activities (Swedish Armed Forces, 2017). Artillery exercises are conducted below, on, and above the water in specially appointed training areas throughout Sweden's coast. Military activities are conducted in all marine spatial planning areas. However, there is a concentration in the Baltic Sea, between Helsingborg and Stockholm, due to the geographic location in relation to other countries in the Baltic Sea. In the Gulf of Bothnia's marine spatial planning area, there is one artillery and training range located slightly north of Sundsvall (County administrative boards 2015), and there are areas with special needs of no obstructions due to military operations on land, mainly in the sea off of Skellefteå.

The interests of the Defence are expected to have good conditions for coexistence with Commercial fisheries, outdoor recreation, and shipping. Permanent installations for energy production at sea can, however, constitute physical obstacles and in various ways affect conditions for the interests of national defence (SwAM, 2018b).

Military exercises add metals to the sea from the use of ammunition, which can cause high concentrations locally with effects on biological activity. In addition to physical impact, artillery and blasting exercises cause underwater noise. Effects on marine life from noise vary to some extent with the time of the year due to the ecosystems' varying sensitivity to disturbances. Consideration to seasonal variations in sensitivity is taken in national defence exercises (SwAM, 2015a).

6.1.1 General

Within the Gulf of Bothnia, there are ports of significance to the transport of, among other things, forest products, petroleum, fuel, iron ore, and steel, and these are of significance for ensuring the long-term needs of industry for cost-effective transport solutions. Staple industries, such as mining and forestry, are currently dependent on functioning shipping. Tour boat traffic inside the baseline that is of benefit to tourism and local residence on islands exists in municipalities with archipelagos such as Östhammar, Luleå, and Haparanda. Passenger traffic outside the baseline is found across Norra Kvarken between Umeå and Vasa in Finland. Umeå Municipality's comprehensive plan also has a vision of a future permanent connection across Norra Kvarken. With increasing maritime transports, there is a greater risk of accidents at sea with negative effects on the marine environment. The risk is amplified by how a planned nuclear power development in Finland in the long term is expected to increase the amount of hazardous goods transported by sea both in and nearby the marine spatial planning area.

Commercial fisheries in the Gulf of Bothnia is small scale. Vendace fishing is of the greatest financial significance in the Bothnian Bay, and herring fishing is dominant in the Bothnian Sea. Salmon fishing is conducted in the entire area. Demand for locally caught fish and processed fish is strong. There are good possibilities to develop fishing operations. Offshore fishing is conducted to a large extent by a Finnish fishing fleet.

In Östhammar Municipality, in the marine spatial planning area's southernmost area, is the Forsmark nuclear power plant. In the Gulf of Bothnia, there are important areas for national defence. There is a marine training area located along the coast in Västernorrland, and a number of areas on land also include risk areas above the water (SwAM, 2016b).

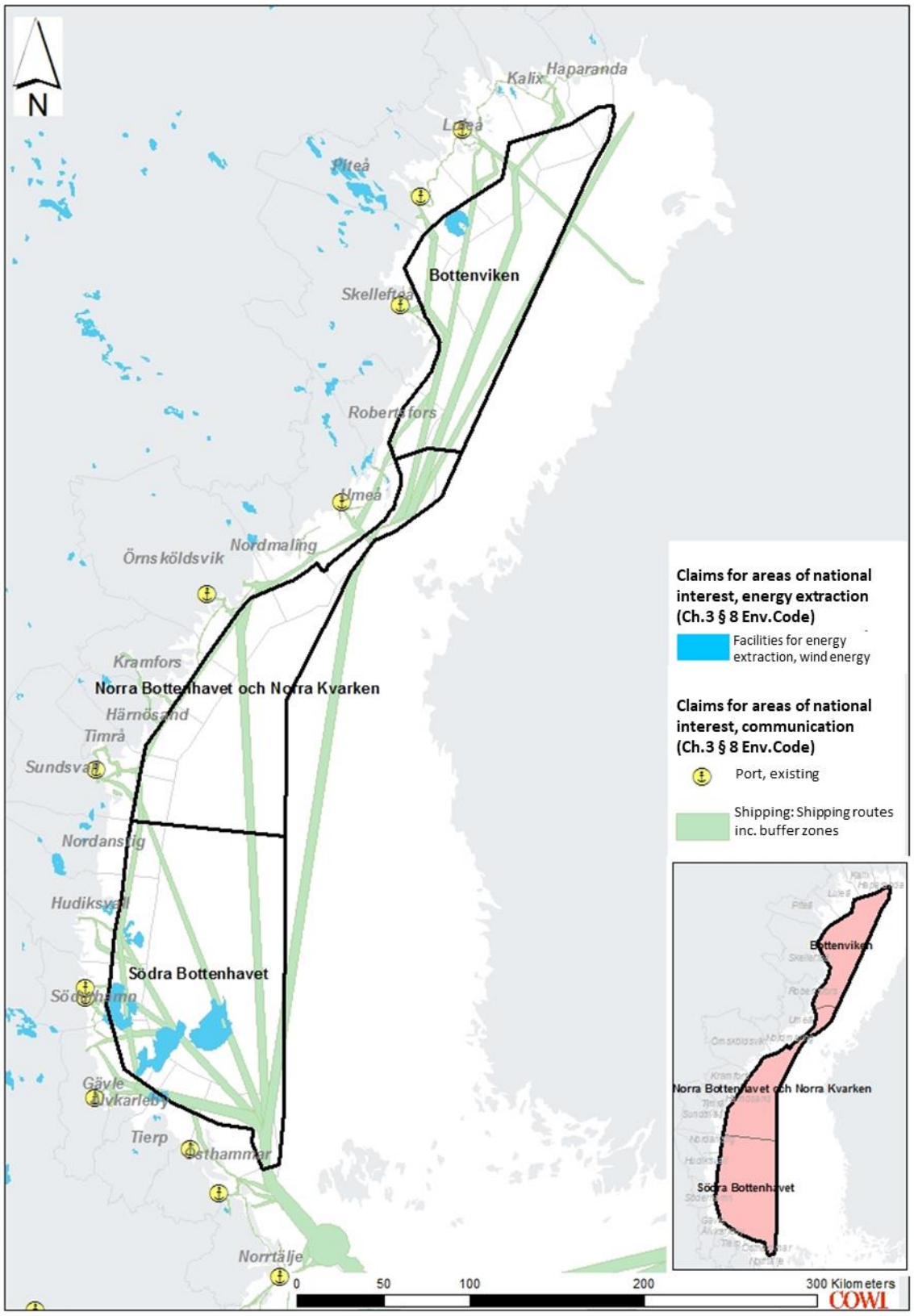


Figure 14 National interests for Transportation and communicationsTransportation and communicationsand energy in the Gulf of Bothnia (not nature conservation).

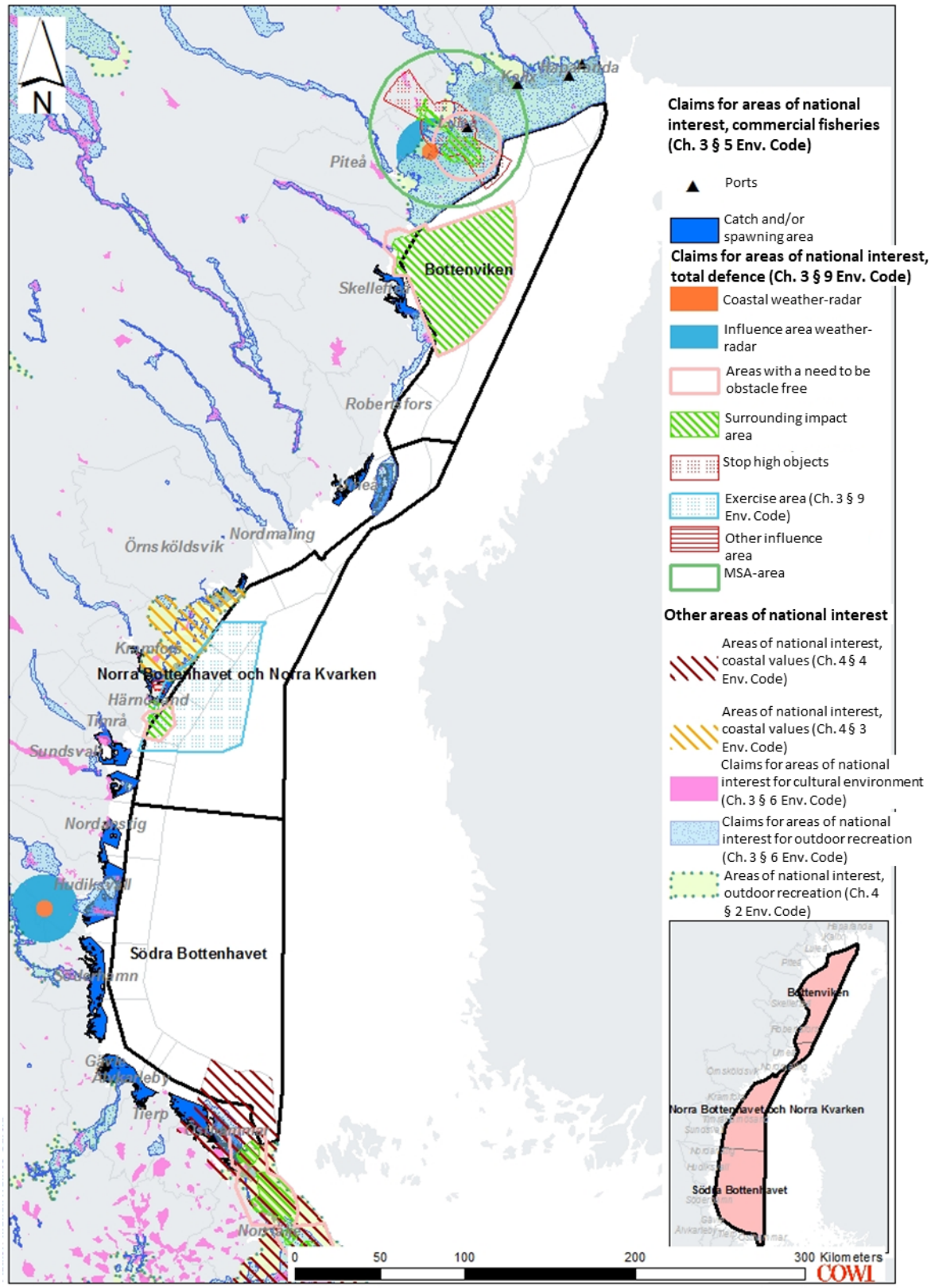


Figure 15 National interests for Commercial fisheries, defence, and other potential protected areas in the Bothnian Bay, the Northern Bothnian Sea, and the Southern Bothnian Sea.

6.1.2 Attractive living environments

The Gulf of Bothnia offers a varied coastal landscape. There is everything from flat archipelago to Höga kusten's unique nature that creates good opportunities for tourism and recreation. There is extensive potential for developing tourism because the area's attractive natural environments can attract both visitors and new companies.

Outdoor recreation that is dependent on water in the marine spatial planning area mainly comprises recreational boat traffic and angling, but also cruise ships and ferry traffic, hunting, safaris, etc. Marine tourism is estimated in Sweden to have a large financial value with up to 50,000 employees and a national turnover of around SEK 70 billion (SwAM, 2017c). The aforementioned value also comprises coastal tourism, including food, lodging, wholesale trade, etc., that to a limited extent can be linked to marine tourism in the marine spatial planning areas. Angling is conducted in the sea by nearly 700,000 people annually with an estimated 3.4 million fishing days (Statistics Sweden, 2017).

Outdoor recreation and tourism contribute to environmental impacts through multiple pressures, such as selective withdrawal of species, underwater noise, air pollution, and littering. Effects of the pressures vary with both time and geography.

One of several drivers for marine tourism is access to cultural environments along the coast. The cultural environments directly impacted by the plans are mainly sunken ships, stone age settlements, and other remains that are now below sea level (SwAM, 2017a). The knowledge of remains on the seabed is insufficient. In the marine spatial planning areas, there are no appointed national interests for cultural environments. At the Swedish National Heritage Board, work is underway to identify guidelines for the appointing of national interests for cultural heritage preservation in the sea. Cultural environments outside the marine spatial planning areas in the archipelago landscape are affected indirectly by the plans, for example, through changes in the landscape or changes in accessibility. Cultural environments underwater can be threatened by other interests making claims on, or otherwise affecting, the physical environment. With an increasingly tough competition for the sea's resources, such a threat is expected to increase over time. The sea's chemical and organic composition can affect cultural environments negatively (SwAM, 2017a).

6.1.3 Energy

With regard to sea-based energy production that is affected in the plans, wind power accounts for the largest part. Sea-based wind power has been in Sweden since the 1990s (Swedish Energy Agency, 2015), but wind power from the sea still has only a marginal role in the energy system. The collective wind power in Sweden accounts for around 9% of the total energy production with an annual production of 15.5 TWh (Swedish Energy Agency, 2017b). In 2016, energy from sea-based wind power amounted to 0.6 TWh, or 3% of produced wind power.

Today, there are four wind farms at sea in Sweden, and seven have approved permits to be built (WSP Sverige AB, 2016). In the Gulf of Bothnia, there is no plant in operation today. There is municipal interest in sea-based wind power in the Gulf of Bothnia, which is reflected in several coastal municipalities' comprehensive plans. In the marine spatial planning area, there are permits for one farm (Storgrundet) and a few on-going permit processes (County administrative boards, 2015). Identified pressures from sea-based energy are mainly impacts on the local seabed and underwater noise from the construction and operation of wind turbines.

Energy production at sea other than wind power is mainly comprised of wave power in Sweden. Several operations for research and development are being conducted, but the scope of commercial production is limited. According to the Swedish Energy Agency (2017c), there is major potential for wave power in Sweden, but technologies need to be developed to lower costs for greater commercialisation.

6.1.5 Storage and extraction of materials

Marine sand and gravel can constitute replacement materials for natural gravel from the land, which is used today as a material in concrete production (Geological Survey of Sweden, 2017). Today, there is only one permit for the extraction of marine sand and gravel in Swedish waters in the Baltic Sea marine spatial planning area – Sandhammar bank south of Ystad. The Geological Survey of Sweden (SGU) assesses that in the long term an annual extraction of marine sand and gravel of 1–2.5 million tonnes would be involved. Extraction is mainly relevant in areas with an extensive need for natural gravel and where there is limited natural gravel on land at the same time. Four areas have been pointed out by SGU as most suitable for extraction on a smaller scale, of which three are located in the Baltic Sea (Sandhammar bank, Sandflyttan, and Klippbanken) and one in the Gulf of Bothnia (Svalans and Falkens grund) (SGU, 2017).

No carbon dioxide storage takes place in Sweden today. Environmental effects of carbon dioxide storage are mainly associated with risks for leakage from the storage site and potential effects of acidification of the water, in addition to pressures in connection with the works, construction, etc., during the associated processes.

6.1.6 Nature

The nature and environment of the Gulf of Bothnia are described under General Conditions, Chapter 5.

6.1.7 Transportation and communications

Shipping plays an important role for the staple industries of mining and forestry and is therefore very important to the region's economy (County administrative boards, 2015). Shipping is seasonally dependent due to the ice cover in the winter, which requires ice breaking to keep shipping lanes open,

which in turn requires large surface areas (SwAM, 2016d). Shipping contributes to environmental problems in several different ways.

In addition to emissions of carbon dioxide that contribute to climate change, combustion of fuels also results in the air pollutants sulphur oxides (SO_X), nitrogen oxides (NO_X), and particulates that, among other things, contribute to acidification and eutrophication problems. Shipping constitutes a large emission source of air pollution. Of the total marine emissions in the entire Baltic Sea area, Swedish shipping accounts for 15–25% of the emissions; in addition to this, there is a significant contribution from international shipping in the marine spatial planning area. Specifically for nanoparticles, half of the emissions to the Baltic Sea come from the boat traffic's fuel combustion. Emissions of NO_X gases from shipping have gradually increased in the Gulf of Bothnia (Swedish Institute for the Marine Environment, 2016b), while emissions of sulphur dioxide are decreasing (SwAM, 2012a). From 1 January 2015, new rules limit shipping sulphur dioxide emissions, and this will hopefully reduce these emissions further (Swedish Institute for the Marine Environment, 2016b). Within the marine spatial planning area, emissions of NO_X gases from shipping are highest in the Southern Bothnian Sea and the border between the Bothnian Bay and the Northern Bothnian Sea, but are much lower than in the other marine spatial planning areas. The particle content has in general decreased in the Baltic Sea's area in recent years (Swedish Environmental Protection Agency, 2016). From a comparative perspective between the marine spatial plans, the sulphur deposit is higher in the Baltic Sea than in Skagerrak and Kattegat, but highest in the Gulf of Bothnia; this is even though emissions are lowest in the Gulf of Bothnia from shipping (per m^2) (Swedish Environmental Protection Agency, 2007).

Emissions of greenhouse gases from shipping are still increasing (SwAM, 2012a) despite an on-going decrease in Sweden's emissions of greenhouse gases in total. In the environmental assessment's context, the emissions of the greenhouse gases carbon dioxide and carbon monoxide from shipping are especially relevant. Methane gas (CH_4) is another greenhouse gas that is relevant because, among other things, it is found in certain sea and lake beds and can therefore be freed upon activities such as resource extraction. Today, carbon dioxide accounts for 65% of the global greenhouse gas emissions, and Sweden's emissions totalled 54.4 megatons of carbon dioxide (ppmv) per year in 2015. This amount can be compared with 15.9 megatons in total that were released from all shipping in the entire Baltic Sea that same year (including international emissions), which corresponded to an increase of 5.6% compared with 2014. In the Baltic Sea area, boat traffic therefore accounts for a large part of the emissions of greenhouse gases, although aviation is also a significant contributing factor. Baltic Sea ferries are currently the vessel type that emits the most carbon dioxide, followed by tank vessels. Tank vessels and freight ships accounted for the largest part of the increase between 2014 and 2015. According to the Swedish Institute for the Marine Environment (2017), shipping's emissions of both greenhouse gases and other air pollutants would be easy to reduce by reducing speeds at sea.

Underwater noise is caused by engines, propellers, sonar, etc., and can, among other things, disturb the communication of marine organisms. Through the emptying of ballast water, there is a risk that the ships spread invasive species that become established in Swedish waters and outcompete native species with potentially major consequences for the ecosystems. Other consequences from shipping are operational releases of oil and other chemicals and a risk of major spills upon running aground or colliding.

6.1.8 Aquaculture and blue biotechnology

Aquaculture in the sea is almost exclusively conducted as coastal activities and not in the marine spatial planning areas. In Sweden, aquaculture is comprised of the farming of fish, shellfish, and algae. The farming of edible fish has increased sharply from 2007 when around 5,000 tonnes were produced in Sweden to 2016 when around 11,400 tonnes were produced (Statistics Sweden, 2017a). The largest percentage is produced in fresh water. Farming of edible fish in the sea mainly pertains to rainbow trout and mainly takes place close to the coast and to the greatest extent on the north-east coast (Statistics Sweden, 2017). Mussel farming in the sea mostly takes place in Skagerrak and Kattegat with a few exceptions. Pressures on marine ecosystems from aquaculture can look different depending on what is farmed, and farming of edible fish is associated with additions of nutrients that contribute to eutrophication, while farming of, for example, mussels and algae results in a net uptake of nutrients that contributes to a reduced nutrient pressure in the sea. Other consequences are seabed losses and impacts on the physical environment. In the Gulf of Bothnia marine spatial planning area, there is no existing facility for aquaculture, and at present no such activities are planned. There is also no survey of areas with good conditions for aquaculture, which is planned for in the scope of the municipalities' comprehensive planning.

6.1.9 Commercial fisheries

Swedish Commercial fisheries is varied, with large boats that most often fish with trawlers and smaller boats with cages, traps, and nets. Trends in Commercial fisheries are, among other things, that it is shifting from small scale and coastal fishing to fishing with larger boats (SwAM, 2016e). A strong negative trend for the number of commercial fishermen has been under way since the mid-1990s (Swedish Environmental Protection Agency, 2014b).

Intensive Commercial fisheries has led to strained stocks. Overfishing of predatory fish affects the food chain with consequences for other parts of the ecosystem, and fishing is deemed to be a contributing cause to the status for half of the 300 marine species on the Swedish Species Information Centre Red List (Swedish Institute for the Marine Environment, 2016a). Bottom trawling is the method that causes the greatest damage to the marine environment, mainly in the form of withdrawals of species, including by-catch, physical damage to the bottom environment from abrasion, and increased turbidity from disturbed sediments. Underwater noise and the introduction of organic materials are also among the consequences from fishing. Consequences from pelagic trawling are

associated with the same types of pressures as bottom trawling except for the physical impact on the bottom environment (SwAM, 2016e).

Fishing in the Gulf of Bothnia marine spatial planning area is clearly seasonally dependent as a result of the winter climate making the area covered with ice during part of the year. Physical and ecological conditions in the Gulf of Bothnia, with relatively simple structures in the ecosystem and relatively low biological diversity, provide only a few species for Commercial fisheries. Fishing for herring with pelagic trawling is the fishing with the greatest significance for the current marine spatial planning area. Bottom trawling takes place only to a minor extent. The ecosystems in both the Gulf of Bothnia and the Baltic Sea are sensitive to excessive withdrawal of fish from both fishing in itself and its environmental consequences (SwAM, 2015a).

6.2 Cumulative effects - present situation

The cumulative effect for the marine spatial planning area of the Gulf of Bothnia and included marine areas has mainly been identified using Symphony. For each marine area, the cumulative effect is described and illustrated based on the sectors that have the main pressure on the environment. Background pressure that cannot be specifically tied to a sector has been identified and included in the cumulative effect. The sectors also entail pressures, such as air emissions, marine litter, invasive species, and cultural environments that are not currently addressed in Symphony. These are described after the analysis of the Symphony results. The environmental effects are described based on the Marine Strategy Framework Directive's pressures, which are described in Chapter 4.

6.2.1 Gulf of Bothnia

The total cumulative environmental effect in the present situation is geographically highest close to the coast (figure not shown here). Within the area for the marine spatial planning, the effect is relatively low compared with coastal areas and more evenly distributed. The area east of Finngrunden demonstrates a higher environmental effect compared with other areas in the marine spatial planning area. In recent years, it is here that the pelagic fishing has been concentrated. A greater environmental effect can also be seen along Höga kusten between Härnösand and Örnsköldsvik, which is due to a high occurrence of oxygen-free bottoms. The areas that show the lowest environmental effect in the marine spatial planning area are in the northern Bothnian Bay and around the Bothnian Sea offshore banks (SwAM, 2018a).

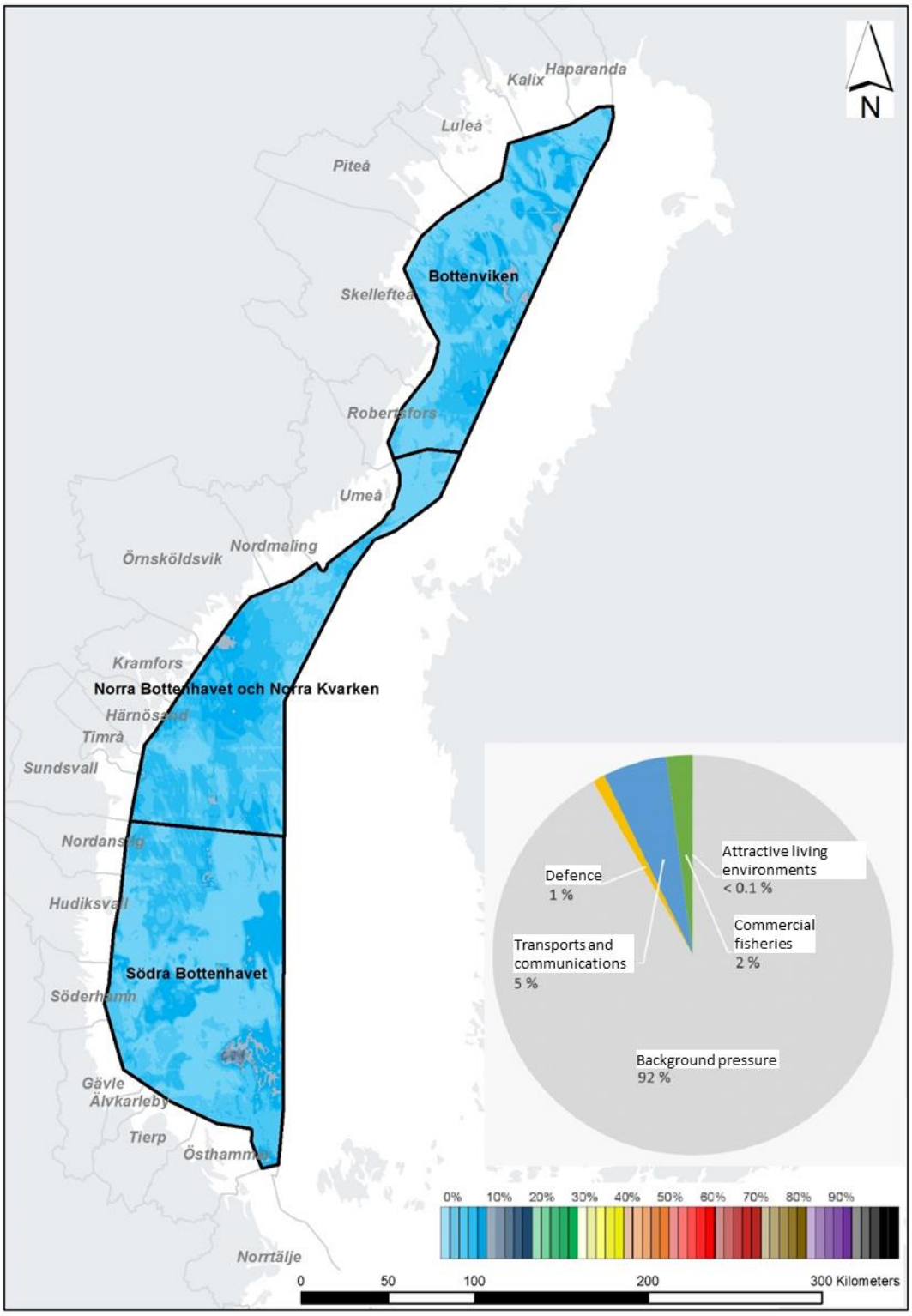


Figure 16 The total cumulative environmental effect in the Gulf of Bothnia marine spatial planning area. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect at present. The colours in the pie chart indicate sectors.

A large part of the cumulative environmental effect in the Gulf of Bothnia marine spatial planning area comes from the background pressure, around 92%. Background pressures are the pressures that are difficult to tie to any specific sector and rather come from a number of sectors and other pollution sources (such as industries, eutrophication, and earlier emissions). The cumulative effect from background pressures comes from phosphorous (approx. 30%) and pollutants in sediment (synthetics approx. 18%, heavy metals approx. 31%), and a small part from nitrogen (approx. 7%) and oxygen-free seabeds (approx. 5%). The Transportation and communicationsTransportation and communicationssector (mainly shipping) contributes to the total cumulative environmental effect with approx. 5%. The sector entails pressures such as *underwater noise* and *introduction of pollutants* (oil spills). Commercial fisheries contributes approx. 2%, mainly through *selective withdrawal of species,* i.e. pelagic trawling. The Defence sector contributes around 1% through *addition of polluting substances,* i.e. the spread of heavy metals. The other sectors contribute to a small extent or not at all. If the coastal areas are included in the total cumulative environmental effect, the background pressure's contribution is decreased, while the pressure from shipping increases somewhat (7%) and impacts from housing development is added (2%) through exploitation of coastal areas (figure not shown here).

The environmental effect is the largest on deep soft seabeds that are accumulation bottoms and on plankton and Herring, and there is also some effect on aphotic transport and soft bottoms, deep transport bottoms, and spawning fish. Through pelagic trawling, the Commercial fisheries sector has the largest effect on herring, while the other sectors affect herring, plant plankton, and spawning fish.

Other pressures that are not analysed in Symphony

Besides the above-listed pressures, the Transportation and communications sector contributes to the cumulative environmental effect with, among other things, air emissions (*introduction of pollutants)*, *introduction and relocation of invasive species*, and *marine litter*. The sectors of Commercial fisheries and Attractive living environments also contribute air emissions (*introduction of pollutants)* and *marine litter*. Today, these pressures are not included in Symphony. Below is a brief description of these pressures based on an assessment of how sensitive the marine areas are to these pressures and, in the subsequent Chapters 7 and 8, the environmental effects are assessed based on the areas' sensitivity.

Air quality

The environmental objective of "Fresh Air" that is to be achieved by 2020 has an interim goal specified as "emissions of sulphur dioxide, nitrogen oxides, and particulates shall have begun decreasing from shipping traffic in the Baltic Sea and the North Sea no later than 2016" (Swedish Environmental Protection Agency, 2016). The interim goal was deemed to have been achieved on time, while there is still a way to go to achieve the environmental quality objective for

2020. The levels are similar between the marine areas (WSP Sverige AB, 2017), and the sensitivity value is therefore deemed to be the same for the three areas. The emission is closely tied to emissions from shipping and thereby sensitive to the development in the shipping sector. Air quality for all areas is therefore given a moderate value (2), see Table 4.

Greenhouse gases

The environmental quality objective "Limited quality impact" specifies that the concentration of greenhouse gases shall be stabilised at 400 ppmv. The objective is deemed to be able to be achieved by 2020. Even if the emissions of greenhouse gases from the marine sector are small in relation to total emissions in Sweden, they correspond to a significant factor and are especially relevant at present because the emissions from shipping are increasing year by year. These emissions must, however, be put into the perspective that shipping from a comparative perspective entails lower greenhouse gas emissions than most other means of transport. As a result of the environmental quality objective and the prevailing awareness of the significance of greenhouse gases to the future climate, the value is set at high (3) for all of the marine sub-regions, see Table 4.

Invasive species

In the environmental objective "A rich plant and animal life", there is the specification that invasive species and genotypes shall not threaten biodiversity. In the areas where invasive species are not present or are few in number, or do not have an impact on biodiversity, the assessment thereof is that the sensitivity value is high (3). Within all marine areas, there are invasive polychaetes, plant plankton, and diatom species. In the Bothnian Bay, there is also the Chinese mitten crab and *Elodea canadensis*. Many invasive animal species have difficulty becoming established, but they entail extensive damage upon establishment and the marine areas are deemed to be sensitive to invasive species. The sensitivity in the Bothnian Bay to the introduction of invasive species is deemed to be somewhat lower than for other marine areas (WSP Sverige AB, 2017). The Northern Bothnian Sea, Norra Kvarken, and Southern Bothnian Sea therefore receive a moderate value (2), while the Bothnian Bay receives a low value (1), see Table 4.

Marine litter

The environmental objective "Sea in balance and living coasts and archipelagos" specifies the preservation of the values of outdoor recreation where marine litter is viewed as a reduction in the recreation values at sea. Today, outdoor recreation is considered not to be especially affected by marine littering in the offshore areas. Because the level of marine litter is low, the value in itself is not deemed to be substantially impacted. The criteria's value is thereby deemed to be high (3) within this aspect for the Bothnian Bay and the Northern Bothnian Sea, but moderate (2) for the Southern Bothnian Sea, see Table 4.

Table 4 Assessed sensitivity for the respective marine areas to the pressures of air quality, greenhouse gases, invasive species, and marine litter. The respective marine area is assessed regarding its sensitivity to the respective pressure according to a three-degree scale – low (1), moderate (2), and high (3).

ASSESSED VALUE[3] BY MARINE AREA	**AIR QUALITY** (NO_x OR PARTICLES)	**GREENHOUSE GASES** (CO_2 OR OTHER GREENHOUSE GASES)	**INVASIVE SPECIES** (EXTENSIVE UNCERTAINTY, - LACK OF KNOWLEDGE)	**MARINE LITTER** (LITTER FROM FISHING, SHIPPING, AND TOURISM)
BOTHNIAN BAY	2	3	1	3
NORTHERN BOTHNIAN SEA AND NORRA KVARKEN	2	3	2	3
SOUTHERN BOTHNIAN SEA	2	3	2	2

6.2.2 Bothnian Bay

The absolutely largest part, around 92%, of the cumulative effect consists of background pressures, which can mostly be attributed to earlier emissions and other sources of pollution. Background pressures consist of leakage of phosphorous (approx. 29%) and pollutants in sediment (synthetics approx. 14%, heavy metals approx. 42%), and a small part from nitrogen (approx. 4%) and oxygen-free seabeds (approx. 3%). A small part of the cumulative effect in the Bothnian Bay comes from the sectors Defence (approx. 3%) and Transportation and communicationsTransportation and communications (approx. 5%). The defence activities' share of the cumulative effect consists of pollutants through *introduction of pollutants*, i.e. heavy metals spread through national defence activities. Transportation and communicationsTransportation and communications mainly have impacts through *underwater noise* and *introduction of pollutants* (oil spills). Transportation and communicationsTransportation and communications also contributes with *air emissions*, *introduction of nutrients and organic materials*, and *invasive species*, and Defence also contributes with *underwater noise.*

The environmental effects mainly arise on deep soft seabeds and plankton communities, which are mainly affected by the background pressure that causes deteriorations in the marine ecosystems. One can also see some effect on seals and spawning fish. The aphotic zone and deep transport and hard bottoms are also affected by the background pressures, but to a lesser degree.

[3] Assessed sensitivity value in accordance with the SEA dialogue (WSP Sverige AB, 2017)

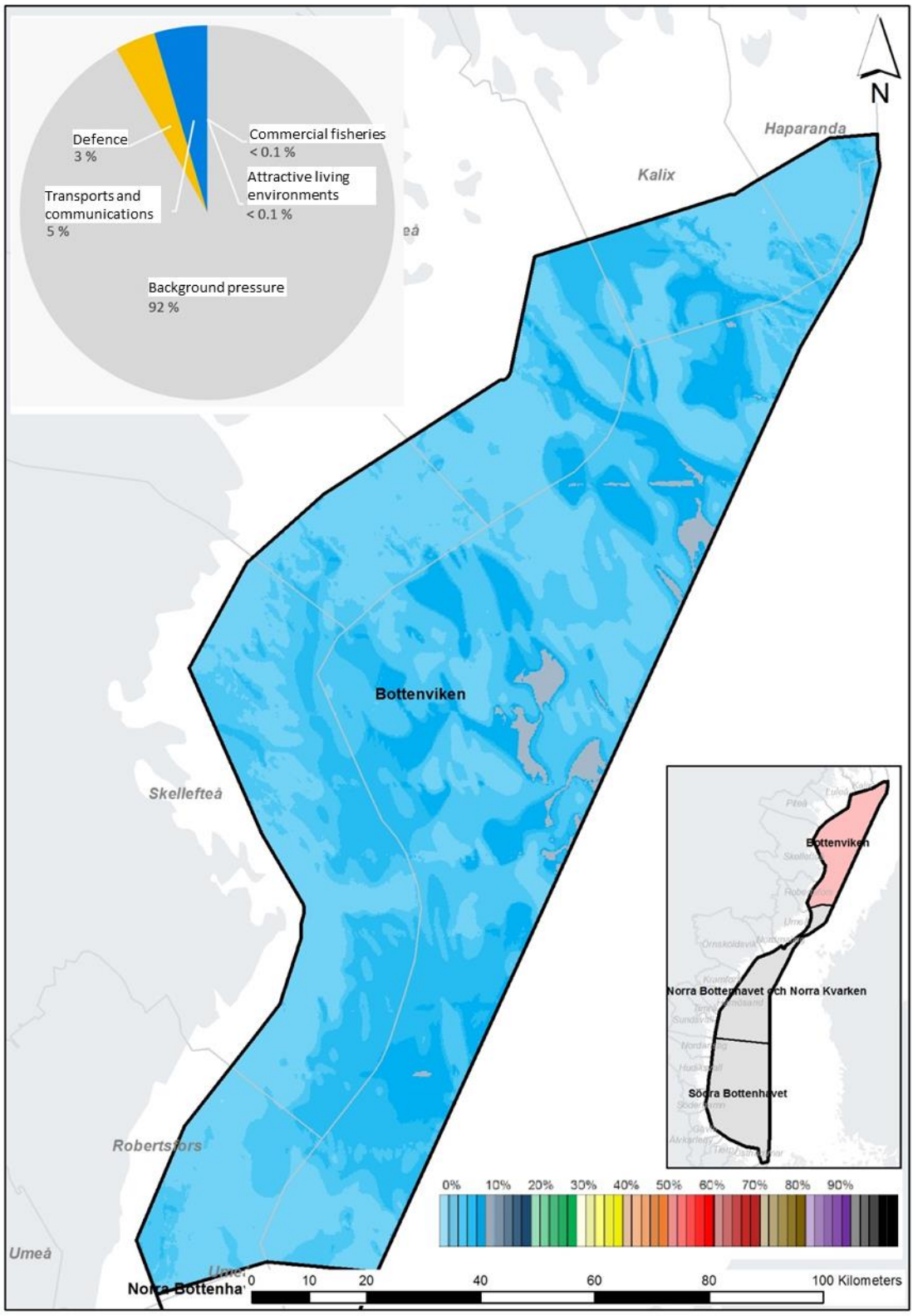


Figure 17 The total cumulative environmental effect in Bothnian Bay. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect at present. The colours in the pie chart indicate sectors.

6.2.3 Northern Bothnian Sea and Norra Kvarken

Like the other marine areas, the absolutely largest part of the cumulative effect in the Northern Bothnian Sea and Norra Kvarken consists of background pressure (approx. 95%). This background pressure consists mostly of pollutants in sediment (synthetics approx. 20%, heavy metals approx. 29%) and phosphorous (approx. 27%), and a small part from nitrogen (approx. 7%) that is caused by several sectors, earlier emissions and other sources of pollution,. Oxygen-free bottoms also account for a part of the effect (approx. 12%). A very small part (<1%) of the environmental effect can be related to mercury dumping.

The sectors that mainly contribute to the cumulative effect in the Northern Bothnian Sea and Norra Kvarken are Transportation and communications, with around 4% of the effect, consisting of *introduction of pollutants* (through oil spills) and *underwater noise*. The sectors that contribute less than 1% are Commercial fisheries, mainly through *selective withdrawals of species* (pelagic fishing and trawling), and Defence, mainly through *introduction of pollutants*, i.e. the spread of heavy metals from defence activities.

Besides the above, Transportation and communicationsTransportation and communications contribute *emissions to air*, *introduction of nutrients and organic materials*, and *invasive species*. Commercial fisheries and Defence contribute very little to the cumulative effect, and thus also contribute only a little with these other pressures (Commercial fisheries: *underwater noise*, *introduction of pollutants*, *marine litter*, and *emissions to air,* Defence: *underwater noise*).

The pressure from various sectors mainly has an effect on deep soft seabeds and plankton, but the herring stock is also affected. One can also see some effect on deep and aphotic soft and transport bottoms, on sprat, and on deep and aphotic hard bottoms.

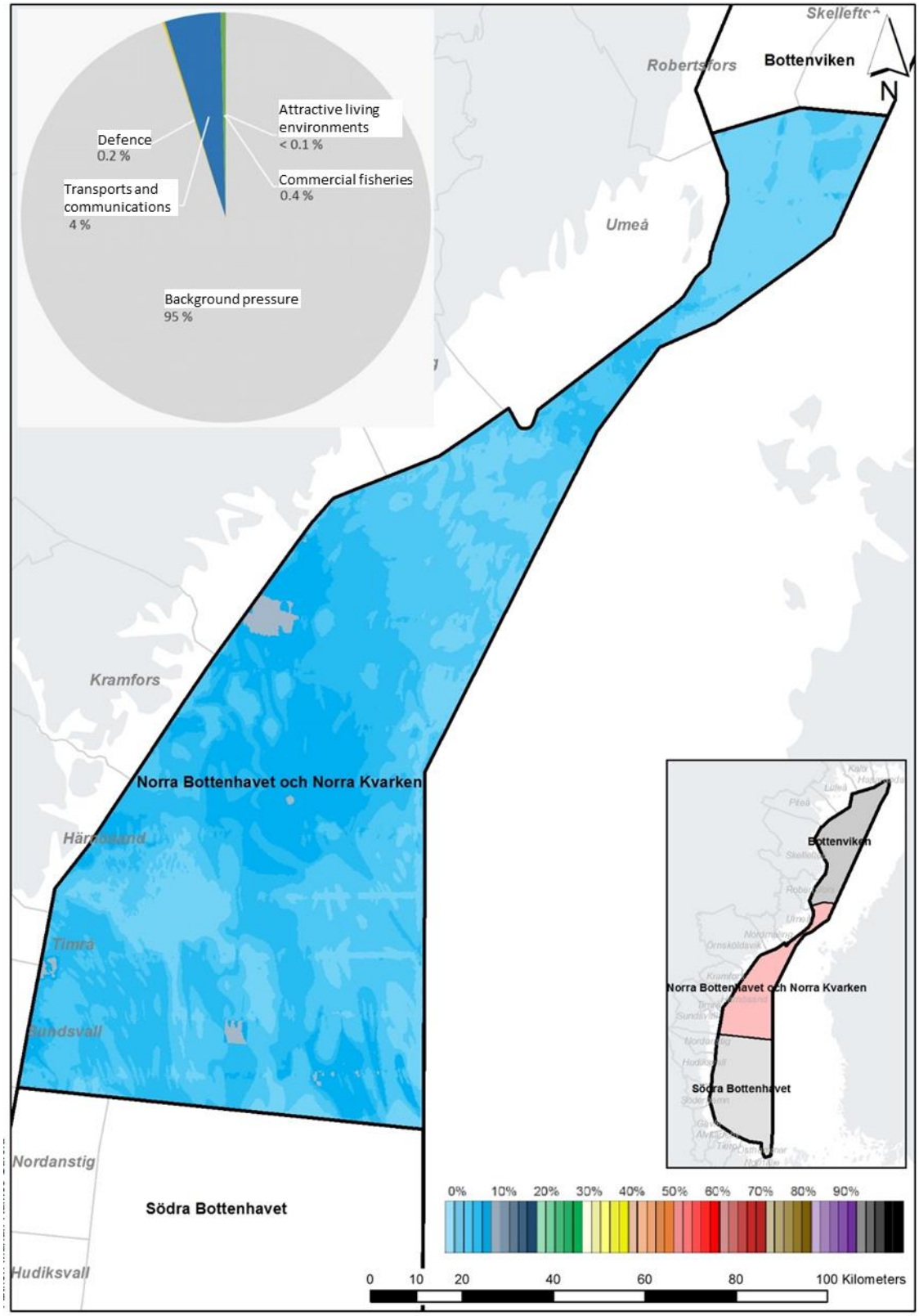


Figure 18 The total cumulative environmental effect in the Northern Bothnian Sea and Norra Kvarken. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect at present. The colours in the pie chart indicate sectors.

6.2.4 Southern Bothnian Sea

For the Southern Bothnian Sea, it is the background pressure that accounts for the largest share of the total cumulative effect, approx. 89%. The background pressure consists of pollutants in sediment (synthetics approx. 19%, heavy metals approx. 26%) and phosphorous (approx. 32%), and a part from nitrogen (approx.10%). Oxygen-free seabeds account for a small share of the effect (approx. 1%), and a very small part (<1%) of the environmental effect can be related to heavy metals from mines. Here, the sectors Commercial fisheries and Transportation and communicationsTransportation and communications contribute around 5% and around 6%, respectively, to the total cumulative effect. The effect from Commercial fisheries is overwhelmingly from *selective withdrawals of species* (pelagic fishing and a small share of bottom trawling). The effect from Transportation and communications consists mainly of the effects *emissions of pollutants* (oil spills) and *underwater noise* from shipping. Besides the above, Transportation and communications contributes *emissions to air*, *introduction of nutrients and organic materials*, and *invasive species*. Commercial fisheries also contributes *underwater noise, introduction of pollutants, marine litter*, and *emissions to air*.

The effects are mostly seen on plankton, deep soft seabeds, and herring stocks. One can also see some effect on aphotic soft and transport bottoms, deep hard and transport bottoms, grey seals, spawning fish, and sprat.

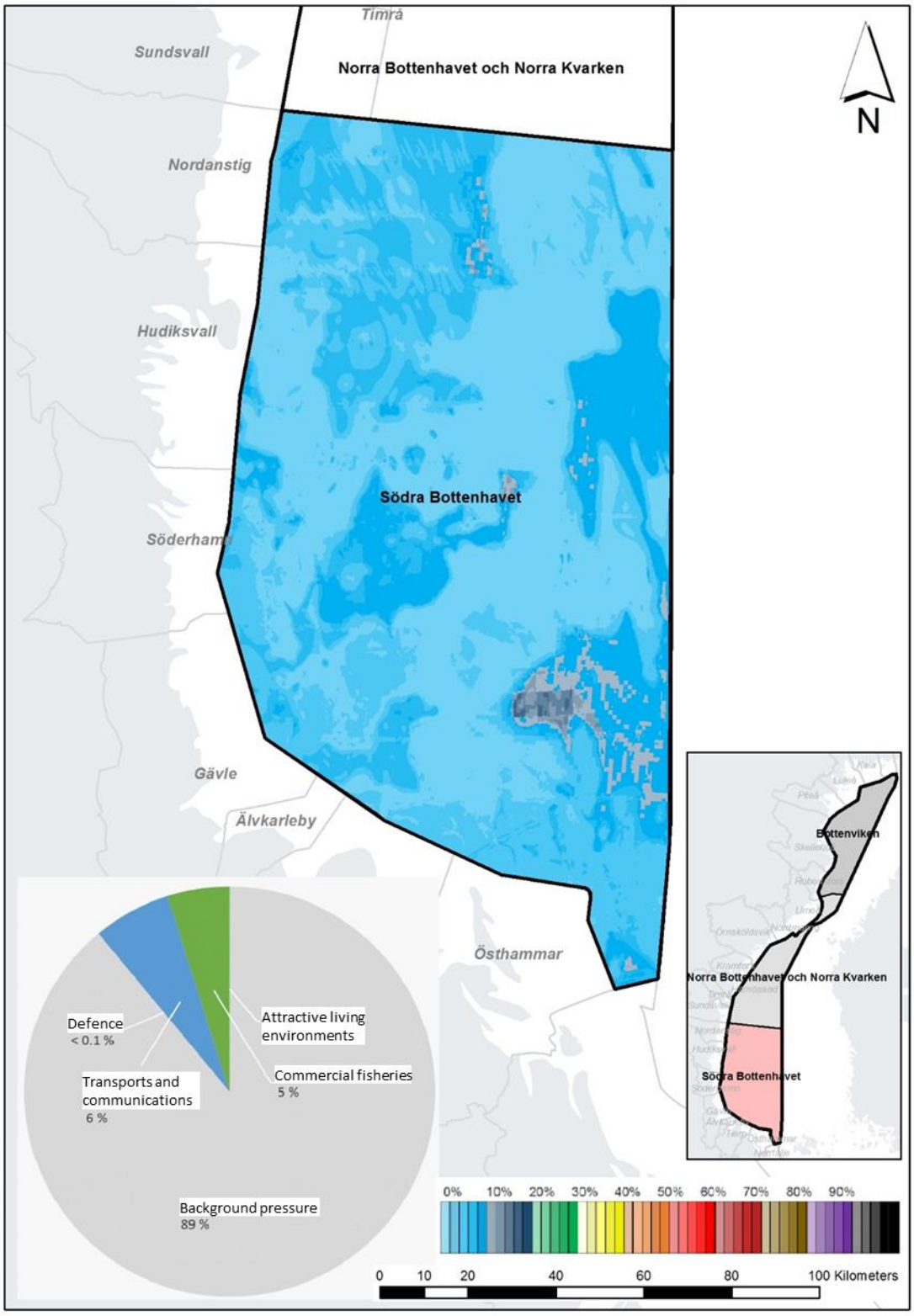


Figure 19 The total cumulative environmental effect in the Southern Bothnian Sea. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect for the zero alternative at present. The colours in the pie chart indicate sectors.

7 Zero alternative

This chapter describes the zero alternative as a trend projection for the plan's sectors until 2030, with a prospective view towards 2050. The cumulative environmental effect for the zero alternative I 2030 (based on the Symphony planning method) is also described. The analysis for the sectors is completed with tables that illustrate the predicted change in pressure. An upwards mark in the tables means an increased pressure and thereby a negative effect.

7.1 Sectors and themes

7.1.1 Attractive living environments

Marine tourism consists of various components that can be expected to develop differently over time. A number of trends of significance to the development of tourism are identified in WSP Sverige AB 2016, including a generally increasing tourism sector, a broader spread of niched tourism and ecotourism, and active holidays. The development of tourism and outdoor recreation is assumed to follow the population growth otherwise (SwAM, 2017a). Marine tourism is expected to continue an upward trend (SwAM, 2017b). In WWF (2010), an annual growth of recreational craft in the country by several percentage points is expected. In this analysis, a more cautious assessment is made of an increase by 5 per cent by 2030 with reference to uncertainty in the estimates and a lack of a clear trend in actual statistics (SwAM, 2017b). However, recreational fishing is assessed to be relatively constant in scope until 2030 (SwAM, 2017b). With regard to ferry and cruise traffic departures, an increase is expected over time in the Baltic Sea, which can be assumed to be the scenario for the Gulf of Bothnia although to a lesser extent considering the relatively lower level of activity (WWF, 2010; SwAM, 2015a).

Underwater noise is expected to increase as a result of more cruise and ferry traffic. In SwAM's action programme for the marine environment, no proposals are made on measures to reduce underwater noise, which is why the pressure is expected to increase in proportion to the sector's development (SwAM, 2017b). Air pollution can also be expected to increase with the development of these activities, but to a somewhat lesser extent because regulations can be expected to be strengthened and complied with to a greater extent over time. With proposed measures in SwAM (2015d) regarding the collection of litter and lost fishing equipment, along with the enactment of prevention measures, littering is expected to decrease (SwAM, 2017).

Table 5 Attractive living environments (Recreation, tourism, cultural environments) - sector development and development of pressures until the reference year 2030.

	SECTOR DEVELOPMENT	PRESSURE DEVELOPMENT			
	*	Withdrawal of species	Underwater noise	Air pollution	Littering
ANGLING	→	→	→	→	↘
RECREATIONAL CRAFT	↗	-	↗	↗	↘
CRUISE TRAFFIC	↗	-	↗	↗	↘
FERRY TRAFFIC	↗	-	↗	↗	↘

* ↑ sharp increase (+10 %), ↗ moderate increase (+5 %), → unchanged situation, ↘ moderate decrease (-5 %), ↓ sharp decrease (-10 %)

7.1.2 Energy

With the current political objectives in the energy and climate area (e.g. a target of 100% renewable energy production by 2040 (Energy Commission, 2017)), there is pressure on the expansion of renewable energy, where wind power is expected to play an important role. According to the Swedish Energy Agency, sea-based wind power has extensive potential, but the expansion of wind power on land is currently relatively competitive, which inhibits the development at sea (Swedish Energy Agency, 2017a). Current support for sea-based wind power through the electricity certificate system is assessed to be inadequate to make the alternative competitive. On behalf of the Government, the Swedish Energy Agency has prepared a proposal on systems for the repeal of connection charges for sea-based wind power. Repealed connection charges would entail a significant reduction in cost[4] (Swedish Energy Agency, 2018). If the connection charge is repealed, it can have a significant positive impact on the establishment of wind power at sea.

Development of wind power in the marine spatial planning area until 2030 depends on multiple factors, such as the development of technology, costs, electricity prices, and political action in the form of incentive funding. The Swedish Energy Agency (2017a) assesses that a limited establishment will take place by 2030 and that the development will not gain speed until after 2030.

Trends identified for technical development are that the turbines are becoming taller and the rotor blades longer, and that the foundation technology is developing (WSP Sverige AB 2016, the Swedish Energy Agency 2017a, SwAM 2017d). The development towards larger rotor blades is going quickly (SwAM, 2017d), and it is having an impact on the number of power stations that are suitable to build per area and their distance in relation to each other. Expected development of floating power stations will make it possible to place wind farms at a deeper depth than today and with potentially lower conflict with

[4] Personal contact with Maria Stenkvist, Swedish Energy Agency, 12 December 2017.

other interests. Establishment of floating power stations is not expected until after 2030 (Swedish Energy Agency 2017a, SwAM 2017d).

Referring to a strong political desire to speed the transition to renewable energy production and on-going investigations in the area, some establishment of wind power can take place in the marine spatial planning area, and the permitted establishments are predicted to become reality. In the zero alternative and associated estimates in Symphony, the assumption is therefore made that wind power will be conducted in the areas that currently have permits and in the areas with existing production.

Potential exists for the development of wave power in Sweden, but development is not expected until possibly after 2030. In light of the activities not being expected to increase in scope by 2030, no change is expected in the activities' pressures on the environment.

Table 6 Energy - sector development and development of pressures until the reference year 2030. Assessment of the pressure is based on the development increasing significantly, but mainly after 2030.

	SECTOR DEVELOPMENT	**PRESSURE DEVELOPMENT**			
	‘	Physical loss	Biological disruption	Underwater noise	Physical disruption
WIND POWER	↗	↗	↗	↗	↗
POWER FROM WAVES, CURRENTS, TIDES AND SALINITY GRADIENTS	→	→	→	→	→

* ↑ sharp increase (+10 %), ↗ moderate increase (+5 %), → unchanged situation, ↘ moderate decrease (-5 %), ↓ sharp decrease (-10 %)

7.1.3 Defence

The Government bill on the defence policy direction (Government bill 2014/15:109) describes a changed defence policy situation that motivates increases in the Defence activities. A parliamentary decision from 2015 on increased investments in military capacity is expected among other things to mean that training activities and signal surveillance will increase in the marine spatial planning areas (Government bill 2014/15:109). A likely development in signal surveillance is that permanent facilities will be replaced by mobile facilities, and today no fixed installations are expected to be established. A likely development is the expanded use of virtual exercises that to some extent can replace the need for physical artillery exercises, but effects can be expected only after 2030 (WSP Sverige AB 2016, SwAM 2016c). Military activities' pressures can be expected to increase proportionately with the sector's development by 2030.

Table 7 Defence - sector development and development of pressures until the reference year 2030.

	SECTOR DEVELOPMENT	PRESSURE DEVELOPMENT	
	*	Underwater noise	Introduction of hazardous substances
ARTILLERY RANGE/TRAINING AREA	↗	↗	↗
DUMPED AMMUNITION	↗	↗	↗

* ↑ sharp increase (+10 %), ↗ moderate increase (+5 %), → unchanged situation, ↘ moderate decrease (-5 %), ↓ sharp decrease (-10 %)

7.1.4 Storage and extraction of materials

In the marine spatial planning area for the Gulf of Bothnia, there are mainly two deposits with sand and gravel with geological conditions for extraction (SGU, 2017). In the marine spatial planning area for the Gulf of Bothnia, there are currently no permits for extraction. Finngrunden's eastern bank in the Southern Bothnian Sea and Svalans and Falkens grund in the Bothnian Bay are two areas with geological conditions for extraction (SGU, 2017). Whether or not sand extraction will take place in the marine spatial planning area by 2030 is uncertain and depends on multiple factors. The demand for natural gravel can be expected to continue to be high at the same time that the supply of finite deposits from land decreases in pace with the extraction that takes place. Other factors that play a role are prices for the production of replacement materials from crushed rock. Extraction of sand and gravel in the sea is also controversial in part because it is associated with significant environmental consequences. In the zero alternative, there is only existing sand extraction (Sandhammar bank) and no new establishment for extraction of marine sand and gravel in the current marine spatial planning area.

A study done in 2016 on behalf of SGU shows that there is extensive potential for carbon dioxide storage in Sweden (SGU, 2016). Because carbon dioxide storage is a technology that is assessed by many to be able to contribute to achieving set climate objectives, demand can be expected to increase in the long term (WSP Sverige AB, 2016). A relatively slow development of the method and a potentially large opposition due to uncertainty regarding risks with the technology contribute to the assessment that the development of carbon dioxide storage will gain speed only after 2030 and then mainly in the Baltic Sea where the geological conditions are considered to be relatively good (SGU, 2016).

Table 8 Extraction and storage of materials - sector development and development of pressures by the reference year 2030.

	SECTOR DEVELOPMENT	PRESSURE DEVELOPMENT	
	*	Physical disruption	Physical loss
CARBON DIOXIDE STORAGE	→	→	→
SAND EXTRACTION	→	→	→

* ↑ sharp increase (+10 %), ↗ moderate increase (+5 %), → unchanged situation, ↘ moderate decrease (-5 %), ↓ sharp decrease (-10 %)

7.1.5 Nature

The assessment is that several interests that affect and make claims on the physical environment will increase by 2030, including shipping, defence activities, aquaculture, and activities linked to outdoor recreation. Other interests such as Commercial fisheries and energy production are not expected to decrease from today's levels. Altogether, the assessment is that the pressures on the marine environment can be expected to increase by 2030. Effects from climate change are also expected to increase by 2030, and taken together are expected to entail further stress on the marine ecosystems from, among other things, acidification, change of the water's salinity, and a greater risk for the spread of invasive species.

The current objective that at least 10% of the sea will be covered by area protection by 2020 is not expected to be achieved in the Gulf of Bothnia (at present it is approximately 5%). However, the objectives will probably lead to an expanded area protection in the Bothnian Sea by 2030. In the zero alternative, it is therefore assumed that area protection will be introduced in areas where the introduction of protection is planned today.

7.1.6 Transportation and communications

According to forecasts by the Swedish Transport Administration (2016), considering among other things population growth, economic development, surrounding world factors, and some regulation of shipping (EU Sulphur Directive), the transport of goods at sea in Sweden is expected to increase by a maximum annual growth of 2.3% (Swedish Transport Administration, 2016). From today to 2030, this entails an increase of around 30% of transport work (tonne kilometres) in Swedish waters. An expected driver for greater transport in the Gulf of Bothnia is increased production and export of iron ore (County administrative boards, 2015). In the zero alternative, an increase is assumed in the pressure from the sector by 35% from today's traffic in the Gulf of Bothnia by 2030. Existing areas for shipping lanes are deemed to be adequate for handling the expected increase. A general trend that is assumed to continue is that the ships will become larger. However, the bridge height in the Great Belt and water depth in Öresund limit the size of ships in the Baltic Sea. Assumptions are made that dredging of existing shipping lanes might need to increase in order to enable the passage of larger ships.

With more activity in existing shipping lanes, the risk of collision and running aground increases, and this brings increased risks to people and the environment (WSP Sverige AB, 2016). Shipping emissions to the air are regulated by several national and international regulations, such as the EU Sulphur Directive and IMO's Sulphur Convention. Regulations and provisions can affect the supporting infrastructure and the possibilities of bunkering as ships transition to alternative fuels, which might in turn affect the routes and movement patterns of shipping. Through the implementation of the IMO

Ballast Water Convention in the autumn of 2017, where ballast water must be cleaned before release, effects in connection with the spread of invasive species are expected to decrease by 2030.

Table 9 Shipping - sector development and development of pressures until the reference year 2030.

	SECTOR DEVELOPMENT	PRESSURE DEVELOPMENT				
	*	Physical disturbance (impact on the seabed)	Underwater noise	Emission of oil and hazardous substances	Emission of air pollutants	Introduction and spread of invasive species
MARITIME TRANSPORTS	↑	↑	↑	↑	↑	↘
DUMPING OF DREDGED MATERIALS	↗	↗	-	-	-	-

* ↑ sharp increase (+10 %), ↗ moderate increase (+5 %), → unchanged situation, ↘ moderate decrease (-5 %), ↓ sharp decrease (-10 %)

7.1.7 Aquaculture and blue biotechnology

Technical and knowledge development can provide better conditions for farming in the sea farther from the coast and might become relevant in the marine spatial planning areas by 2030. Considering the uncertainty in development, however, it is assumed that aquaculture will not be conducted in the marine spatial planning areas in the assessment's zero alternative in 2030.

Table 10 Aquaculture and blue technology - sector development and development of pressures by the reference year 2030.

	SECTOR DEVELOPMENT	PRESSURE DEVELOPMENT	
	*	Introduction of nutrients	Physical loss
AQUACULTURE	↗	→	→

* ↑ sharp increase (+10 %), ↗ moderate increase (+5 %), → unchanged situation, ↘ moderate decrease (-5 %), ↓ sharp decrease (-10 %)

7.1.8 Commercial fisheries

Demand for fish as food is extensive and is expected to grow (WSP Sverige AB, 2016). The structural conversion of Commercial fisheries already under way from smaller boats and one-man companies being replaced by larger units with higher capacity is expected to continue (SwAM, 2016e). The trend of a lower number of active fishermen is expected to be a part of this development. Management, including regulations of fishing, is expected to lead to more possibilities of catches in the long term (SwAM, 2017b). However, fishing is expected to be stable until 2030. One of many uncertainties for the future is how climate change with a higher water temperature and expected lower pH in the seas will affect marine environments and fishing.

The establishment of marine area protection with fully or partly regulated fishing are measures that can be expected to lead to the protection of sensitive bottom environments and nursery areas for fish and other marine organisms. The on-going development of fishing equipment and methodologies to reduce the impact on the environment from fishing is expected to continue. Examples are the development of selective equipment for the reduction of by-catch and techniques for minimising damage to bottom environments (SwAM, 2016e). The withdrawal limits for commercial species that are set at a supranational level through the Common Fisheries Policy play an important role for the withdrawal of catches and thereby also for the consequences linked to the pressure *selective withdrawal of species*. Altogether, pressures from Commercial fisheries through *physical disturbance* and *withdrawal of fish* are expected to decrease by 2030.

Table 11 Commercial fisheries - sector development and development of pressures until the reference year 2030.

	SECTOR DEVELOPMENT	PRESSURE DEVELOPMENT	
	*	Selective withdrawal of species	Physical disturbance (from trawling)
BENTIC TRAWLING	→	↘	↘
PELAGIC TRAWLING	→	↘	↘
OTHER FISHING	→	↘	↘

* ↑ sharp increase (+10%), ↗ moderate increase (+5%), → unchanged situation, ↘ moderate decrease (-5 %), ↓ sharp decrease (-10 %)

7.2 Outlook towards 2050

7.2.1 Attractive living environments

In the maritime strategy prepared by the Ministry of Enterprise and Industry that points out the vision and strategy for maritime industries by 2050 (Ministry of Enterprise and Industry, 2015), the development potential for marine tourism is described as good. Demand from both national and international tourism to participate in archipelago life and to use the sea for recreation is expected to increase. One of several conditions is that important natural and cultural values are preserved. Identified trends towards more active holidays, niched tourism, and ecotourism can also lead to other uses of the sea than today with a potentially increased pressures on sensitive environments. With increased use of the sea for recreation, the activities' pressures can also be expected to increase even if they to some extent can change over time with other with different types of activities and pressures.

7.2.2 Energy

Political objectives regarding renewable energy production and technical development will probably lead to it becoming more economically advantageous to build and operate wind power at sea in 2050 and that

development will gain speed. By 2050, development of floating wind turbines might also make it a commonly applied technology that also enables placement of wind turbines at a greater depth and at locations different from today. Regarding sea-based energy in the form of wave power and currents, development can be expected to take place until 2050. Investments from the Swedish Energy Agency are being made to increase the possibility of commercialisation (Swedish Energy Agency, 2017c). With expected strong development of sea-based wind power and some development of other types of energy at sea, pressures in the form of noise, light pollution, and physical loss and disturbance are expected to increase. An expected use of floating wind turbines might contribute to physical disturbance increasing to a lesser extent than the actual sector.

7.2.3 Defence

Technical development and changes in the defence policy situation make it very difficult to assess the national defence outlook for 2050 (WSP Sverige AB, 2016). Described trends for scenario 2030 can be expected to also continue to 2050. Technical development is expected to enable virtual training and might reduce the sector's pressures from artillery exercises in the long term (WSP Sverige AB 2016).

7.2.4 Storage and extraction of materials

It is likely that extraction of sand from the seabed will become increasingly important over time considering natural gravel resources on land being a finite resource that at the same time is important to preserve. By 2050, it is expected that demand and technology will develop so that the conditions for carbon dioxide storage are good. Assumptions are made on the increase in carbon dioxide storage mainly in the Baltic Sea where the conditions according to studies are considered the best (SGU 2016).

7.2.5 Nature

By 2050, even greater pressure on the marine environment is expected than in 2030. A probable development is that energy production at sea will become more profitable and that establishment of wind farms will have gained speed, but to some extent also other energy sources at sea. Sand extraction, aquaculture, defence activities, and shipping can be expected to be conducted to a greater extent in the marine spatial planning areas. It is also probable that political incentives and technical development will drive reduced pressures from these activities. For example, floating wind turbines might be common with less pressure on the physical environment and with potentially less conflict with other interests such as nature conservation.

A continued downward trend of nutrients to the Baltic Sea will probably have positive effects on eutrophication problems. But recovery of the ecosystems is a complex process and takes place slowly and the status of the Baltic Sea in 2050 is uncertain. Regulation of withdrawals of marine species is still important for the status of the ecosystems' status and should take place adaptively according to the status of the stocks. In 2050, effects from climate change can be expected

to be more extensive with potentially larger effects from acidification, warmer water temperatures, changed salinity levels, and the spread of invasive species.

7.2.6 Transportation and communications

Shipping in the marine spatial planning areas is deemed to continue to increase until 2050. A potential scenario is that it in 2050 it will be common to have automatically controlled and unmanned vessels that might lead to a more efficient use of shipping lanes (SwAM, 2016d). A possible development is that regulation of shipping fuels will become more stringent over time to reduce the environmental effects from air pollution and climate emissions. Such a development can lead to reduced emissions for individual transports, but it can be considered less likely that it will compensate for the higher amount of shipping, and the total pressure can therefore be expected to increase.

7.2.7 Aquaculture and blue biotechnology

The demand for seafood can be expected to continue to be extensive in 2050. It is possible that there will be other and developed areas of use, for example, algae for the production of food, feed, and biogas. It is likely that an increased demand will contribute to a higher use of aquaculture in 2050. Technical development might make it possible for farming farther out at sea, and it is possible that co-existence will take place with permanent installations for, for example, energy production. To reduce nutrient leakage to surrounding environments from the farming of edible fish, farming in closed systems will probably take place in closed systems to a greater extent than today.

7.2.8 Commercial fisheries

The expected increased demand for fish and other seafood can potentially be partly met by production from aquaculture in the sea and on land. In addition to the activities' pressures on the marine environment and the fishing stocks, the possibilities of future withdrawals will also be affected by other pressures and the seas' environmental status. The Baltic Sea and the Gulf of Bothnia are especially sensitive to disruptions that can affect fishing because the ecosystems are heavily burdened from, for example, eutrophication, pollution, overfishing, etc. The ecosystems' health, effects from climate change, etc., are uncertainties that make it difficult to forecast Commercial fisheries to 2050. Fisheries management is under constant development, and technical developments to minimise the environmental impact of fishing are expected to continue (SwAM, 2016e).

7.3 Cumulative effects - zero alternative

The cumulative effect for every marine area in the Gulf of Bothnia for the zero alternative has been identified using Symphony. For the MSP and each marine area, the cumulative effect is described and illustrated based on the sectors that have the main pressure on the environment. Background pressures that cannot be specifically tied to a sector have been identified and included in the

cumulative effect. The type of impact that the sectors contribute is linked to the pressures of the Marine Strategy Framework Directive.

7.3.1 Gulf of Bothnia

The collective cumulative environmental effect in the marine spatial planning area of the Gulf of Bothnia shows marginal geographic differences compared with the current situation, see **Fel! Hittar inte referenskälla.**. The percentage increase in the environmental effect for the entire marine spatial planning area is around 1% compared with the current situation.

The cumulative environmental effect in the zero alternative mainly comes from background pressures, around 90% of which consist of pollutants in sediment (heavy metals approx. 31% and synthetics approx. 18%), phosphorous (approx. 29%), and a small part from nitrogen (approx. 7%) and oxygen-free seabeds (approx. 5%). The largest contribution comes from the sectors Transportation and communications and Defence. Transportation and communications contribute around 7%, mainly through *underwater noise* and *introduction of pollutants* (oil spills) and mainly have an effect on plankton and fish. Commercial fisheries contributes 2%, and the largest part is through *selective withdrawals of species* (mainly pelagic trawling) of herring and sprat, but there are also affects on ringed seals and through bottom trawling also *physical disturbance* of the bottom environment. Defence activities account for around 1% and also cause pressures through the *introduction of pollutants* (spread of heavy metals). Attractive living environments and Energy contribute marginally. Attractive living environments contributes with bird hunting and *underwater noise* and *introduction of pollutants* from recreational boats, and Energy contributes with *underwater noise* and *biological disturbance*.

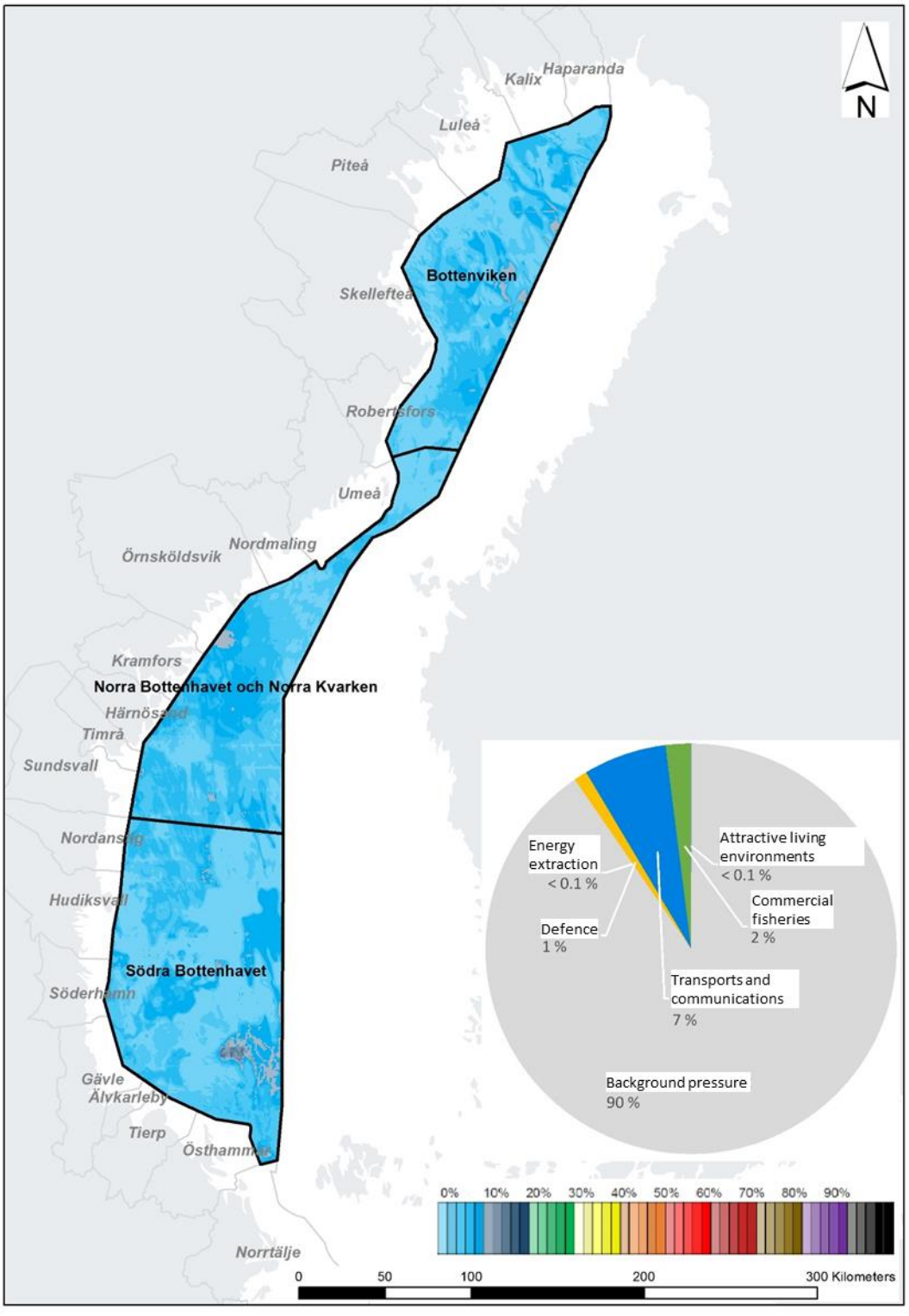


Figure 21 The total cumulative environmental effect in the Gulf of Bothnia marine spatial planning area. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect for the zero alternative. The colours in the pie chart indicate sectors.

The trend analysis shows that the Transportation and communications sector will grow up to 2030, which is reflected in an increase of more than 1% of its percentage share of the total cumulative effect compared with the current situation.
Defence will also increase somewhat, which entails a small increase in the *introduction of pollutants* (spread of heavy metals). Commercial fisheries will remain unchanged, but the impact is estimated to decrease somewhat depending on the development of fishing equipment and better fishing regulations.

The cumulative effect is mainly seen on deep soft seabeds and plankton, but also some effect on herring, aphotic transport and soft seabeds, deep transport and hard seabeds, spawning fish, ringed seals, grey seals, and sprat.

Other pressures that are not analysed in Symphony
Tourism and recreation are expected to increase in the Gulf of Bothnia, which entails among other things more ferry and cruise traffic, which results in more pressure from emissions to air and a risk of greater spread of invasive species. Littering is, however, expected to decrease as a result of the collection of litter and lost fishing equipment and preventive measures. Commercial fisheries is expected to be stable up to 2030 and is thereby not expected to entail any change in the pressures compared with the current situation. Shipping is expected to increase by 35% until 2030 and entail an increase in pressures. Shipping emissions to the air are regulated by several national and international regulations, such as the EU Sulphur Directive. Through the implementation of the IMO Ballast Water Convention, where ballast water must be cleaned before release, effects in connection with the spread of invasive species are expected to decrease by 2030.

Altogether, the environmental effect of emissions of greenhouse gases and marine litter to the Gulf of Bothnia is deemed to have moderate effects based on the marine areas' sensitivity assessment and the sector analysis until 2030, see Table 12. Air quality and the spread of invasive species are deemed to have small effects.

Table 12 Assessed environmental effect in the respective marine area for the pressures of air emissions, invasive species, and marine litter based on the sector analysis until 2030. The scale is as per Table 3.

ASSESSED ENVIRONMENTAL EFFECT	AIR QUALITY (NO_X OR PARTICLES)	GREENHOUSE GASES (CO_2 OR OTHER GREENHOUSE GASES)	INVASIVE SPECIES (EXTENSIVE UNCERTAINTY - LACK OF KNOWLEDGE)	MARINE LITTER (LITTER FROM FISHING, SHIPPING, AND TOURISM)
BOTHNIAN BAY	Small-moderate effects	Moderate effects	Small effects	Moderate effects
NORTHERN BOTHNIAN SEA AND NORRA KVARKEN	Small-moderate effects	Moderate effects	Small-moderate effects	Moderate effects
SOUTHERN BOTHNIAN SEA	Small-moderate effects	Moderate effects	Small-moderate effects	Small-moderate effects

7.3.2 Bothnian Bay

The background pressure contributes to the total cumulative environmental effect in the Bothnian Bay marine sub-region with around 91%, see **Fel! Hittar inte referenskälla.**, consisting mainly of pollutants in sediment (heavy metals approx. 41% and synthetics approx. 14%) and phosphorous (approx. 29%), and a small share also comes from nitrogen in sediment (approx. 4%) and oxygen-free seabeds (approx. 3%). The cumulative effect from sectors in the zero alternative for the Bothnian Bay mainly comes from Transportation and communications, with around 6%. This consists of effects from *underwater noise* and *introduction of pollutants* (oil spills from shipping). *Underwater noise* has a relatively large impact on ringed seals. Defence contributes with around 4% with the *introduction of pollutants* (spread of heavy metals). Attractive living environments and Commercial fisheries contribute marginally through *selective withdrawals of species*, *physical disturbance*, *underwater noise*, and *introduction of pollutants*.

The cumulative effect is mainly seen on deep soft seabeds and plankton, but also some effect on ringed seals, aphotic transport and soft seabeds, deep transport and hard seabeds, and spawning fish.

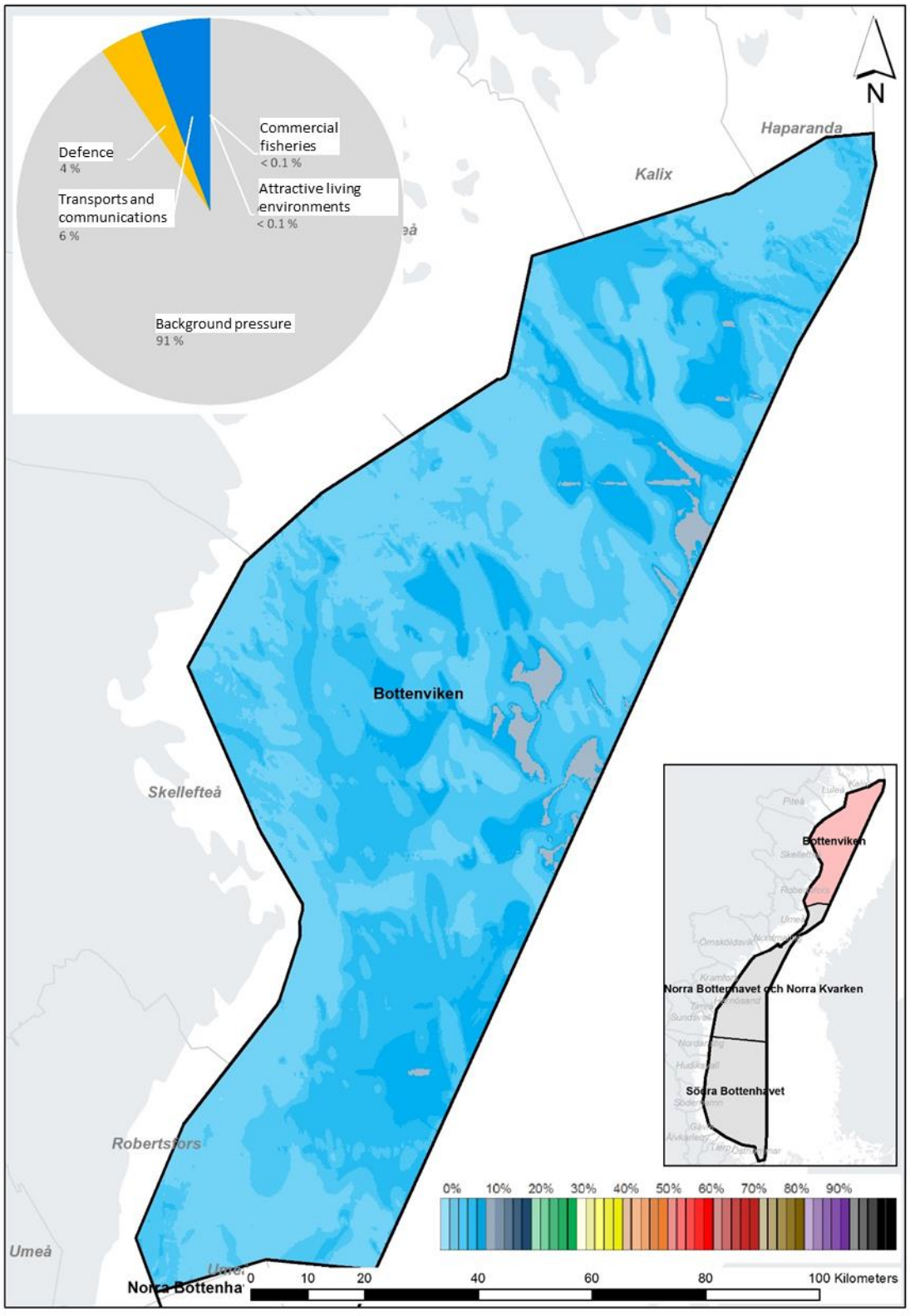


Figure 22 The total cumulative environmental effect in Bothnian Bay. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect for the zero alternative. The colours in the pie chart indicate sectors.

In a comparison between the zero alternative and the current situation, the zero alternative provides a generally higher environmental pressure in the Bothnian Bay marine subregion, approx. 2% compared with the average for the environmental effect in the present situation. The additional environmental impact in the zero alternative can be seen in Figure 20 that shows the change between the zero alternative and the present situation. The change in the cumulative environmental effect is evenly distributed in the Bothnian Bay marine sub-region and is a result of the sectors' general development up to 2030. Development of the Transportation and communications and Defence sectors is reflected in an increase by around 1% of the sectors' percentage of the total cumulative effect compared with the present situation.

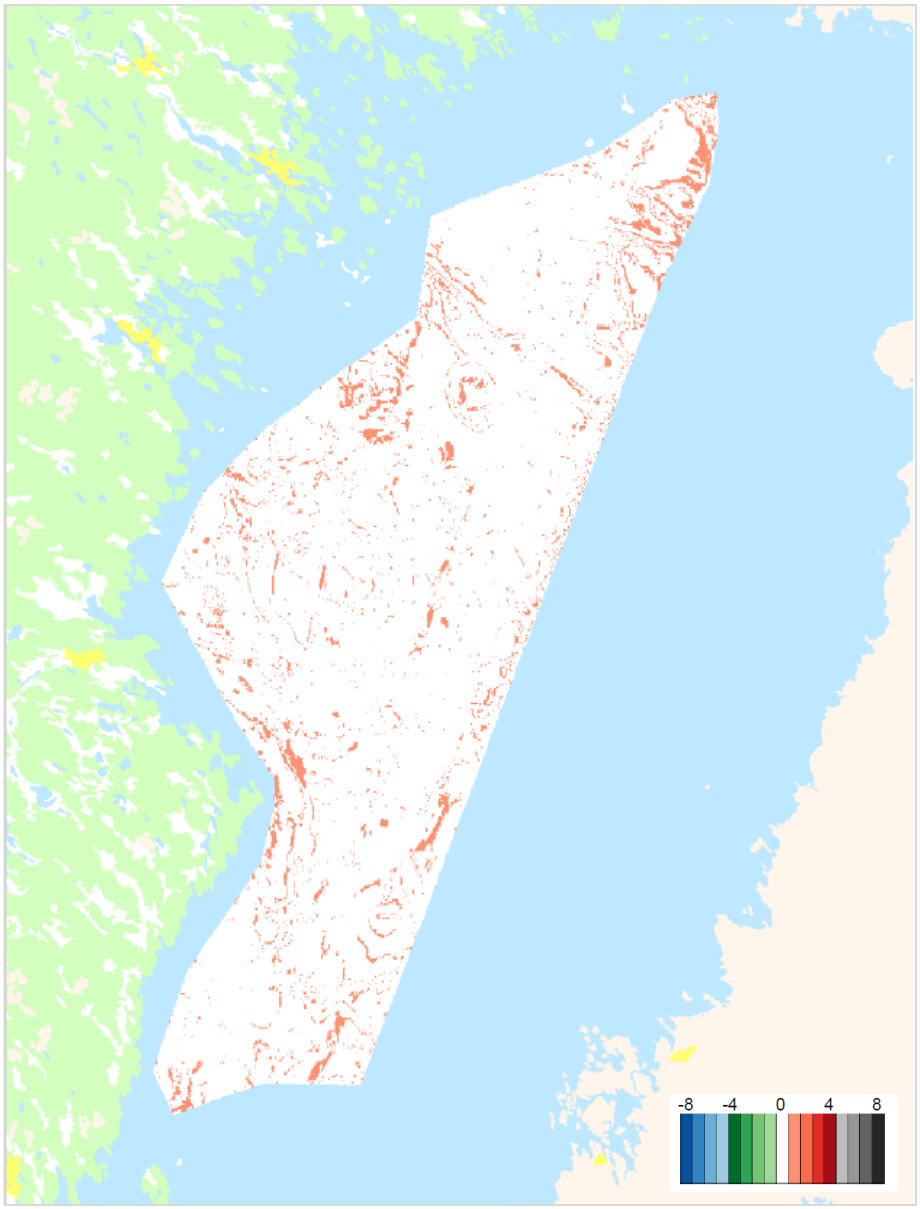


Figure 20 Change in cumulative environmental effect in per cent in the Bothnian Bay in the zero alternative compared with the present situation. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the present situation.

7.3.3 Northern Bothnian Sea and Norra Kvarken

In the Northern Bothnian Sea and Norra Kvarken, the background pressure contributes around 94% to the cumulative effect, see Figure 21, which consists of pollutants in sediment (heavy metals approx. 28% and synthetics approx. 20%) and phosphorous (approx. 27%) and a small share of oxygen-free seabeds (approx. 12%) and nitrogen in sediment (approx. 7%)

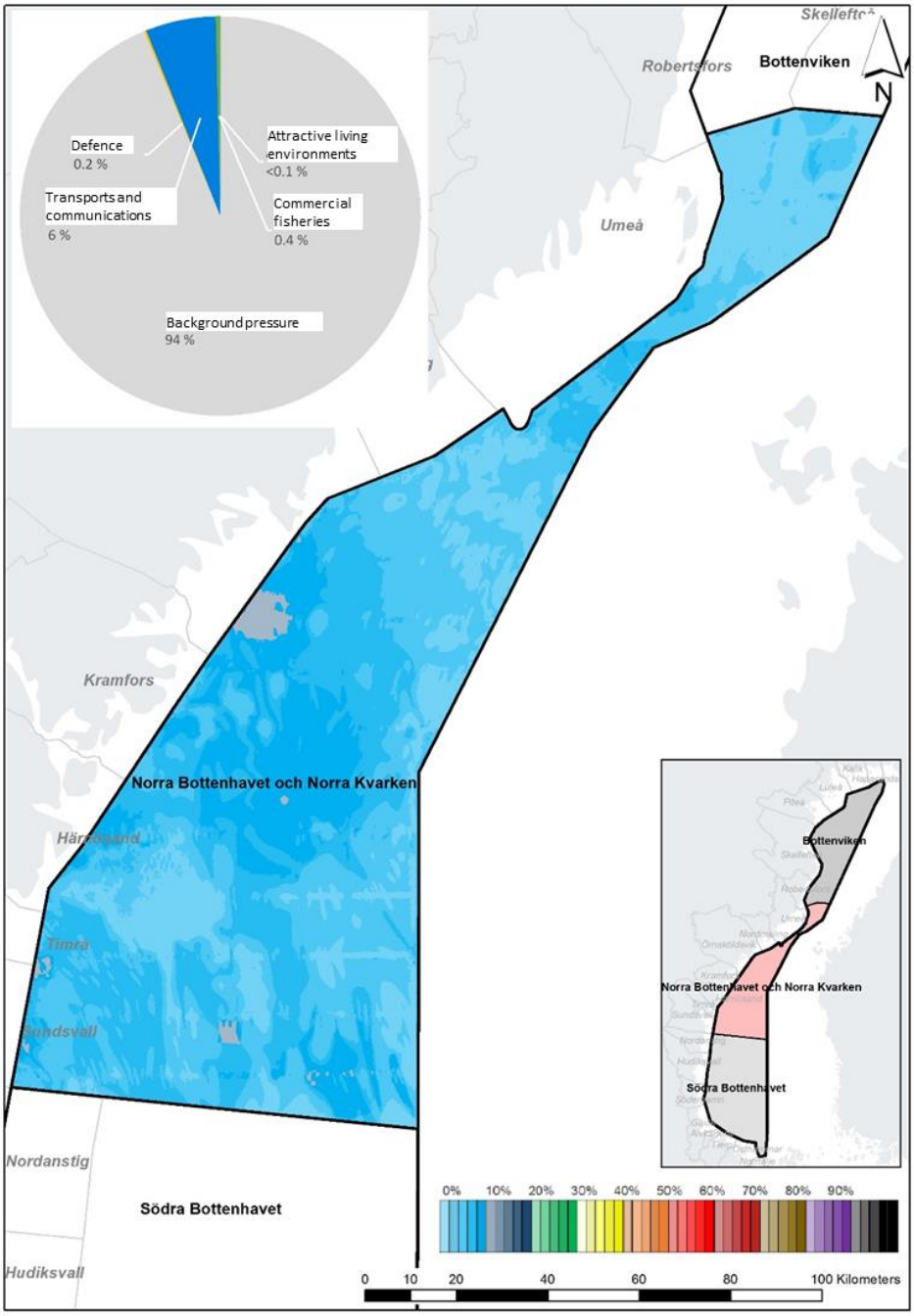


Figure 21 The total cumulative environmental effect in the Northern Bothnian Sea and Norra Kvarken. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contribution to the cumulative effect for the zero alternative. The colours in the pie chart indicate sectors.

The Transportation and communications sector contributes around 6% to the total cumulative effect, which includes *underwater noise* and *introduction of pollutants* (oil spills from shipping). The development of the Transportation and communications sector up to 2030 means that the share of the sector's impact in the total cumulative effect will increase by 2% compared with the present situation. The sectors Defence (*spread of heavy metals*) and Commercial fisheries (*selective withdrawals of species*) contribute less than 1% each without a noticeable change compared with the present situation. Attractive living environments have a marginal contribution to the cumulative effect. The cumulative effect is apparent mainly on deep soft seabeds and plankton, but also on herring, deep and aphotic transport seabeds, aphotic soft seabeds, sprat, and deep and aphotic hard seabeds.

The environmental pressure and environmental effect in the Northern Bothnian Sea and Norra Kvarken marine sub-region are increasing compared with the present situation, by approximately 1%. The largest difference compared with the present situation in Norra Kvarken is considered to be a result of the increased pressure from shipping, see Figure 22.

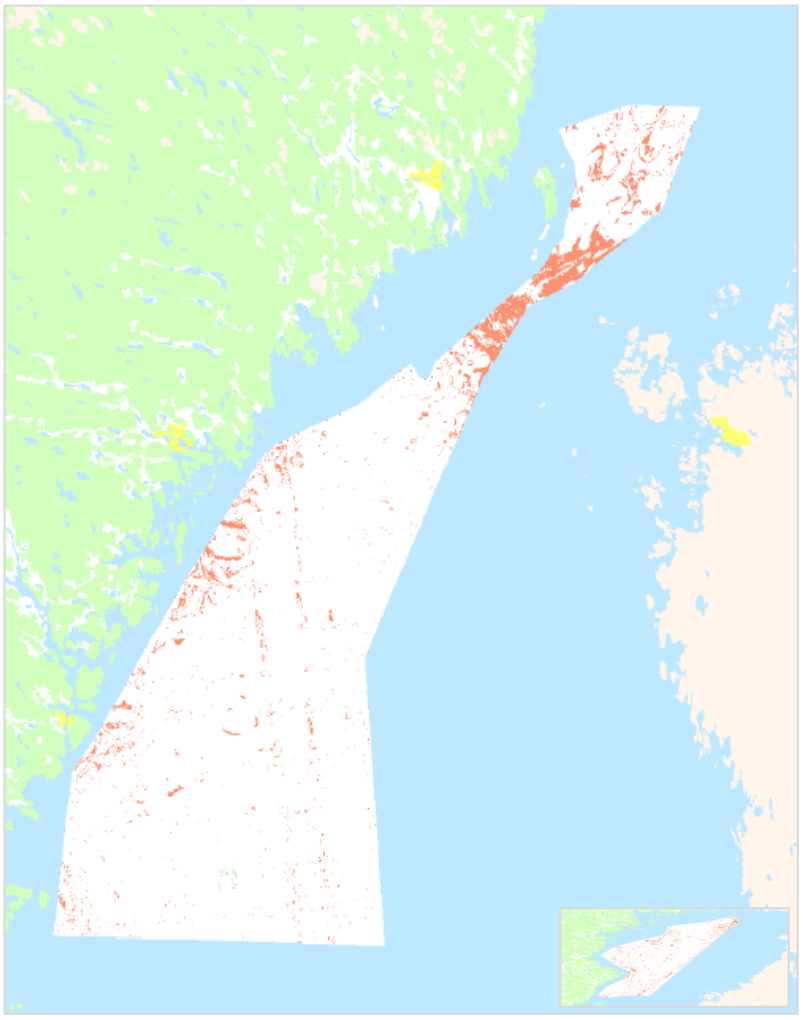


Figure 22 Change in the cumulative environmental effect in per cent in the Northern Bothnian Sea and Norra Kvarken in the zero alternative compared

with the present situation. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the present situation.

7.3.4 Southern Bothnian Sea

The background pressure contributes to the total cumulative environmental effect in the Southern Bothnian Sea by around 88%, which consists of phosphorous (approx. 32%) and pollutants in sediment (heavy metals approx. 26%, synthetics approx. 19%), but also nitrogen (approx. 9%) and to a small extent oxygen-free seabeds (approx. 1%).

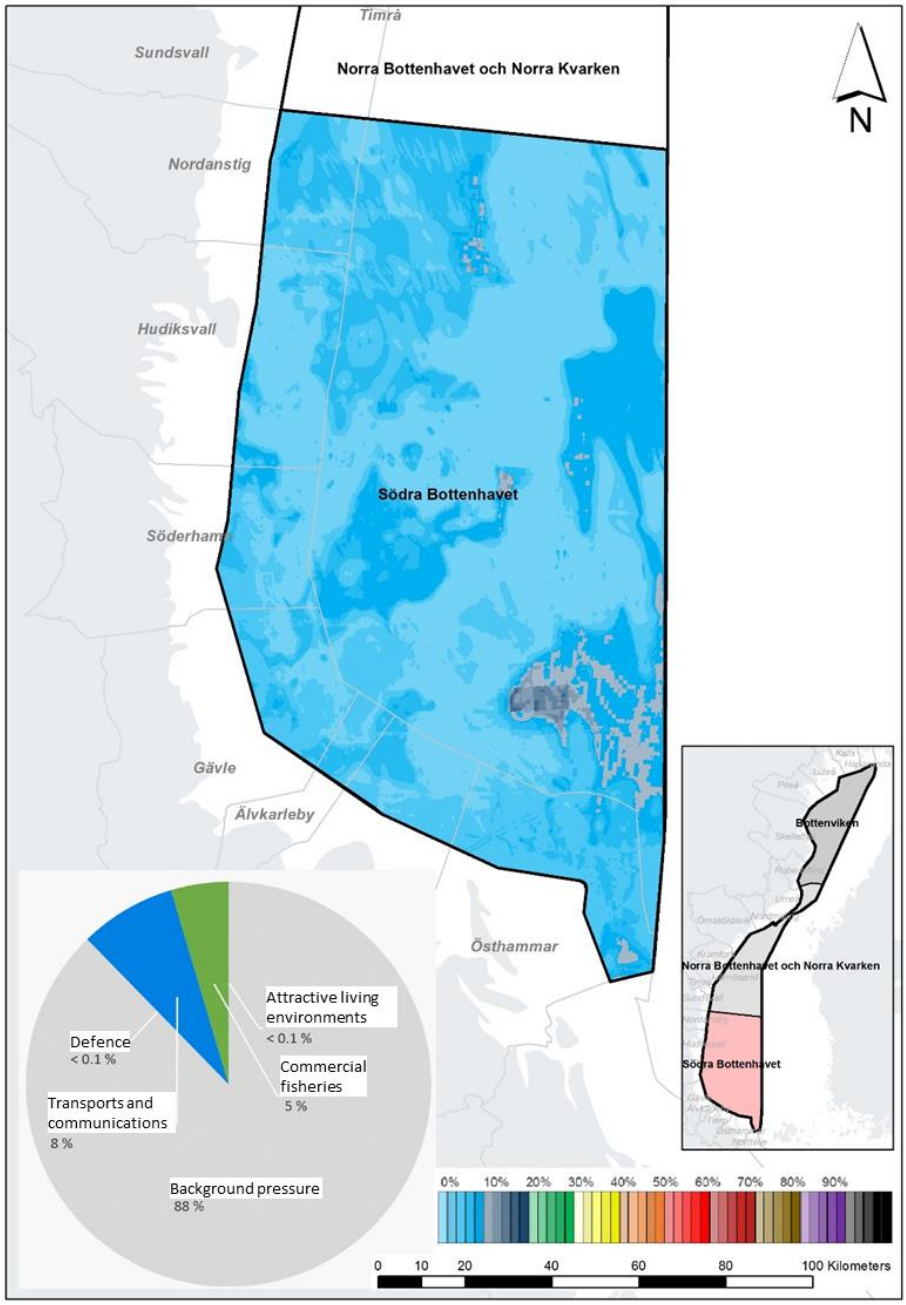


Figure 23 The total cumulative environmental effect in the Southern Bothnian Sea. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect for the zero alternative. The colours in the pie chart indicate sectors.

The sectors that contribute to the cumulative effect in the Southern Bothnian Sea are Transportation and communications with around 8%, which comes from *underwater noise* and *introduction of pollutants* (oil spills from shipping) and Commercial fisheries with around 5% from *selective withdrawals of species* (mainly pelagic trawling). Compared with the present situation, Transportation and communications will increase, and with it its contribution to the total cumulative effect will increase by around 2%. Attractive living environments and Defence contribute marginally.

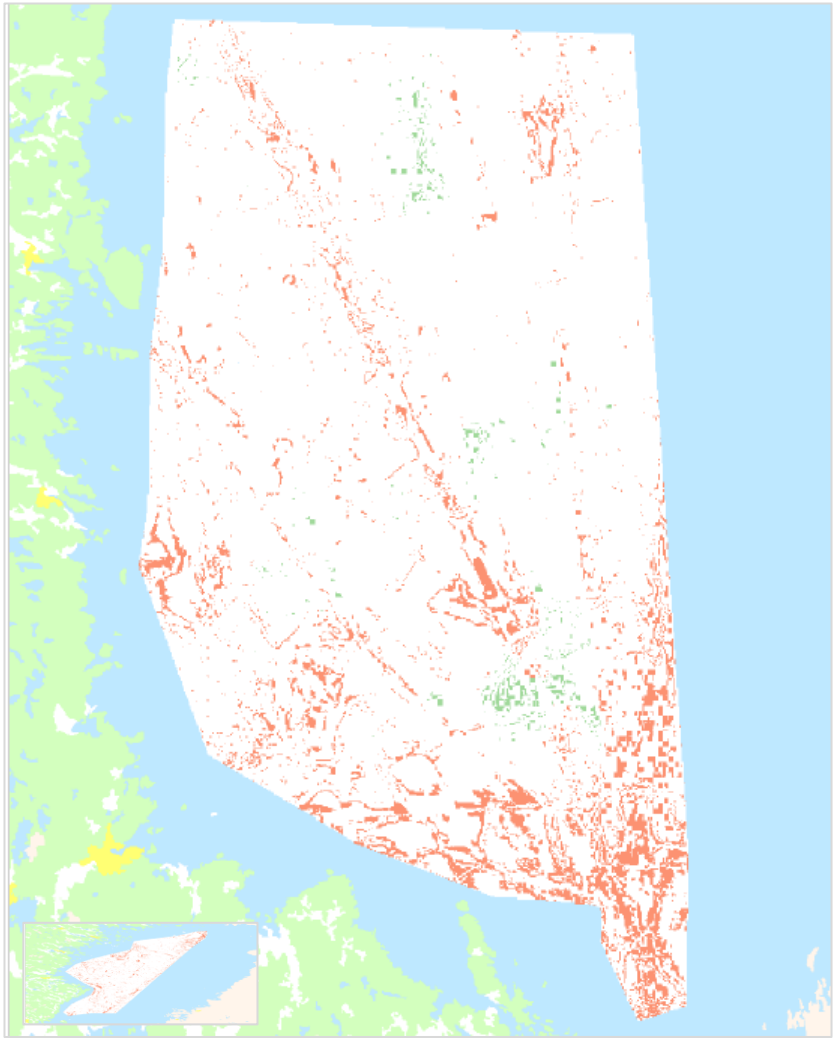


Figure 24 Change in the cumulative environmental effect in per cent in the Southern Bothnian Sea in the zero alternative compared with the present situation. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the present situation. Negative values, in blue and green, result in a smaller cumulative environmental effect compared with the present situation.

In a comparison between the zero alternative and the present situation, the zero alternative provides a greater environmental pressure and environmental effect (1%) in the Southern Bothnian Sea marine sub-region, see Figure 24. The increased environmental effect is mainly concentrated in the southern part of the Southern Bothnian Sea. The cumulative effect is mainly noticed on plankton, deep soft seabeds, and herring, but also on aphotic soft and transport seabeds, deep hard seabeds, sprat, spawning fish, grey seals, and deep

transport seabeds, and it is mainly through background pressures. The Commercial fisheries sector contributes the most with an effect on herring through *selective withdrawals of species*, and Transportation and communications has an effect mostly with *underwater noise* on grey seals.

8 Plan alternative

8.1 Sectors and themes

This chapter describes the plan alternative based on the plan's sectors and themes. Differences from the zero alternative are emphasised in particular. In the subsequent assessments of the cumulative environmental effect, the Symphony planning method and its included values were used as a base.

8.1.1 Attractive living environments

Attractive living environments are based on the national interest areas in the sea for active outdoor recreation, unbroken coastline, and a highly developed coast, as well as national interest claims for cultural environments and recreation where angling is included along with UNESCO's World Heritage sites.

The sector of Attractive living environments is identified in the southern part of the Southern Bothnian Sea marine sub-region, off of Gräsö towards Södra Kvarken – an area of national interest of highly developed coast – and in the Northern Bothnian Sea off of the municipalities of Kramfors and Örnsköldsvik. In the marine spatial planning area, there are no appointed national interest claims for cultural environments. However, there are cultural environments outside of the marine spatial planning area that could indirectly be affected by the formulation of the plan.

8.1.2 Energy

In the marine spatial planning area, there is a current project, Storgrundet, located in the Southern Bothnian Sea, with a permit for 70 stations and an installed capacity of 350 MW. There are several areas (mainly in the southern Bothnian Bay and the Southern Bothnian Sea), which in the MSP are intended for the Energy theme. This means a strong increase in energy extraction within the marine spatial planning area. Cables from wind farms to land are also additional in the marine spatial planning area. Within these areas, the themes Transportation and communications, Commercial fisheries, and Attractive living environments (tourism and recreation) are assumed to decrease, while the themes Defence and Nature can coexist with Energy. In Robertsfors Municipality in the south at Rata Storgrund, there are two areas with the use Energy. Wind power is deemed to be a public interest of material significance in these areas. From national energy perspectives, Gävlebukten is a strategic area for sea-based wind power (SwAM, 2017).

The planning alternative's estimations of the cumulative effect are included in existing establishments and permitted wind power establishments, and a number of areas are considered to be suitable for new establishment for energy extraction.

Investigation areas

Several wind power projects are active in the marine area, of which Storgrundet off of Söderhamn has received a permit. Around the project at Storgrundet, there is space for more wind power, but the possibility of wind power should be investigated further, mainly based on national defence, nature values, and shipping.

Finngrunden's western, northern, and eastern banks all have good conditions for wind power, which is confirmed by national interest claims for wind power. Natura 2000 areas have also been introduced on the banks to protect valuable types of nature. The uncertainty regarding the impact of wind power on long-tailed ducks has been a crucial factor in wind power on Finngrundet's eastern bank not being assessed to be compatible with the Natura 2000 legislation in the area. Finngrunden's eastern and northern banks are the most important wintering places for long-tailed duck in the marine area. In contrast to the other banks, Finngrunden's eastern bank has also been pointed out as particularly important to exclude from all forms of development through the Swedish Environmental Protection Agency's offshore bank inventory. Finngrunden's eastern and northern banks therefore have the use of Nature (N) while other shallow areas at Finngrunden have the use *energy extraction* with *particular consideration to high nature values (n)*.

Large-scale wind power establishment creates a small change in the bottom environments in terms of area. The establishment might entail displacement effects for some wintering marine bird species. It is important that the formulation of potential installations be designed with *particular consideration to the nature values (n)*, which also applies to wind power at Storgrundet and Gretas klackar, both of which are off of Söderhamn.

In the expansion of energy extraction, *particular consideration must be taken to the interests of national defence (f)*. The many areas for energy extraction that the MSP indicates within the marine area entail a risk for cumulative impact on the national defence interests.

8.1.3 Defence

The flight exercise area at Kallax is one of the world's largest. A small part of a prohibited area for tall objects enters the marine spatial planning area due to its proximity to a military airport. Tåmesvarten is the artillery range for Norrbotten's tank battalion and is one of Sweden's largest artillery ranges. An influence area extends from the artillery range out into the marine spatial planning area.

The Härnön marine training area, including surrounding impact areas from Skärsviken's artillery range and the offshore bank Vänta Litets Grund, is one of the most valuable offshore banks in the Gulf of Bothnia. Despite the high environmental values along the coast, coexistence between Nature and Defence is deemed possible.

Coexistence is also deemed to be able to apply for the Energy and Defence sector through *particular consideration to national defence interests (f)* being shown. In the plan, several areas in the Bothnian Sea have been given the designation "f", which means that *particular consideration to national defence interests* should be taken in the energy expansion in these areas. This might entail limitations in the scope of the energy expansion.

8.1.4 Storage and extraction of materials

Today, no carbon dioxide storage takes place in Sweden, and the potential for future storage is being investigated (SGU, 2016). Within the Gulf of Bothnia marine spatial planning area, no sand extraction is currently conducted, but in the MSP proposal, one area north of Svalans and Falkens grund has been appointed a possible area for the extraction of sand. The area is seen as suitable from sustainability perspectives based on geological and ecological criteria. Within and adjacent to this area, from Svalans and Falkens grund and in towards land, there is valuable nature. The MSP's guiding proposal is therefore that *particular consideration to high nature values (n)* shall be taken in any possible sand extraction.

As an alternative to the proposed MSP, this SEA will evaluate an MSP without the proposed area for sand extraction in the Bothnian Bay.

8.1.5 Nature

The national interest for nature and outdoor recreation extends far out into the MSP and are safeguarded, like the marine spatial planning area's nature reserves and Natura 2000 areas, through the use Nature. Vänta Litets grund in the south is one of the Natura 2000 areas that have been classified as the most valuable offshore banks in the Gulf of Bothnia. The bank is within the Härnön marine training area and the area with a surroundings impact from the Skärsviken artillery range. Despite the high values along the coast, coexistence between Nature and Defence is deemed possible through consideration in the planning of national defence activities. In the MSP, nature values are safeguarded by the use of Nature or through *particular consideration to high nature values (n)* in the following areas: the nature area at Marakallen, Finngrunden's three banks, and the other offshore banks.

The following areas have been classified with *special consideration to high natural values (n)*; the designation Bxxx is the designation for the area in the MSP:

- B100 – Special untouched area. Fish recruitment and mammal areas with little impact, partly pointed out as a HELCOM marine protection area.
- B104 – Fish recruitment and mammal areas with little impact. Special untouched area, spawning area for fish and occurrence of ringed seals.
- B121 – Fish recruitment and bird area with valuable bottom environment. A high value for birds in the southern parts of the area, generally rich fish fauna and valuable bottom environment.
- B124 – Reef environment with spawning, mammal, and bird area.
- B141 – Fish recruitment area. Fishing.
- B142 – Fish recruitment and mammal area with valuable bottom environment. Important area for seals, fish, and bottom environments.
- B145 – Fish recruitment area with valuable bottom environment; high biological diversity. Important area for fish and bottom environments.
- B146 – Fish recruitment area with valuable bottom environment; high biological diversity. Important area for fish and bottom environments.
- B147 – Fish recruitment and bird area with valuable bottom environment.
- B150 – Fish recruitment and bird area; reef environment and spawning and bird area with high biodiversity.

8.1.6 Transportation and communications

The MSP entails a marginal change for Transportation and communications compared with the zero alternative, i.e. an increase in shipping by around 35%. The areas in the planning map where shipping is indicated as a use are either areas covered by national interest claims for communication and shipping or areas that are considered to be of significant public interest for communication.

Because the ice is weather-dependent and unpredictable, shipping needs large areas and alternative routes. The shipping sector is therefore widespread in the entire marine spatial planning area with several shipping lanes. Shipping traffic in the marine spatial planning area is crucial to many industries, with important ports both along the marine spatial planning area's coast, in the rest of Sweden, and in Finland.

Investigation areas

In the south, part of the Gävle shipping currently goes over Campsgrund. An investigation of shipping routes through the area indicates that shipping's fuel consumption and emissions would decrease markedly if the ships instead took a course north of this shallow area (SwAM, 2017b). This does not give rise to any change in shipping in relation to shipping's national interest claims through the area, but there might be reason to change this route in the long term.

8.1.7 Aquaculture and blue biotechnology

In the MSP, no areas have been pointed out for use by the theme Aquaculture and blue biotechnology, and the plans are not expected to affect the conditions for the development of the theme otherwise. Consequently, no assessment is made in this investigation regarding aquaculture and blue biotechnology.

8.1.8 Commercial fisheries

Commercial fisheries is sparse in the Gulf of Bothnia's offshore waters, but there is a long tradition of using and managing fish. Spring fishing for vendace roe is important, as is the herring fishing. The fishing that is conducted is with passive equipment and close to the coast. This fishing mainly takes place outside the marine spatial planning area. The sector is affected by the plan, mainly through *particular consideration to high nature values (n)*, and Energy is included, within which areas of *selective withdrawals of species* are to be reduced.

8.2 Outlook towards 2050

At present, there is no set development of the plan until 2050. The MSP will be revised at least once every eight years to be adapted to new knowledge, new needs, and sector development.

8.3 Cumulative effects - plan alternative

The cumulative effect for every marine area in the Gulf of Bothnia for the MSP alternative has been mainly identified using Symphony. For the MSP and its marine areas, the cumulative effect and the sectors that have the main impact on the environment are described and illustrated. Background pressures that cannot be specifically tied to a sector have been identified and included in the cumulative effect. The type of impact that the sectors contribute is linked to the pressures of the Marine Strategy Framework Directive.

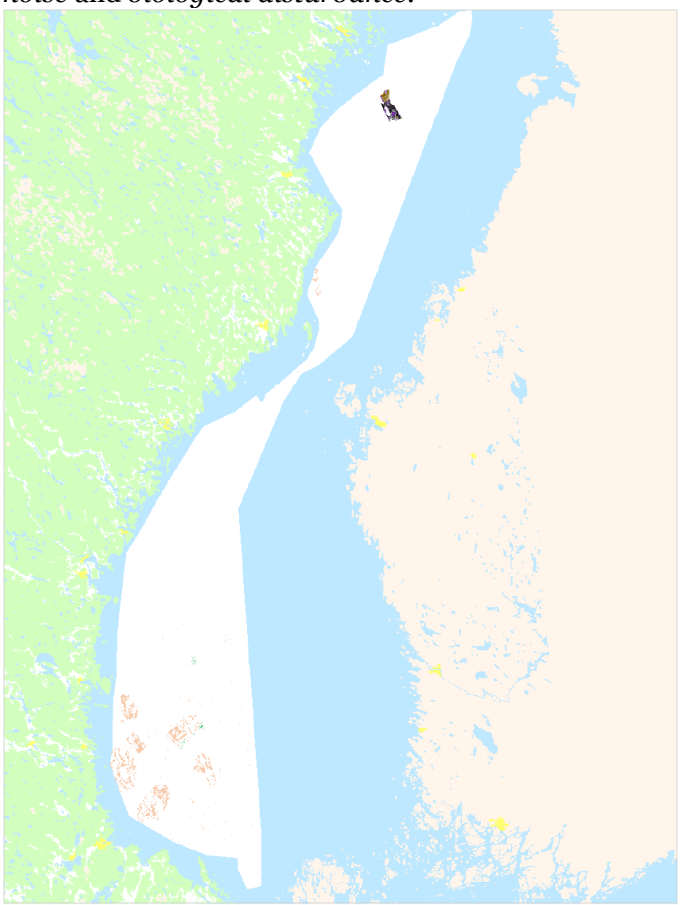
8.3.1 Gulf of Bothnia

The MSP entails little change in the total cumulative environmental effect (2% of the zero alternative) within the marine spatial planning area of the Gulf of Bothnia, see Figure 25. A more detailed analysis of the respective marine area is provided in subsequent sections. In general, guidance on new uses, such as energy extraction and sand extraction, entails an increased pressure and an increased cumulative effect within the marine spatial planning area. That these new uses have a relatively large impact on the analysis depends partly on the environmental impact generally being low within the marine spatial planning area. The areas with *particular consideration to high nature values (n)* provide a small effect outside the energy areas due to the dominant pressures in the Gulf of Bothnia not being affected by the MSP (SwAM, 2018a).

The background pressure contributes by around 89% to the total cumulative effect in the Gulf of Bothnia in the plan alternative and consists mainly of

pollutants in sediment (heavy metals approx. 30%, synthetics approx. 18%) and phosphorous (approx. 29%) and a small share of nitrogen (approx. 7%) and oxygen-free seabeds (approx. 5%). Transportation and communications comprise a sector that contributes the most to the total cumulative effect, and a small share comes from Commercial fisheries, Storage and extraction of materials, Defence, and Energy. In the marine spatial planning for the Gulf of Bothnia, the sectors of Energy and Storage and extraction of materials have been added, but they contribute relatively little to the total cumulative effect for the Gulf of Bothnia and rather have a local effect, see **Fel! Hittar inte referenskälla.**.

Transportation and communications, which account for around 6%, consist of effects from underwater noise (approx. 2%) and introduction of pollutants (oil spills from shipping, more than 4%). Commercial fisheries contributes around 2% and consists mainly of effects from *selective withdrawals of species* (pelagic trawling) and to a small extent from *physical disturbance* to the bottom (abrasion and increased turbidity). Storage and extraction of materials contributes by more than 1% with *physical disturbance* (sediment spread in sand extraction) and *physical loss* (habitat loss in sand extraction). Defence, which contributes around 1%, consists mainly of *introduction of pollutants* (spread of heavy metals). Energy contributes less than 1% with *underwater noise* and *biological disturbance*.



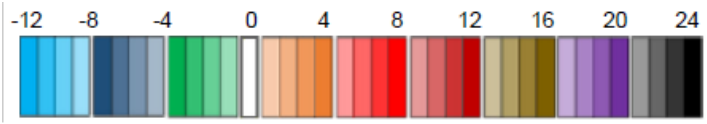


Figure 25 Change in the cumulative environmental effect in per cent in the Gulf of Bothnia marine spatial planning area compared with the zero alternative. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the zero alternative. Negative values, in blue and green, result in a smaller cumulative environmental effect compared with the present situation.

The cumulative effect is mainly seen on deep soft seabeds, plankton, and herring, as well as aphotic soft and transport seabeds, deep hard and transport seabeds, spawning fish, ringed seals, sprat, and grey seals. These are effects from background pressures, such as pollutants in sediments and phosphorous, but underwater noise is significant for fish and seals.

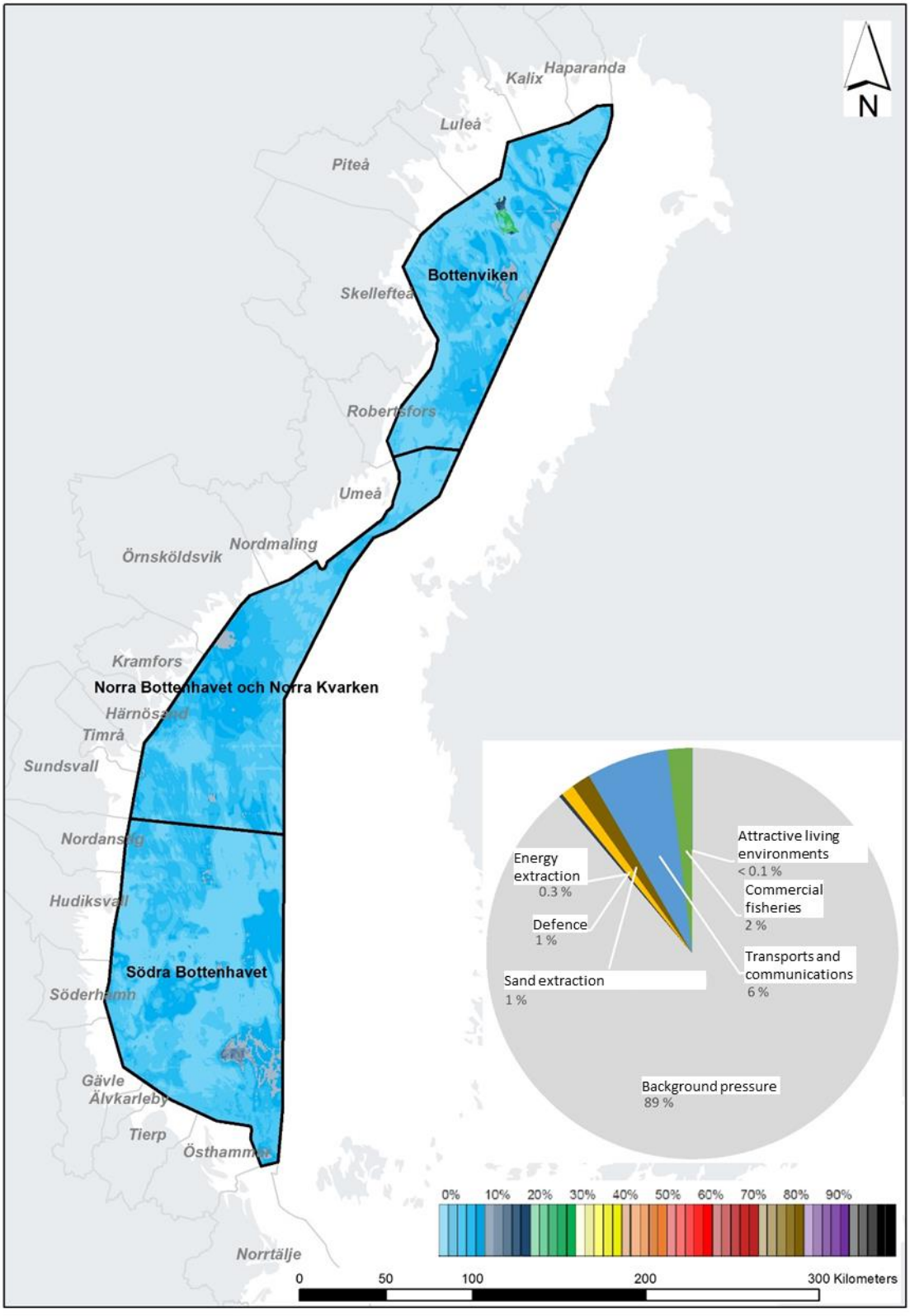


Figure 29. The total cumulative environmental effect in the Gulf of Bothnia marine spatial planning area. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect. The colours in the pie chart indicate sectors.

The sectors Transportation and communications, Defence, and Commercial fisheries are marginally affected by the changes that the MSP entails because the sectors' impact areas in most cases are only moved within the marine area. This means that the impact from these sectors does not change appreciably with application of the MSP compared with the development described in the zero alternative. However, on a smaller geographic scale, relocation of shipping lanes entails a decrease in the environmental effect locally, and this way high cultural and nature values are protected. The planning proposal entails a relocation of shipping lanes that currently pass over Finngrunden where there is some concentration of wrecks, see Figure 26. By moving shipping traffic from the shallow area, potential wear through erosion is reduced on sunken wrecks in the area. The sectors Energy and Storage and extraction of material are included as uses in the Gulf of Bothnia's MSP, and these sectors' impacts in terms of *physical disturbance* and *biological disturbance* will also contribute more to the total cumulative environmental effect. At the same time, the wind farms can have a positive effect by creating areas similar to marine reserves with artificial reef environments. These new uses might also affect Attractive living environments (recreation, cultural environments, and landscape appearance).

The environmental objective of "A Balanced Marine Environment,Flourishing Coastal Areas and Archipelagos," specifies that the natural and cultural values of the marine, coastal, and archipelago landscapes shall be preserved and that conditions shall exist for continued preservation and development of the values. A further specification is that the status remains unchanged for cultural heritage remains under the water. Due to the prevailing lack of knowledge regarding cultural heritage environments under the water, the assessed cultural heritage value for the sea areas is only an estimate of the likelihood that there are cultural heritage values in the marine areas. All marine areas have few remains under water (data on underwater remains from the Swedish National Heritage Board's database for archaeological sites and monuments (FMIS)), see Figure 26. A collection of wrecks exists in the Southern Bothnian Sea and for some areas, which are planned for Energy, there might be a conflict. In detailed development plans of the wind power farms in these areas, a study of marine archaeology needs to be carried out to minimise the impact on the cultural environment.

Construction of wind farms might also affect the landscape appearance. The landscape appearance's value at the sea consists, among other things, of a horizon free from anthropogenic pressure. This value exists for an observer both on land and at sea. Here, anthropogenic pressure refers to the construction of wind turbines. Today, there are no wind power establishments and the impact on the landscape appearance is therefore not currently relevant, but in the plan alternative the landscape appearance is deemed to be affected by the plan pointing out areas for Energy. Altogether, mainly the Energy areas are deemed to have a moderate environmental effect on the cultural environment and the landscape appearance.

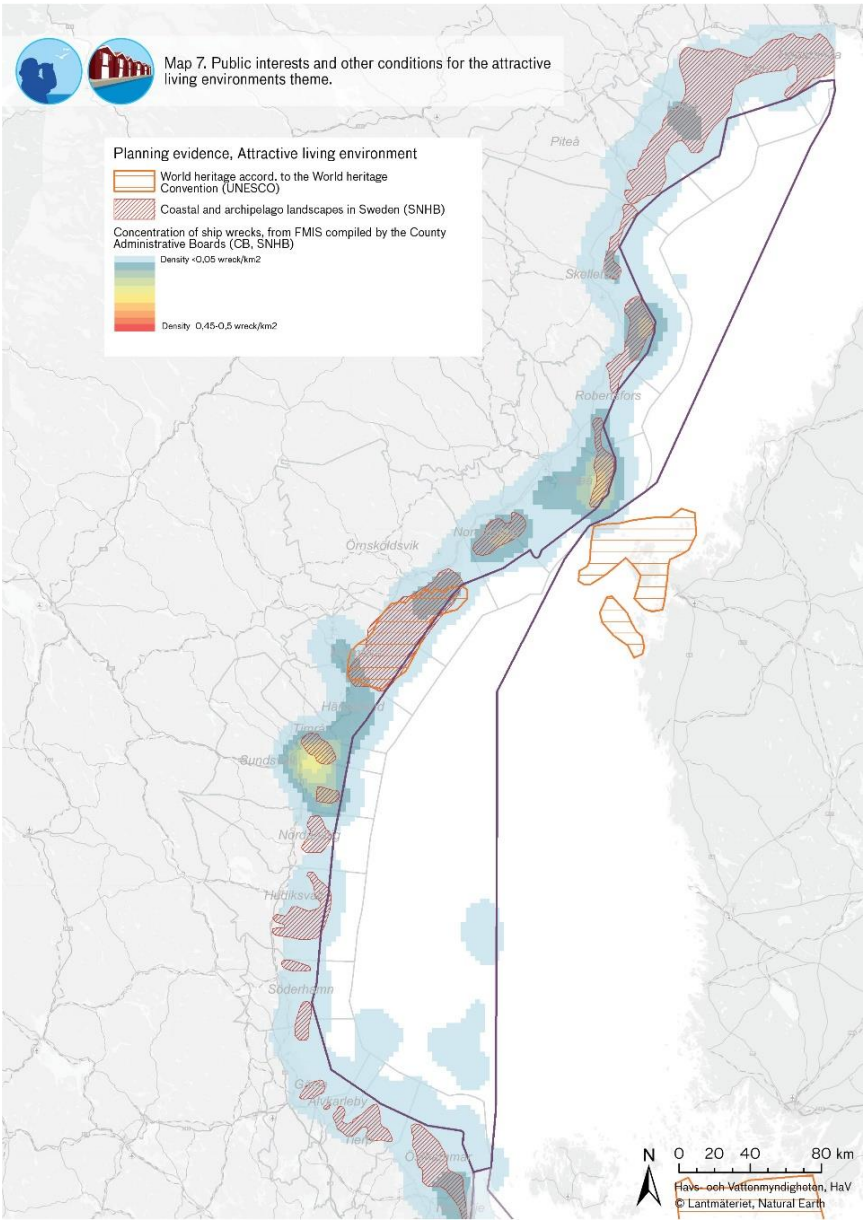


Figure 26 Public interests and other prerequisites for the theme Attractive living environments in the marine spatial planning area (SwAM, 2018b).

For every marine area in the Gulf of Bothnia marine spatial planning area, the environmental effect for the pressures of air emissions, invasive species and marine litter was assessed. The MSP in 2030 entails only a small increase in the pressures of air quality and greenhouse gases in the Southern Bothnian Sea. It is changes in the theme Transportation and communications (shipping) in the Southern Bothnian Sea that contribute these pressures. This entails further small environmental effects that are added with the MSP 2030 guidance compared with the effects that the zero alternative 2030 entail (text in light grey).

Table 13 Assessed environmental effect in the respective marine area for the pressures air emissions, invasive species, and marine litter with the MSP in 2030 compared with the zero alternative for 2030. The scale is according to Table 3, and "-" indicates that the plan entails no change in pressure.

ASSESSED ENVIRONMENTAL EFFECT	AIR QUALITY (NO_X OR PARTICLES)	GREENHOUSE GASES (CO_2 OR OTHER GREENHOUSE GASES)	INVASIVE SPECIES (EXTENSIVE UNCERTAINTY - LACK OF KNOWLEDGE)	MARINE LITTER (LITTER FROM FISHING, SHIPPING, AND TOURISM)
BOTHNIAN BAY	Plan alternative: - *Zero alternative: Small-moderate effects*	Plan alternative: - *Zero alternative: Moderate effects*	Plan alternative: - *Zero alternative: Small effects*	Plan alternative: - *Zero alternative: Moderate effects*
NORTHERN BOTHNIAN SEA AND NORRA KVARKEN	Plan alternative: - *Zero alternative: Small-moderate effects*	Plan alternative: - *Zero alternative: Moderate effects*	Plan alternative: - *Zero alternative: Small-moderate effects*	Plan alternative: - *Zero alternative: Moderate effects*
SOUTHERN BOTHNIAN SEA	Plan alternative: Small effects *Zero alternative: Small-moderate effects*	Plan alternative: Small effects *Zero alternative: Moderate effects*	Plan alternative: - *Zero alternative: Small-moderate effects*	Plan alternative: - *Zero alternative: Small-moderate effects*

8.3.2 Bothnian Bay

The changes that the MSP entails in the Bothnian Bay compared with the zero alternative increase the total environmental effect in the marine area by 6%. These changes are mainly seen within an area in northern Bothnian Bay, but also a number of smaller areas in the south-western Bothnian Bay, see Figure 27. In the MSP, the area in the northern Bothnian Bay is designated with "Gn", which means *general use* (*G*) with *particular consideration to high nature values (n)*. It is an especially untouched spawning area for fish and an area with an occurrence of ringed seals. Establishment of sand extraction (Storage and extraction of material) that is included in the MSP in this area at Svalans and Falkens grund means that high nature values can be affected by activities, such as increased turbidity and loss of valuable habitat (*physical loss* and *physical disturbance*). However, this disturbance is local and below the photic zone. The difference in the calculations of the cumulative effect between the zero and the plan alternatives is comprised of pressures from extraction at Svalans and Falkens grund, which is only indicated in the plan alternative. The MSP entails a negative change (Figure 27) because guidance is provided on a new activity that did not previously affect the area and the area is currently somewhat unaffected (SwAM, 2018a).

In the south-western Bothnian Bay, there are areas where the plan entails a change in environmental effects. These are marked with "Ef", which means Energy with *particular consideration to national defence*. With the establishment of wind power, *underwater noise* and *biological disturbances*

increase, but also habitat loss and change (*physical loss and physical disturbance*). At the same time that the areas with natural habitat claimed for use, the wind turbine foundations might create artificial reefs that can benefit biodiversity and contribute positively to reduced climate changes. Wind power establishment also entails change to the landscape appearance (Attractive living environments/Cultural environment). Commercial fisheries and recreation (Attractive living environments), such as bird hunting and recreational boating, are limited as a result of wind power establishment, which can have a positive effect on the local area because the wind farm areas might constitute protected areas similar to marine reserves. In summary, the MSP entails a small negative change locally in this area because a new use is introduced.

Figure 27 Areas in the Bothnian Bay where the MSP entails a change of use of the marine area compared with the zero alternative and thereby a changed cumulative effect in per cent. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the zero alternative.

The total cumulative environmental effect in the Bothnian Bay comes from the sectors of Transportation and communications, Defence, Energy, and Storage and extraction of materials, see **Fel! Hittar inte referenskälla.**. Transportation and communications account for around 6% and consist of *underwater noise* and *introduction of pollutants* (oil spills from shipping). Defence contributes around 3% and consists mainly of *introduction of pollutants* (spread of heavy metals). Storage and extraction of materials consists of *physical disturbance* (spread of sediment in sand extraction) and *physical loss* through habitat loss in sand extraction and contributes around 5%. In the MSP for the Gulf of Bothnia, the sector Storage and extraction of material has been added, which means that the distribution of the sectors' contribution to the cumulative effect changes. The themes Attractive living environments, Energy, and Commercial fisheries contribute a small share to the cumulative environmental effect (<0.1%). The background pressure contributes by around 86% and consists mainly of pollutants in sediment (heavy metals approx. 39%, synthetics approx. 13%) and phosphorous (approx. 27%), and a small share of nitrogen (approx. 4%) and oxygen-free seabeds (approx. 3%).

The effects are noticed mainly on soft seabeds and plankton, and to a small part on ringed seals, aphotic deep and transport seabeds, deep transport bottoms, spawning fish, and deep and aphotic hard seabeds. Underwater noise has the largest effect on ringed seals, and oil spills have the largest effect on plankton.

The plan proposal does not include sand extraction in the part of Svalan and Falkens grund that is within the defence area. However, it has been included in the SEA to provide a collective picture of potential environmental effects of sand extraction in the area proposed by SGU. From a risk perspective, sand extraction is not suitable in the artillery range's influence area (B105). Sand extraction is, however, deemed to be suitable from an environmental assessment perspective in the adjacent area (B104) on the condition that sand extraction is done below the photic zone and with *particular consideration to high nature values (n)*.

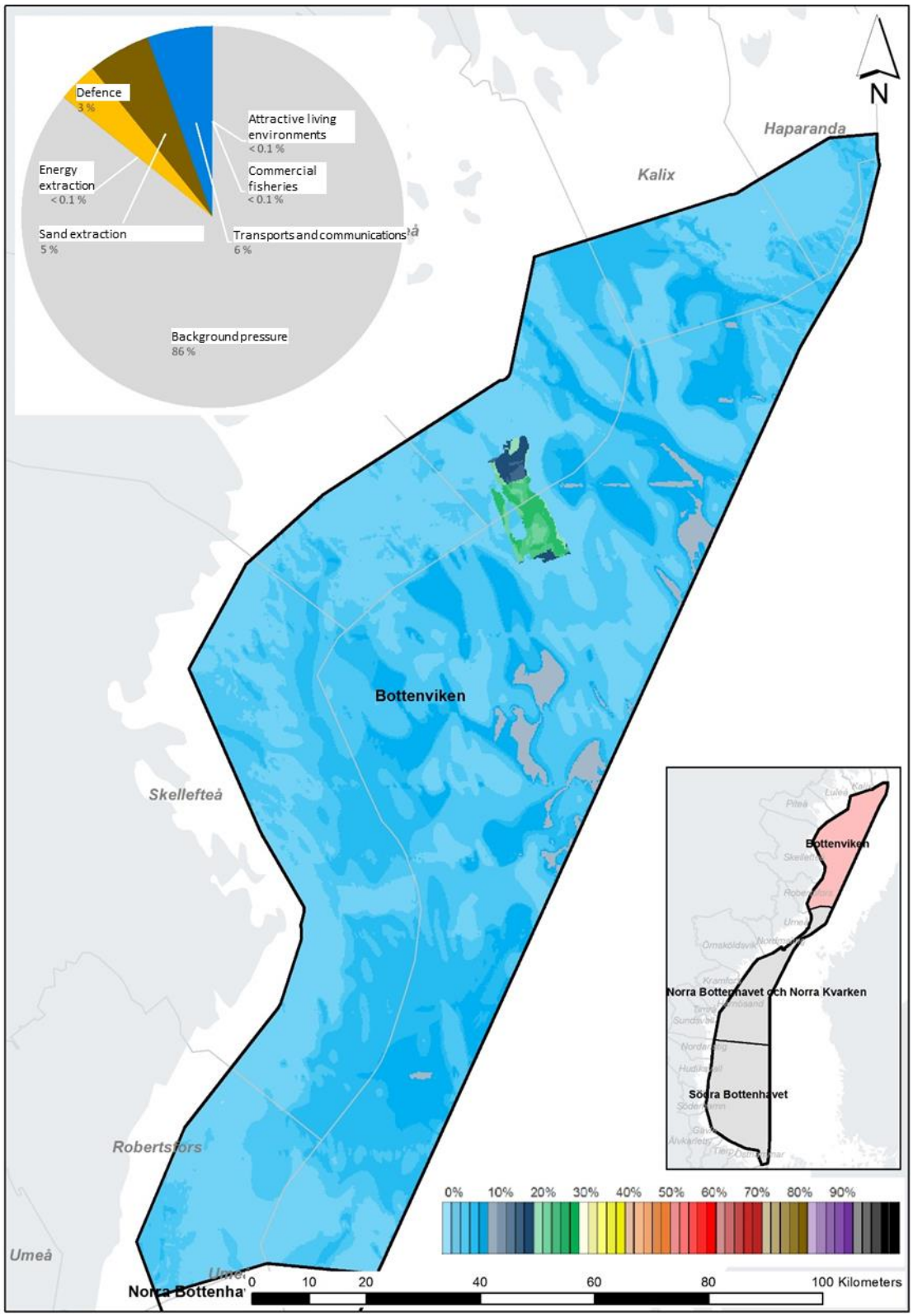


Figure 32 The total cumulative environmental effect in Bothnian Bay. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect. The colours in the pie chart indicate sectors.

Alternative for Storage and extraction of materials

In the zero alternative, an assumption is made that no sand extraction takes place until 2030, in addition to the existing operations in Southern Baltic Sea. Thereafter and during the period until 2050, it is assumed that some extraction of marine sand can take place in all areas identified by SGU. In the study done by SGU, nine places were pointed out as suitable for extraction activities.

Both the zero alternative and the plan alternative build on the same sector analysis, i.e. that no sand extraction probably takes place before 2030. With regard to the MSP's long-term perspective and for the purpose of serving as a guide, three locations in the Baltic Sea (including the existing one in the Southern Baltic Sea) and one in the Gulf of Bothnia have been identified as best suited for sand extraction based on a study done by SGU. Through the guiding proposals on areas for sand extraction, the MSP is assumed to stimulate sand extraction before 2030. Because sand extraction is included in the planning proposal, the environmental effects become clear when the plan is compared with the zero alternative.

The future for sand extraction with or without the plan is uncertain, but it is likely that when extraction of marine sand begins, it will be advantageous to have the most suitable places with the least environmental impact already pointed out compared with the zero alternative where extraction is assumed to be able to take place at all locations pointed out in earlier studies by SGU.

Through an analysis of the areas that in the planning proposals are comprised by guidance for the use of sand extraction, alternatives have been prepared for the Gulf of Bothnia and the Baltic Sea planning areas. The three relevant extraction areas have been analysed individually without mutual comparisons based, among other things, on Symphony data. Based on the analysis, an alternative MSP is proposed for sand extraction where the least-suited extraction locations, i.e. those with greatest environmental impact, have been removed.

In the table below, locations of the appointed areas for sand extraction are compiled based among other things on the photic zone, nature protection areas, what ecosystem components are affected by pressures, and the cumulative environmental effect as estimated in Symphony. Relative contribution to the cumulative environmental effect within the respective extraction area and marine area expresses how large a share of the pressures from the actual sand extraction account or the relative pressures from the other sectors in the area.

Table 13 Compilation of environmental effects of appointed locations for sand extraction in the Baltic Sea and the Gulf of Bothnia.

Location / **Assessment grounds**	Svalans and Falkens grund	Klippbanken	Sandflyttan
Below the photic zone	YES	YES	PARTLY
Nature protection area, N or n area	n	n	N
Pressure on ecocomponents, number	8 (plankton, fish, seals)	6 (plankton, fish, seals)	13 (plankton, fish, seals, birds)
Relative contribution in the extraction area, %	87%	47%	65%
Relative contribution in the marine area, %	5.29%	0.33%	0.2%

Sand extraction at Svalans and Falkens grund within the Bothnian Bay marine area accounts for around 5% of the cumulative environmental pressure in the Bothnian Bay marine area. In the area, there are high nature values that include, among other things, ringed seals, grey seals, and spawning fish. These are affected through *increased turbidity*, *physical disturbance* (habitat loss), and *physical loss* in sand extraction. Extraction of sand in the appointed area only takes place on transport bottoms below the photic zone, and natural replacement of sand takes place continuously in the area (SwAM, 2018). This means that the environmental effect becomes relatively local and accounts for around 87% of the total cumulative environmental effect in the sand extraction area. The share is relatively high because it is only Transportation and communications that contributes by around 3% and the remaining 10% comes from background pressures.

Within the Bothnian Bay marine sub-region, there are few sectors that contribute to the environmental effect and consequently a new use is a relative large pressure. The alternative MSP without sand extraction (Storage and extraction of materials) will therefore have a lower environmental effect. A possible small negative environmental effect of the alternative without sand extraction could be that sand is taken from finite resources or from sand

extractions sites that entail a longer transport route and thereby entail a negative consequence for *air and climate*.

8.3.3 Northern Bothnian Sea and Norra Kvarken

The changes that the MSP entails compared with the zero alternative are mainly seen in a very small area in Norra Kvarken. In the MSP, this area is designated with "Gn", which means general use with *particular consideration to high nature values (n)*. Southern parts of this area are of high value for birds and have generally rich fish fauna and fish recruitment, as well as valuable bottom environments. *Particular consideration to high nature values (n)* means that the pressure from Commercial fisheries is limited through regulation of fishing periods and the development of equipment and that recreation activities, such as bird hunting (Attractive living environments), decrease. The MSP does not entail any noticeable change in any area within the marine sub-region and accordingly no change in the cumulative environmental effect, see Figure 28.

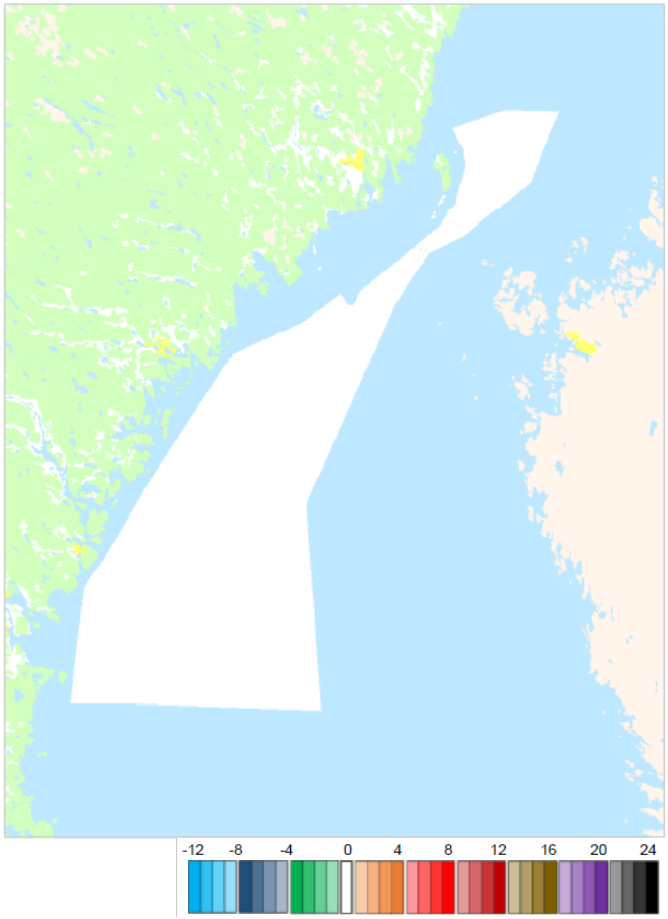


Figure 28 Areas in the Northern Bothnian Sea and Norra Kvarken where the MSP entails a change of use of the marine area compared with the zero alternative and thereby a changed cumulative effect in per cent. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the zero alternative.

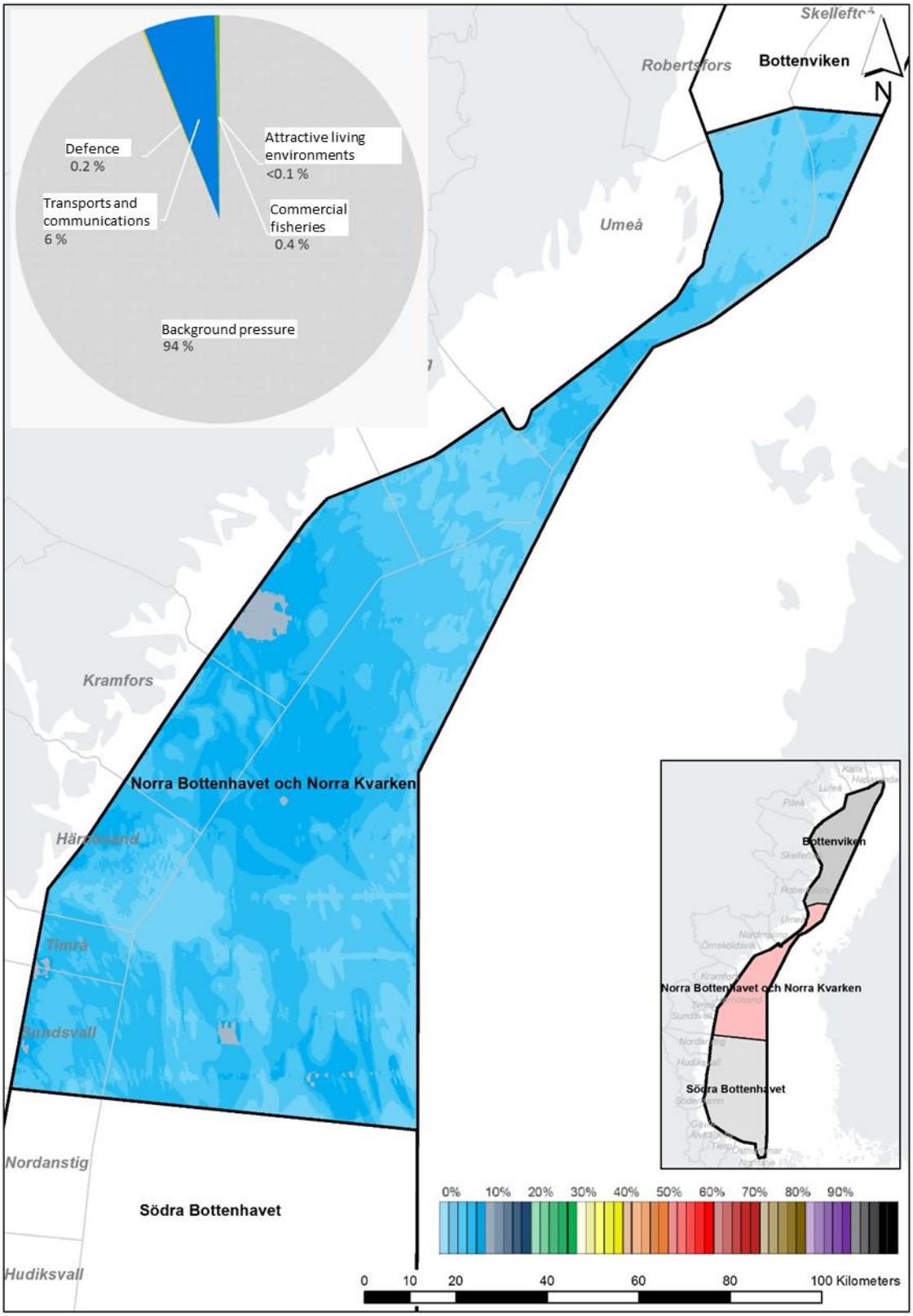


Figure 29 The total cumulative environmental effect in the Northern Bothnian Sea and Norra Kvarken. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect. The colours in the pie chart indicate sectors.

The cumulative effect in the Northern Bothnian Sea and Norra Kvarken mainly comes from background pressure, which contributes around 94% to the total cumulative effect and consists mainly of pollutants in sediment (heavy metals approx. 28% and synthetics approx. 20%) and phosphorous (approx. 27%) and a small share of oxygen-free seabeds (approx. 12%) and nitrogen (approx. 7%), see Figure 29. A very small share comes from mercury dumping. The Transportation and communications sector, which contributes around 6% to the cumulative environmental effect, consist of *underwater noise* and *introduction of pollutants* (oil spills from shipping). Defence and Commercial fisheries contribute less than 1% and consist mainly of *introduction of pollutants* (spread of heavy metals) and *selective withdrawals of species* (pelagic trawling). The theme Attractive living environments contributes a very small share.

The cumulative effect is mainly seen on deep soft seabeds, plankton, and herring, and to a small extent on deep and aphotic transport bottoms, aphotic hard and soft bottoms, sprat, deep hard bottoms, grey seals, and spawning fish. It is phosphorous, heavy metals, and synthetic environmental toxins, which are included in the background pressures, that have the greatest effect.

8.3.4 Southern Bothnian Sea

The relatively small changes that the MSP entails (1%) compared with the zero alternative are mainly reflected in a number of smaller areas in the central and south-western parts of the Southern Bothnian Sea and an area in the northern part of the Southern Bothnian Sea.

In the MSP, the area in the northern part of the Southern Bothnian Sea is designated with “Gn”, which means *general use* with *particular consideration to high nature values (n)*. Within the area, there is an especially untouched spawning area for fish and fish recruitment that illustrates the area’s high nature values. *Particular consideration to high nature values (n)* means that the pressure from the sector of Commercial fisheries decreases through regulation of, for example, fishing equipment and fishing periods.

In the central and south-western part of the Southern Bothnian Sea, there are areas that are added with the MSP. These are marked with “Ef” and “Efn/Enf”, which means Energy with *particular consideration to national defence (f)* and *high nature values (n)*. The risk of cumulative effects on defence interests is to be observed in the energy expansion in these areas, which might entail limitations in the scope of the wind power expansion. The “Enf” areas are valuable fish recruiting and mammal areas and have a valuable bottom environment. Shipping (Transportation and communications), Commercial fisheries (pelagic and bottom trawling), and recreation activities, such as bird hunting (Attractive living environments), are limited in connection with the plan. This means that a number of impact factors will decrease or disappear entirely from these areas. However, the energy expansion that the plan allows entails a potential increase in *underwater noise* and *biological disturbance* and loss and change of habitat (*physical loss* and *physical disturbance*). In some

areas (such as Södra Midsjöbanken in the Baltic Sea) where there are sea birds, *physical disturbance* might mean that sea birds avoid wind power areas to some extent, which can affect the population especially if it suffers from habitat limitations. Wind turbine foundations might mean that artificial reefs are created, which can benefit biological diversity and thereby decrease the negative effect (*physical loss*). The results in Symphony are, however, that the plan's energy areas in the Southern Bothnian Sea have a negative environmental effect in smaller to larger parts of each area.

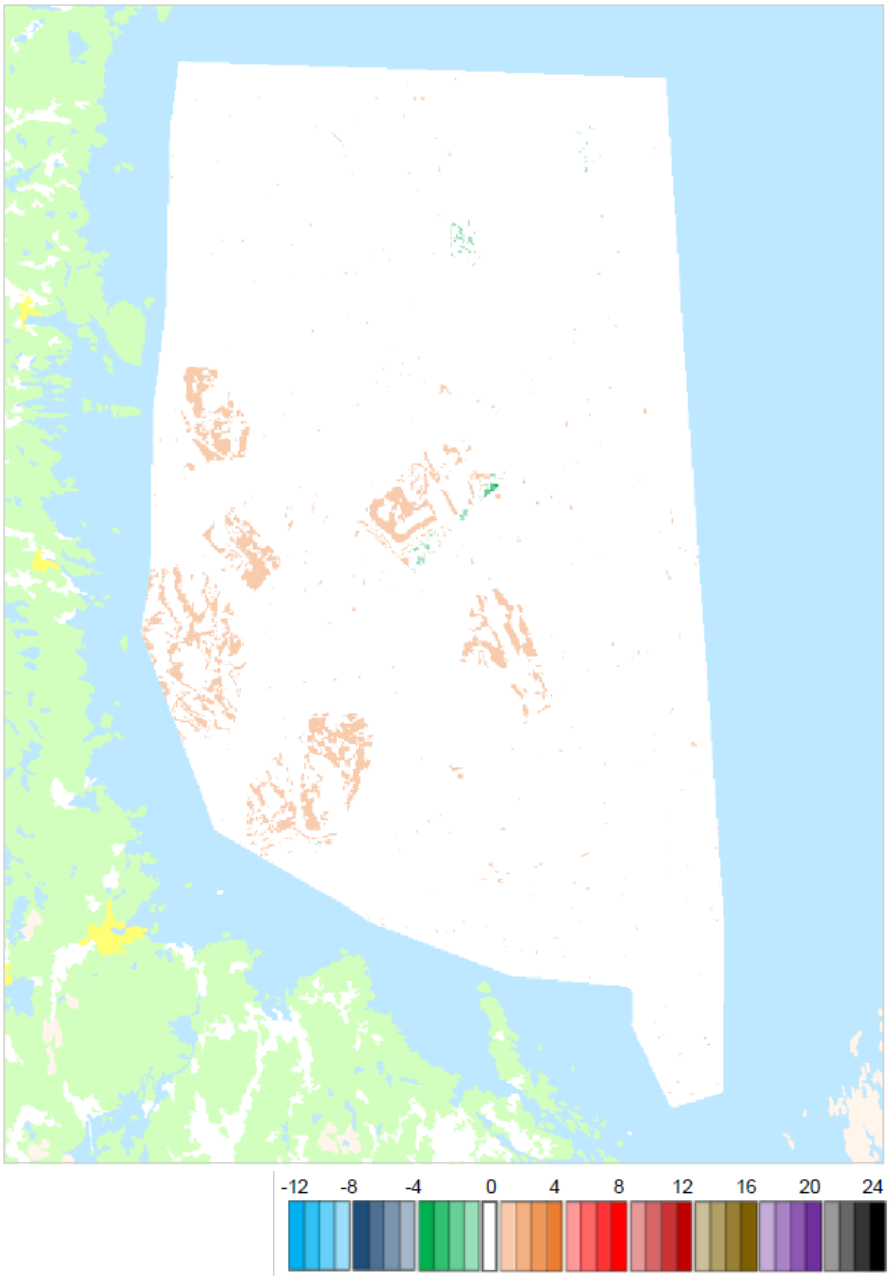


Figure 30 Areas in the Southern Bothnian Sea where the MSP entails a change of use of the marine area compared with the zero alternative and thereby a changed cumulative effect in per cent. Positive values result in a larger cumulative environmental effect compared with the zero alternative. Negative values, in blue and green, result in a smaller cumulative environmental effect compared with the present situation.

The background pressure contributes by around 87% to the cumulative effect and consists of pollutants in sediment (heavy metals approx. 26%, synthetics approx. 19%) and phosphorous (approx. 32%), and a small share of nitrogen (approx. 9%) and oxygen-free seabeds (approx. 1%). A very small share comes from mercury dumping. The cumulative effect in the Southern Bothnian Sea in the plan alternative also comes from the sectors Transportation and communications, Commercial fisheries, Energy, and Defence. Energy has been added through marine spatial planning, which means a decrease in the background pressures' percentage of the pressures compared with the zero alternative, see Figure 31. The sectors Transportation and communications account for around 8% and consist of effects from *underwater noise* and *introduction of pollutants* (oil spills from shipping). In the MSP, the shipping lane is moved in two subsections to benefit the establishment of wind power (Energy). This also entails a positive effect for cultural heritage remains in the area as wear through erosion decreases. The cumulative effect is mainly unchanged where the sector Transportation and communications is removed because this entails a decrease in the impact from the sector over the entire marine area, but locally the environmental effect from this sector will decrease. Commercial fisheries contributes around 5% and consists of effects from *selective withdrawals of species* (mainly pelagic trawling) and effects of *physical disturbance* to the bottom from trawling (abrasion and increased turbidity). Commercial fisheries is marginally affected by changes that the MSP entails because only small relocations are made of the sector's impact area in the marine spatial planning area. The theme Energy is introduced with the MSP and contributes around 1% and consists of effects from *underwater noise* (wind power). Besides *underwater noise*, wind farms (Energy) contribute *physical loss*, *physical disturbance*, and *biological disturbance*. The themes Attractive living environments and Defence contribute a very small share to the cumulative environmental effect.

The cumulative effect is mainly noticed on plankton, deep soft seabeds, and herring, but also on aphotic soft and transport seabeds, deep hard seabeds, sprat, spawning fish, grey seals, and deep transport seabeds. Even if background pressures have the largest share of the cumulative effect, *selective withdrawals of species* and *underwater noise* have significant effects on herring, sprat, and grey seals.

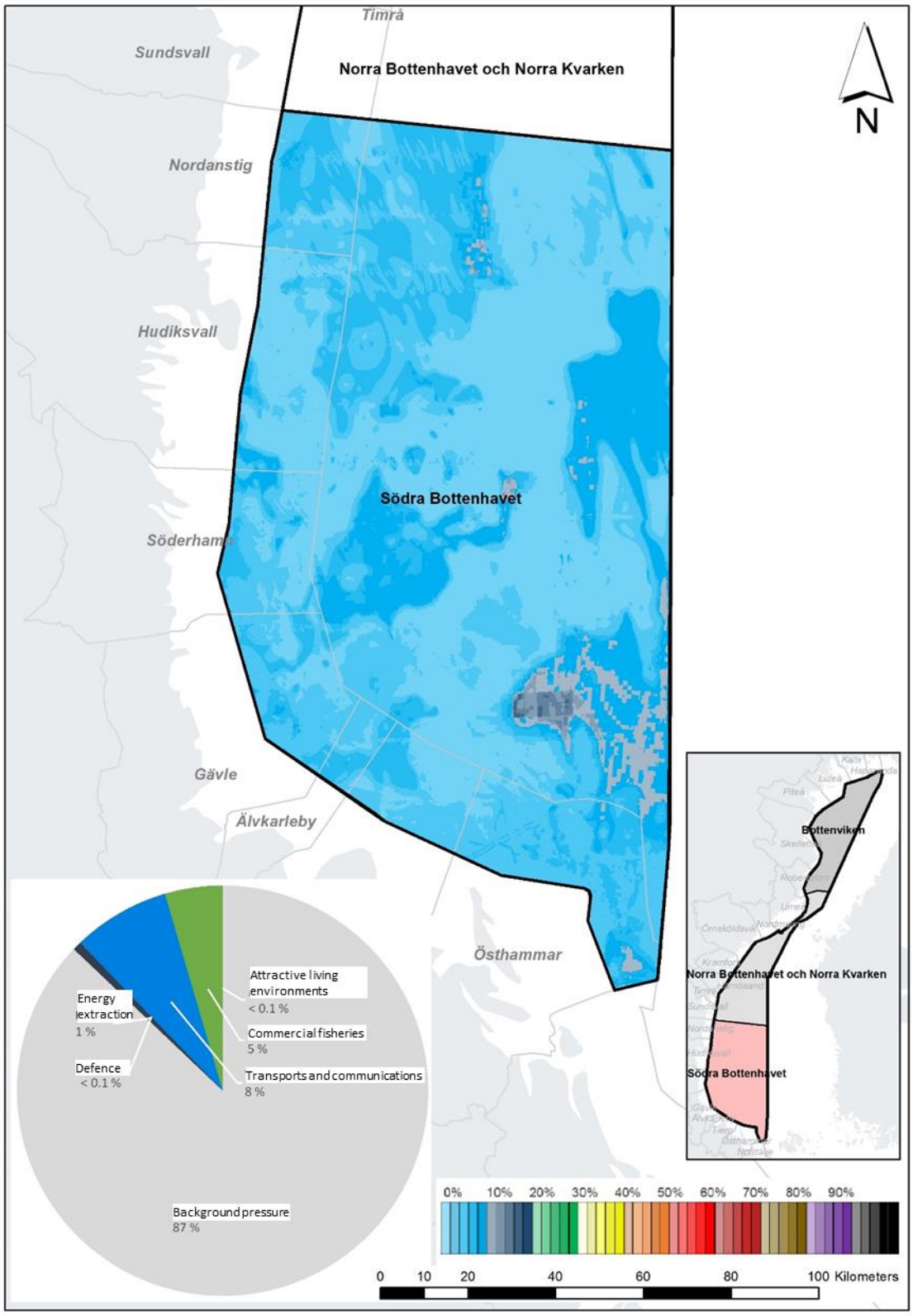


Figure 31 The total cumulative environmental effect in the Southern Bothnian Sea. The colour scale in the map applies to all of the Gulf of Bothnia, including coastal areas, and shows the percentage of the maximal cumulative effect in the Gulf of Bothnia. The pie chart shows the relative percentage distribution of the sectors' contributions to the cumulative effect. The colours in the pie chart indicate sectors.

9 Collective assessment

9.1 Environmental impact

The objective of the SEA is to integrate environmental aspects in the planning and decision-making so that sustainable development is promoted (Chapter 6 Section 1 of the Environmental Code). With the help of mainly the planning method Symphony, the collective cumulative environment impact within the marine spatial planning area has been estimated and analysed with the aim of assessing the result of the MSP in relation to the zero alternative for 2030.

Table 14 Summary of environmental impact in the Gulf of Bothnia of the MSP on environmental aspects as per the Environmental Code, compared with the zero alternative. Scale: positive, none, small negative, moderate negative, large negative impact.

ENVIRONMENTAL ASPECTS ENVIRONMENTAL CODE / MSP'S THEME	POPULATION AND PEOPLE'S HEALTH	ANIMAL OR PLANT SPECIES AND BIODIVERSITY OTHERWISE	LAND, SOIL, AND WATER	AIR AND CLIMATE	LANDSCAPE, BUILT ENVIRONMENT, AND CULTURAL ENVIRONMENT	MANAGEMENT OF LAND, WATER, AND THE PHYSICAL ENVIRONMENT, AS WELL AS MATERIALS, RAW MATERIALS, AND ENERGY
ATTRACTIVE LIVING ENVIRONMENTS	Positive	None	None	None	None	None
ENERGY	None	Small negative	Small negative	Positive	Small negative	Positive
DEFENCE	None	None	None	None	None	Positive
STORAGE AND EXTRACTION OF MATERIALS	None	Small negative	Small negative	None	Small negative	Positive
NATURE	Positive	Positive	Positive	None	None	Positive
TRANSPORTATION AND COMMUNICATIONSTRANSPORTATION AND COMMUNICATIONS	None	None	None	Small negative	Positive	None
AQUACULTURE AND BLUE BIOTECHNOLOGY	-	-	-	-	-	-
COMMERCIAL FISHERIES	None	None	None	None	None	Positive

This chapter summarises the cumulative environmental effect for the respective environmental aspect that is taken up in the environmental code's Chapter 6. In parallel with the environmental assessment of the MSP for the Gulf of Bothnia, a sustainability assessment was done, which is summarised below in the following section.

Most sectors' operations and development entail an impact on the environment and biological diversity. The results from Symphony indicate that the majority of the environmental impact can be traced to land-based or historical emissions. However, the present MSP proposal entails no or very small changes in the spread of most sectors. The MSP entails a change from the current situation only for energy extraction and sand extraction and, to some extent, Commercial fisheries. It is therefore primarily these sectors' environmental impact that gives rise to environmental consequences that can be traced to the MSP even if they contribute relatively small environmental effects according to the analyses in Symphony.

9.1.1 Population and people's health

Our seas contribute in various ways to our welfare and our well-being from food to various conditions for recreation activities. Through trade and fishing, the seas have also played a crucial historical role for Sweden's development and are thereby also important from a cultural heritage perspective. A concept that is used to describe the benefits of the sea is ecosystem services. The services, often exemplified as fish, crops, or timber, are benefits that contribute to society's well-being or that bear a financial or other value for people.

In the sustainability assessment for the Gulf of Bothnia (COWI, 2018b), marine ecosystem services are used to take into account the socioeconomic values that are created or threatened as a result of the proposed MSP. Through their pressures, all marine sectors in some way affect the marine environment and thereby also the marine ecosystem services. Among the sectors covered by the sustainability assessment, there are two that are also directly dependent on the marine ecosystem services for their activities – Commercial fisheries and Attractive living environments.

Within the marine spatial planning of the Gulf of Bothnia, outdoor recreation is mainly comprised of recreational boat traffic and angling, but also cruise ships and ferry traffic, hunting, safaris, etc. In the future, demand to partake of archipelago life and use of the sea for recreation is expected to increase from both national and international tourism. One of several conditions is that important natural and cultural values are preserved, which areas with *particular consideration to high nature values (n)* are intended to do. The planned rerouting of shipping lanes also means that both natural and cultural values are preserved in the shallow areas that are currently impacted by shipping. The MSP entails certain restrictions on outdoor recreation in the areas where energy extraction is pointed out as the most suitable use, which also means that the landscape appearance changes in these areas.

Human health is impacted by the emissions and the littering that takes place to the air and sea. The spatial changes that an adopted MSP has on the Gulf of Bothnia are not deemed to impact these pressures more than marginally. It is rather the sectors' development that has an impact and environmental effects that the plan has no control over. Otherwise, outdoor recreation is not affected in the marine spatial planning area more than marginally.

The collective assessment is that the MSP has a positive impact on the environmental aspect *Population and people's health*.

9.1.2 Animal or plant species that are protected under Chapter 8 of the Environmental Code, and biological diversity otherwise

Pressures on the marine environment are generally expected to increase until 2030 and likewise the effects of climate changes. In the Gulf of Bothnia, the objective of at least 10% of the sea being covered by area protection by 2020 is not deemed to be achieved. The objective probably entails increased area protection in the Gulf of Bothnia until 2030. In the plan, areas are pointed out that are important spawning areas for fish and the occurrence of ringed seals and marine birds, within which *particular consideration to high nature values (n)* is to be taken. This means that consideration is to be taken in the establishment of new activities, but this also results in the regulation of Commercial fisheries and activities within outdoor life and recreation. In the Southern Bothnian Sea and a small area in Norra Kvarken, the assumptions made for *particular consideration to high nature values (n)* entail a decreased pressure from Commercial fisheries through regulation, from shipping through relocation, and from reduction of certain recreation activities such as bird hunting. The reduced pressure means that the cumulative environmental effect for the plan alternative in the area decreases compared with cumulative environmental effects in the zero alternative, which depends on the sectors' development until 2030. At the same time, several of the areas in the Southern Bothnian Sea, which are important habitats and where *particular consideration to high nature values (n)* is to be taken, have been identified as interests for energy extraction and/or the interests of national defence. Consideration designations set extensive requirements on adaptations within these areas in order for this coexistence to not counteract the positive effect the plan seeks to have.

SwAM's work (2017) on proposals on climate refuges for a number of selected species indicates the possibilities of creating space for especially vulnerable species to successfully adapt and continue to exist in a changed climate. Areas in the northern Gulf of Bothnia have been identified as possible climate refuges for ringed seals, which is further reason that extensive consideration shall be taken to nature values.

With the prevailing political objectives in the energy and climate area, there is pressure on the expansion of renewable energy in which sea-based wind power

plays a significant role. The sea-based wind power has an impact through *underwater noise* and *physical disturbance* during construction of the facilities, which is a short-term disturbance that is not handled in the Symphony planning method. *Underwater noise* in the operating phase is deemed to constitute a small share compared with shipping noise, but *underwater noise* is a pressure the cumulative effects of which must be taken into consideration. Use of the seabed entails some *physical disturbance* and *physical loss*, i.e. habitat loss, as a result. Energy extraction's use of seabed habitats for wind turbine foundations might create artificial reefs that can benefit biodiversity in general, at the same time that wind power limits access for fishing, shipping, and recreational activities within these areas. There are habitats within these areas that are very valuable for fish stocks, as well as other parts of the ecosystem, and establishment of wind power can thereby also have an effect outside these areas. In the areas where there are sea birds, *physical disturbance* might mean that sea birds avoid wind power areas to some extent, which can affect the population especially if it suffers from habitat limitations. In the MSP, an assessment is made that co-existence can be achieved through the energy extraction areas being provided with a designation for *particular consideration to high nature values (n)* and *national defence* (*f)*, which entails extensive requirements on adaptations for wind power establishment. In future permit processes regarding wind power establishment in the plan's areas for energy extraction, the negative environmental effect is taken into account and managed to minimise the cumulative effect and to meet the plan's recommendation regarding *particular consideration to high nature values (n).*

In the MSP, sand extraction is present as the most suitable use in an area in the northern Bothnian Bay, which is one of four that SGU has identified as most suitable for extraction of marine sand and gravel. The area has high nature values (spawning areas for fish and occurrence of ringed seals), which entails a negative environmental effect with increased turbidity and loss of valuable habitat. Demand for natural gravel is expected to remain high in the future and in pace with the depletion of finite deposits on land, and thus extraction of marine sand and gravel might increase. Extraction of sand in the appointed area only takes place on transport bottoms below the photic zone, and a natural replacement of sand takes place continuously in the area (SwAM, 2018). Here, the MSP entails a small negative environmental effect on the marine environment (*physical loss* and *physical disturbance*), but the effect is deemed to be of a local significance. *Particular consideration to high nature values (n)* within the same areas is deemed to limit the negative effects from sand extraction.

The Gulf of Bothnia's physical and ecological conditions provide a few species that are important for Commercial fisheries. This means that its marine life is sensitive to over-withdrawal of fish, but other pressures, such as eutrophication and pollutants, also affect the ecosystems. Fishing is expected to be stable until 2030 at the same time that there is continuous development of fishing equipment and methodology to reduce the impact from fishing. Within the

MSP areas for energy extraction, the use Commercial fisheries will be limited, which entails a reduced pressure from fishing. Through the areas in the MSP where *particular consideration to high nature values (n)* is to be taken, the plan's guidance is expected to result in further regulation of Commercial fisheries by a competent administrative authority.

The MSP entails a negative environmental effect in the Gulf of Bothnia as a result of energy extraction and sand extraction, and the plan thereby also entails a slightly negative consequence for the environmental aspect of *Animals, plants, and biological diversity*. At the same time, the environmental effect from Commercial fisheries and transports decreases, partly through areas with *particular consideration to high nature values (n)*, which entails a positive consequence on the environmental aspect. The collective assessment is that the MSP in total entails a small negative consequence on the environmental aspect *Animals, plants, and biological diversity* and that extensive consideration needs to be taken to nature values in the area in the planning, permit review, establishment, and operation of various activities.

Alternative for Storage and extraction of materials
The relatively large difference in the cumulative environmental effect between the zero and plan alternative is comprised of the assumption of no sand extraction by 2030 and that the MSP could accelerate sand extraction before 2030 through guiding proposals in the plan, i.e. Svalans and Falkens grund. Even if the future for sand extraction is uncertain, it is advantageous to have identified suitable locations once extraction of marine sand begins. Sand extraction at Svalans and Falkens grund accounts for a relatively large part of the cumulative environmental effect (approx. 5%) within the Bothnian Bay marine area and locally around 87% within the sand extraction area. Within the Bothnian Bay marine sub-region, there are few sectors that contribute to the environmental effect and consequently a new use is a relative large pressure. Sand extraction has a local effect through *increased turbidity*, *physical disturbance* (habitat loss), and *physical loss*, and within the sand extraction area there are high nature values that include ringed seals, grey seals, and spawning fish. Extraction of sand in the appointed area only takes place below the photic zone on the transport bottom. The alternative MSP without sand extraction will therefore have a lower environmental effect.

9.1.3 Land, soil, water, air, climate, landscape, built environment, and cultural environment

Shipping plays an important role for the staple industries of mining and forestry and is therefore very important to the region's economy. Until 2030, shipping is predicted to increase by 35% in the Gulf of Bothnia. Combustion of fuel results in emissions to the air that contribute to climate changes and acidification and eutrophication problems. Shipping also affects the environment through several other emissions that are regulated with multiple national and international regulations. The MSP entails certain limitations for shipping in connection with wind power establishment and areas in which

particular consideration to high nature values (n) and to some extent *to the interests of national defence (f)* shall be taken.

In the Southern Bothnian Sea, the plan means that shipping can take a different route. The longer distance that shipping is expected to take entails greater emissions to air (net emissions of carbon dioxide of around 470 tonnes) and thereby an increased pressure on the marine environment. Considering that only a small part of the shipping in the Gulf of Bothnia marine spatial planning area is affected and that the extension of shipping lanes (7.5 and 1.6 km) is relatively limited, the greater pressure is deemed to only have a small negative consequence.

The relocation of shipping entails a reduced pressure and a positive effect on the cultural environment. Cultural heritage remains such as shipwrecks might also be affected in energy establishment through fixed constructions for wind power and claims of seabed areas in sand extraction (see Section 9.1.2), which must be taken into account in future permit processes to minimise the impact on potential valuable cultural remains.

In the Gulf of Bothnia, there is one of the Swedish Armed Forces' marine training areas and influence areas for artillery ranges on land that affect the marine environment through emissions of metals from ammunition. Locally, this can cause large concentrations that have effects on the marine environment. The Swedish Armed Forces' activities in the area also generate underwater noise. A possible development is that national defence might increase the use of virtual methods to reduce the need for physical artillery exercises, according to the SwAM thematic work. An effect of this can probably be expected only after 2030. By 2030, the impact of defence activities is expected to increase proportionally with the development of the sector. In relation to other human activities, the interests of national defence are deemed to have good possibilities for coexistence with Commercial fisheries, outdoor recreation, and shipping. Permanent installations for energy extraction might entail physical obstacles and cause technical disruptions that can compete with defence activities. In the Southern Bothnian Sea, the MSP provides guidance on areas for energy extraction within which *particular consideration to national defence interests (f)* are to be taken in wind power establishment. This might entail limitations in the scope of the wind power expansion.

Besides a local impact on the seabed and the marine nature values, establishment of wind power also entails a change in the landscape appearance, which is addressed in Section 9.1.1. The positive effect of planned areas for energy extraction is on the climate through the reduction of emissions. The plan entails a potential emissions reduction in the Gulf of Bothnia of around 316,000 tonnes of carbon dioxide and is thereby deemed to have a positive effect (COWI, 2018b).

For the environmental aspect *Land, soil, water, air, climate, landscape, built environment, and cultural environment*, the MSP is deemed to mainly entail

local negative environmental effects in the areas where new establishment is proposed, such as material and energy extraction, while a positive effect is expected where *particular consideration to high nature values (n)* shall be taken and an effect from energy extraction on climate. The longer distance that shipping must take in the Southern Bothnian Sea is deemed to have a small negative consequence. The collective assessment is that the MSP entails a small negative consequence for *Land, water, and cultural environment*, no consequence on *air and climate*, and a slightly negative consequence for the other environmental aspects of *landscape, built environment, and cultural environment*.

9.1.4 Management of land, water, and the physical environment otherwise and Other management of materials, raw materials, and energy.

The objective of the marine spatial planning is to plan the marine spatial planning area to be able to use the areas for the purposes that they are best suited for considering their character, situation, and needs. The areas where a difference between the MSP and the zero alternative entails a change in the cumulative environmental effect and can have an effect on this environmental aspect are the areas where new use is introduced, i.e. sand extraction and energy extraction, but also *particular consideration to high nature values (n)* and *national defence (f)*.

At present, there is no need for sand extraction at sea in the Gulf of Bothnia, but within the MSP's horizon year the need is expected to arise. If extractions are made with good management, material should be able to be taken out without it resulting in a major impact on the sand and gravel deposits in question. With regard to energy extraction at sea, interest in renewable energy is also expected to increase in pace with technical development, which means that sea-based wind power will become more competitive. Both sand extraction and energy extraction are preceded by an environmental permit process in which local impacts and environmental effects are analysed and assessed with the aim of minimising the environmental impacts. In the MSP, some sectors are deemed to be able to coexist, and areas with *particular consideration to high nature values (n)* and *national defence (f)* have been pointed out in co-existence with one or more other uses.

Adaptations will need to be made to minimise the impact and effects in these areas worth protecting in order to achieve the aim of appointing these areas as such, mainly when it comes to the establishment of wind turbines. In most cases, these areas are important spawning grounds and recruiting areas for fish and constitute a resource. Through these areas, consideration is shown in the establishment of other activities, and some regulation of the fishing can be introduced, which will benefit the fish stocks.

Altogether, the MSP is deemed to entail a positive consequence for the environmental aspects of *Management of land, water, and the physical environmental otherwise* and *Other management of materials, raw materials, and energy* because the plan works for the coexistence between various uses and because sand extraction replaces extraction of natural gravel on land and energy extraction contributes energy from a renewable source.

9.1.5 Other parts of the environment.

No other areas have been identified in the impact assessment of the MSP than the environmental aspects assessed above.

9.1.6 Impact of climate change on sectors

The changes in the environment predicted from climate change will in the long term affect water temperature, ice cover in winter, length of the seasons, length of the growing seasons, and the ranges and survival of species. The sectors that are mainly affected by climate change are Transportation and communications, Commercial fisheries, Energy, and Nature.

For the Gulf of Bothnia, effects are mainly assessed to be noticeable with regard to reduced ice cover in the northern Bothnian Bay and that the seasons will change with shorter winter seasons. Positive effects are expected for shipping through smaller ice cover and shorter winter seasons, providing noticeably increased navigability. This provides positive time and cost savings for shipping, and with it market advantages. Energy extraction and defence activities are also positively benefited by reduced ice cover and a shorter winter season.

With regard to nature and ecosystems, reduced ice cover will mainly have negative effects on the ringed seal's living conditions and survival because they are dependent on the ice cover to be able to raise their young. For nature, animal, and plant species, climate changes can create negative effects as temperature and salinity change. Algal blooms can be expected to increase with higher water temperatures, and nutrient chains will be negatively impacted as salinity and temperature change and new invasive species move into the Gulf of Bothnia (COWI, 2018a).

9.2 Evaluation of the plan – sustainability and goal attainment

The ecosystem approach is a starting point in the EU Directive on maritime spatial planning, and in the Swedish Marine Spatial Planning Ordinance (2015:400) it states that SwAM shall apply an ecosystem approach in the work of drafting MSPs. The ecosystem approach is an international strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. The goal is to ensure that ecosystems are used without compromising their long-term survival in terms of their structure, dynamics, and function.

Application of the ecosystem approach in Swedish marine spatial planning involves, among other things, regularly referring back to the environmental strategic objective of good environmental status, as provided within the framework for the Marine Environment Ordinance (2010:1341). According to the Swedish Marine Spatial Planning Ordinance, the marine spatial planning should contribute to achieving and maintaining a good environmental status in Sweden's marine areas. Marine spatial planning therefore needs to take into account aspects that are required so that the environmental quality standards can be met.

According to the Environmental Code, an environmental impact assessment shall contain a description of how relevant environmental quality objectives and other environmental considerations are taken into account in the plan. In the environmental impact assessment, the Marine Strategy Framework Directive (Marine Environment Ordinance) and fulfilment of environmental quality standards have also been included.

9.2.1 Plan guidance towards guiding objectives

The MSP shall contribute to good environmental status in the marine environment being achieved and maintained, the sea's resources being used sustainably so that sea-related industries can develop, and the promotion of co-existence between different activities and areas of use.

The proposed MSP for the Gulf of Bothnia has been reconciled with objectives in the Marine Strategy Framework Directive against the plan's effects with regard to the Swedish environmental objective work, and the maritime strategy for people, jobs, and the environment has been evaluated in general, which is compiled below.

Marine Strategy Framework (introduced through the Marine Environment Ordinance)

Good environmental status (GES) is the desired status in the environment where the use of the marine environment is at a level that is sustainable. Marine spatial planning is a tool for adapting the utilisation of the sea so that development needs are met at the same time as environmental objectives and good environmental status are achieved and maintained. The Marine Strategy Framework Directive (2008/56/EC), implemented in Sweden through the Marine Spatial Planning Ordinance, aims to achieve or maintain good environmental status in the EU's marine areas by 2020. This shall be achieved through adaptive management and shall be based on the ecosystem approach (SwAM, 2015b).

As a guide for achieving good environmental status, Sweden has chosen to use so-called environmental quality standards. These shall among other things be based on the definition of good environmental status provided in the Marine Strategy Framework Directive and shall take into account both impacts and pressures. Environmental quality standards with indicators constitute an

important part in the assessment and monitoring of the sea. The environmental quality standards shall not be violated, which is why marine environmental management needs to take these aspects into account and formulate action programmes so that environmental quality standards are met and so that good environmental status is achieved. It is the authorities and municipalities that are responsible for compliance with the standards.

Through Regulation HVMFS 2012:18, SwAM has determined what characterises good environmental status for Sweden's marine areas and has set environmental quality standards with 11 associated indicators (SwAM, 2012a). These standards are structured in consideration of pressures and impacts as described in Table 2 in the Directive's Annex III. Environmental status is described using 11 descriptors.

Table 15. Marine Strategy Framework Directive's descriptors (HVMFS 2012:18, Appendix 2).

D1	Biodiversity
D2	Invasive species
D3	Commercial use of fish and shellfish
D4	Marine food webs
D5	Eutrophication
D6	Sea-floor integrity
D7	Lasting changes in hydrographical conditions
D8	Concentrations of hazardous substances
D9	Hazardous substances in fish and shellfish
D10	Characteristics and amounts of marine litter
D11	Introduction of energy, including underwater noise

The environmental quality standard *Good environmental status for the North Sea and the Baltic Sea* (including Kattegat, Skagerrak, and the Gulf of Bothnia) is evaluated using all 11 descriptors and the conditions that shall be achieved in the marine environment in order for the standard to be viewed as fulfilled (HVMFS 2012:18). The standard is evaluated on a management area level, meaning partly for the North Sea (all Swedish waters from the baseline to the boundary of the Swedish exclusive economic zone north of the Öresund bridge) and partly for the Baltic Sea (all Swedish waters from the baseline to the boundary of the Swedish exclusive economic zone south of the Öresund bridge).

Environmental quality standards with indicators are evaluated on a finer geographic scale and are applied in internal and external coastal waters and offshore waters in all Swedish marine areas. In contrast to the standard for *Good environmental status for the North Sea and the Baltic Sea,* these standards focus on specific environmental pressures and are divided into four groups:

A. Introduction of nutrients and organic materials (one norm: A1)
B. Introduction of hazardous substances (two standards: B1 and B2)
C. Biological disturbances (four standards: C1 -C4)
D. Physical disturbances (four standards: D1 – D4)

The evaluation of the plan proposal's contribution to achieving good environmental status according to the Marine Strategy Framework Directive builds on the connection between the plan's assessed environmental effects and the 11 descriptors, see Table 15. For example, an increase in the environmental pressure from a maritime sector would entail a negative effect on the relevant environmental quality standard.

The results from the evaluation of the plan's consequences in terms of environmental effects show that the sectors *Energy* and *Storage and extraction material* are of significance. For the energy sector, it is the potentially comprehensive expansion of wind power in the Southern Bothnian Sea that is deemed to be able to result in a greater environmental pressure, mainly through *physical impact* on the bottom areas that are then claimed for use, but also through *underwater noise*. For Storage and extraction of materials in the Gulf of Bothnia's planning area, Svalans and Falkens grund in the northern Bothnian Bay is the only location pointed out for the extraction of sand and gravel. The environmental pressures assessed to be able to arise as a result of the operations are mainly *physical loss* of the seabed.

The plan's consequences for the environmental permit in the Gulf of Bothnia are deemed to concern the following Environmental Quality Standards:

- *Environmental quality standard: Good environmental status for the North Sea and the Baltic Sea*

  Through the impacts *physical loss*, *physical disturbance*, and *underwater noise* on the descriptors D1, D6, and D11 in the Southern Bothnian Sea, and through the impact *physical loss* on D6 in the Bothnian Bay, the plan proposal potentially contributes negatively to achieving the environmental quality standard *Good environmental status* in the management area of the Baltic Sea.

  In terms of pressures linked to energy extraction, the negative effects are deemed to be extensively linked to the construction phase and then to decrease substantially in the operating phase. The exception is *physical loss* and parts of *D11 - Supply of energy including underwater noise* and the impact on sea birds (descriptor D1), the effects of which remain during the operating phase.

  The proposed plan's expected positive effect from the guidance on *particular consideration to high nature values (n)* through measures in Commercial fisheries is deemed to be able to lead to reduced pressure (*biological disturbance* of species) and thereby a positive effect on descriptors D1, D3, and D4. However, the effects are assessed to be relatively small because Commercial fisheries in the areas in question is less extensive. Correspondingly, the consideration designation (n) is assessed to entail limited positive environmental effects within an area with guidance on sand extraction (Svalans and Falkens grund (B104)). In the areas with the guidance on energy extraction with *particular consideration to high nature values (n)*, (B142) and (B147), detailed project planning of

wind power stations is expected to take place to minimise the impact on sea birds (descriptor D1). Through the consideration designation (n), the plan's potential negative environmental effect is thereby mitigated, see SwAM (2018b), and thereby contributes positively to the possibility of achieving the environmental quality standard.

- *Environmental quality standard: D1 – The seabed area unaffected by human activity shall, by substrate type, provide conditions to maintain the structure and function of the seabeds in the North Sea and the Baltic Sea*

  Through the impacts of *physical loss* and *physical disturbance* on descriptor D6 in the Southern Bothnian Sea as a result of guidance on energy extraction on unaffected seabeds in the Natura 2000 area Finngrunden Västra banken (B151), the proposed plan potentially contributes negatively to achieving *environmental quality standard D1* in the Bothnian Sea's offshore waters. Gretas klackar (B142) and another area (B147) are also potentially affected in the same way.

As a result of the environmental pressures, mainly linked to the establishment of wind power, a cautious assessment is that the plan proposal potentially contributes negatively to the possibility of achieving the environmental quality standard of *Good environmental status*. This result shows that the plan entails both positive and negative effects; however, the pressures that are pursuant to the planning proposal's guidance on energy extraction are deemed to be greater than the positive effects, which are assumed to result from the consideration designation (n).

In terms of the possibility of fulfilling the environmental quality standard *D1 – The seabed area unaffected by human activity shall, by substrate type, provide conditions to maintain the structure and function of the seabeds in the North Sea and the Baltic Sea*, the plan proposal is deemed to potentially entail a negative effect due to guidance on energy extraction in an unaffected area (Finngrunden – Västra banken (B151)). Gretas klackar (B142) and another area (B147) are also potentially affected in the same way.

Sweden's environmental quality objectives

For the evaluation of the Swedish national environmental quality objectives, both the environmental assessment and the sustainability assessment focused on the environmental objective of *A Balanced Marine Environment,Flourishing Coastal Areas and Archipelagos,*. The proposed MSP also concerns other environmental objectives, but the aforementioned environmental objective is considered to be of greatest significance to the marine spatial planning. The Government has established 11 specifications of the environmental objective, and of them the following are evaluated:

- **Good environmental status**
  Coastal and sea waters have a good environmental status with regard to

physical, chemical, and biological conditions in accordance with the Marine Environment Ordinance (2010:1341).

- **Favourable conservation status and genetic variation**
  Habitat types and indigenous species linked to the coast and sea have favourable conservation status and sufficient genetic variation within and between populations, and naturally occurring fish species and other marine species thrive in viable populations.
- **Threatened species and restored habitats**
  Threatened species have recovered and habitats have been restored in valuable coastal and marine waters.
- **Preserved natural and cultural heritage values**
  The natural and cultural values of the marine, coastal, and archipelago landscape are preserved and conditions exist for the continued preservation and development of these values.
- **Cultural heritage remains under the water**
  The condition is unchanged for cultural heritage remains under the water.
- **Outdoor recreation and noise**
  The marine, coastal, and archipelago landscape values for recreational fishing, bathing, boating, and other outdoor activities are safeguarded and preserved, and the impact from noise is minimised.
- **Ecosystem services**
  Ecosystem services - important ecosystem services of coasts and seas are preserved.

For this environmental quality objective, the MSP entails positive conditions for several of the specifications as a result of the plan's areas with *particular consideration to high nature values (n)*. For the cultural environment, the moving of the shipping lane at Finngrundet entails a positive effect because shipping is moved from shallow areas to deeper areas and the impact on cultural heritage remains is thereby reduced. This positive effect from the relocation of shipping must, however, be taken into account in the planning of sea-based wind power in the areas for energy extraction regarding placement of foundations and cables. The areas with *particular consideration to high nature values (n)* are also deemed to entail positive secondary effects for outdoor recreation, but at the same time the establishment of wind farms can entail negative effects. Similar reasoning applies to the ecosystem services. The plan is deemed to potentially entail both negative and positive effects for the marine ecosystem services in the area. The positive effect is from the areas with *particular consideration to high nature values (n)*, and the negative effect, which is considered to be relatively significant, is mainly tied to the potential expansion of sea-based wind power.

The plan's combined effect in terms of *maintenance of ecosystem services* is difficult to assess. An overall assessment is that the plan does not entail any negative effect on the possibility of achieving the environmental objective of *A*

Balanced Marine Environment,Flourishing Coastal Areas and Archipelagos, in the Gulf of Bothnia.

9.2.2 MSPs from a sustainability perspective

The sustainability assessment is intended to analyse the proposed plan's impact from a sustainability perspective. Among other things, this means identifying the geographic or thematic areas where the proposed MSPs are at risk of leading to conflicts of interest or priorities that put at risk society's overall objective of a good environmental status and sustainable growth. The result from the assessment shall thereby be a basis for considerations in the continued planning work, which shall lead to sustainable management of the marine environment.

The sustainability assessment is based on the three sustainability dimensions of *Economy*, *Ecology*, and *Social aspects*. The sustainability assessment of the proposed MSP for the Gulf of Bothnia indicates a slightly positive result on a general level compared with the use of a zero alternative without an applied MSP (COWI, 2018b):

Economic sustainability
Within economic sustainability, the plan proposal is deemed to not entail any unambiguous result because positive and negative effects are expected to cancel each other out. The positive effects are deemed to come from extensive establishment of wind power, sand extraction in the Bothnian Bay, and generally stronger ecosystem services in the planning area as a result of more consideration to nature. At the same time, a potential expansion of sea-based wind power is deemed to entail negative economic consequences, partly through the visual disturbance that the sea-based wind turbines give rise to, which is of significance to Recreation and tourism, and partly through the impact on sensitive natural environments, which is of significance to, among other things, Commercial fisheries.

Ecological sustainability
Within ecological sustainability, the analysis indicates an altogether positive result as a result of climate effects from the potential expansion of wind power and greater consideration to nature. The plan is also deemed to entail negative environmental effects mainly linked to the construction phase in wind power establishment in the planning area, but also some local environmental pressure from sand extraction. Greater greenhouse gas emissions also arise as a result of the extended route for shipping because the energy areas according to the planning proposal's use constitute physical obstacles to ships.

Social sustainability
The proposed plan is deemed to have a small positive contribution in social sustainability as a result of employment effects from a possible expansion of wind power. The plan is not expected to have any effects with regard to *identity-creating activities and factors* in the area, *gender equality*, or *cultural*

environments. However, a potential expansion of wind power entails reduced *accessibility* and *coexistence* between various sectors and interests in the area.

9.2.3 Cross-border environmental impact

Sectors that cross borders in the Gulf of Bothnia are mainly Commercial fisheries and Transportation and communications (shipping), but also the possibility of establishing climate refuges for, e.g. ringed seals. Because both the spread of the sea ice and the ringed seal population extend across the border to Finland, it is desirable to have cross-border protected areas to increase the area's function as a climate refuge.

Commercial fisheries is under way in the border area between Sweden and Finland in the northern Gulf of Bothnia, and this has potential cross-border effects. The MSP points out the area for Commercial fisheries, but no negative effects can be seen. In the Northern Bothnian Sea and Norra Kvarken, it is mainly shipping in Norra Kvarken that creates the impact on the environment because shipping is intensive in the area and some areas have a more sensitive environment. Cooperation between Sweden and Finland in the area in terms of shipping's impact on the environment is well established.

The analysis carried out with the help of Symphony shows that the areas where the MSP points out shipping and Commercial fisheries in the same areas generally indicates a burden on the environment, which might need to be managed through cross-border cooperation because these sectors are mobile and their environmental impact is cross border. Mobility also provides opportunities for improvements where one can jointly create limitations to fishing and shipping in some particularly pressureed areas through cooperation across the borders. In the Southern Bothnian Sea, it is mainly Commercial fisheries in the border area between Sweden and Finland that can create cross-border environmental impacts. The MSP also points out the area as important for shipping, which is why a combination of these sectors can create greater impacts. The MSP proposes the relocation of a shipping lane to create space to be able to establish wind power and to keep shipping from passing over shallow banks.

The sustainability assessment (COWI, 2018b) shows that the proposed plan in the Gulf of Bothnia is deemed to potentially lead to cross-border effects through indirect impact from two sectors/interests – Energy and Nature. An expansion of sea-based wind power is deemed to lead to negative impacts due to the offshore areas where the bottom environments are of major significance to the new recruitment of commercial fish species. The effect is deemed to be significant during the construction phase and then to decrease as water clouding and underwater noise subside. The effect of the actual claiming of use of the seabed is deemed to decrease as foundations and pillars are recolonised by bottom-dwelling flora and fauna. The negative impact that is expected during the construction phase might, however, lead to decreased fish stocks in the affected marine areas, mainly in the Bothnian Bay, with

potentially decreased catches for Finnish fishermen as well. When it comes to the interest Nature, the plan provides guidance on *particular consideration to high nature values (n)* in around 10% of the MSP area's environmentally most important areas with high nature values, or in areas of significance to Commercial fisheries with regard to spawning and nursery areas. These effects are either in combination with General use or in combination with the use Energy extraction. The plan's application of *particular consideration to high nature values (n)* could potentially strengthen access to the ecosystem services that Commercial fisheries and a significant part of Tourism and outdoor recreation are dependent on. The effect could entirely or partially offset the potential negative impact from the wind power expansion and could possibly have a positive effect on Finnish Commercial fisheries as well.

In addition to the potentially significant effects mentioned above, the plan is also deemed to entail somewhat elevated emissions to air from the combustion of ship fuel because the plan entails a somewhat extended travel route as a result of relocations of two shipping lanes. The effect is deemed, however, to be small and without cross-border effects.

The environmental impact that extends over national borders requires cooperation and dialogue between the countries. SwAM (2014) has initiated a dialogue with all nine neighbouring countries that Sweden borders on in the sea. The discussions indicate a common set of problems and a good cooperation climate.

The dialogue arrived at the following conclusions regarding these problems:

- A shared and collective illustration of the present situation as a starting point for the planning is desirable, and this includes planned, but not yet implemented, projects.
- Regarding the method for the ecosystem approach, there are partly different perspectives.
- Linear objects must be coordinated between the countries, such as power lines, bridges, shipping routes, and pipelines.
- Common guidelines for safety distances for wind power facilities in relation to shipping are desirable.
- Both early and on-going cooperation and exchange of planning documentation throughout the planning process and not just in connection with the Espoo consultation are important.
- Exchange of data and planning information between countries is necessary if it is to be possible to make plans that are coordinated with each other, but this is difficult because one often ends up in secrecy issues.
- Integration of the Marine Strategy Framework Directive and the Maritime Spatial Planning Directive is a challenge, not least because there are different administrations in several countries that are

responsible for the implementation of the respective directives. The marine spatial planning is not seen as a distinct tool for the implementation of the Marine Strategy Framework Directive, and the connections to the spatial perspective are perceived to be weak, except for protected areas.

- Wind power, tourism, shipping, and aquaculture are the thematic sectors that the majority of countries see as possible growth sectors. However, although there is much planning and discussion about wind power and to some extent aquaculture at sea, implementation of concrete projects is as yet progressing slowly.
- The interaction between the work on blue growth and an improved environment and how these different perspectives should be combined is highlighted as a challenge.

There is a need to handle chemical weapons and leftover munitions in some parts of the marine spatial planning areas (SwAM, 2014).

Other common cross-border issues concern wind farms in shallow areas and other energy production, sand extraction, cables and power lines, trawler areas, and cooperation between authorities and follow-up and monitoring.

The report (SwAM, 2014) also confirmed that there are good conditions for coordinated marine spatial planning because the majority of the neighbouring countries will be closely in phase with each other in terms of their marine spatial planning.
Marine spatial planning in the Baltic Sea has elements of issues of an inter-state nature that might require political negotiations and agreements, e.g. secrecy issues regarding the exchange of data between states or unresolved border issues.

The EU-funded cooperation within the Baltic SCOPE project indicated the advantages of cooperation between countries that are preparing MSPs and how method development can be done jointly. Among other things, the importance of cooperation between relevant authorities and of paying attention to bilateral and cross-border environmental issues.. There is also an opinion that the planning authorities should create a good and symbiotic cooperation with the authorities that have sector responsibility and that they should be permitted to influence the marine spatial planning. The process should map common conflicts and synergy effects, and it should apply knowledge in methodology for risk assessment and conflict management in the work. The importance is also pointed out of using the ecosystem approach and its checklists in the approach to the work.

Cooperation across borders is dependent on how far the countries have come in their marine spatial planning process, but several of the neighbouring countries have opened up for cooperation and have the possibility for exchanging experiences with the Swedish process (European Union 2017, SwAM 2014). For the Gulf of Bothnia, the cross-border cooperation is directed at Finland, which

has not come as far in the marine spatial planning process as Sweden. There are several joint issues, and this is why cooperation should be sought in terms of certain specific issues.

9.2.4 Alternative formulations

Within the scope of this SEA, alternatives for *Storage and extraction of material* were analysed (refer to Section 8.3.2 and 9.1.2). In summary, it can be said that an alternative MSP without the use of sand extraction entails a reduced local environmental effect. This is because sand extraction accounts for a relatively large share of the cumulative environmental effect in the sand extraction area (approx. 87%), and also a significant share of the cumulative environmental effect in the Bothnian Bay marine area.

Within the Gulf of Bothnia's marine spatial planning area, there are range areas within which alternative formulations would be possible. These have not been possible to evaluate within this environmental assessment because the alternatives are not chosen or specified.

9.2.5 Proposed revisions to the plan

Plan alternative compared with the zero alternative
Analyses implemented mainly with Symphony show that, despite the increased areas for energy and sand extraction, the MSP does not entail any clear change in the cumulative environmental effect compared with the zero alternative. Within the Gulf of Bothnia marine spatial planning area, related activities will marginally increase the planned use, and the total environmental effect will increase by around 1% compared with the zero alternative. Within smaller areas, both increases and decreases will arise in the cumulative environmental effect, and the MSP thereby generally entails a redistribution of the environmental impact.

The expansion of sea-based wind power in the areas for energy extraction and the effects of this expansion are the most significant difference in relation to the zero alternative.

The theme Nature is favoured by the plan as a result of the instruction for *particular consideration to high nature values (n)*. These areas are assessed to provide local positive effects that can also provide positive environmental effects in surrounding areas when the plan's guidance is translated into measures within different sector administrations.

The plan is assessed to contribute positively to meeting goals and set targets, which is largely due to the good effect that the areas with *particular consideration to high nature values (n)* are deemed to be able to provide.

The sustainability assessment done in parallel with the environmental assessment indicates an overwhelmingly positive effect for the plan alternative with regard to financial, ecological, and social sustainability.

Proposed revisions
Proposed revisions to the plan proposal are formulated in consideration of the overall and strategic level at which the plan works. The revision proposals therefore primarily aim to influence the plan's overall formulation in a direction that to the greatest possible extent enables the fulfilment of the plan's guiding environmental and sustainability objectives.

In general, the positive effect that the areas with *particular consideration to high nature values (n)* provide can be pointed out here based on related assumptions, both environmentally and from a sustainability perspective. The good effect of consideration for these areas is weighed up to some extent by the impact from wind power establishment and sand extraction in an analysis of the cumulative environmental effect with the help of the Symphony planning method. One recommendation is, however, that more areas be identified where some form of special environmental consideration should be taken and to find possible coexistence with various sectors within these areas.

Another recommendation is to also identify areas worthy of protection with high and important environmental values and to ensure that nature values in these areas receive marine protection, which provides stronger protection than the aforementioned areas with environmental consideration.

SwAM can propose regulations for areas if these are considered necessary to achieve the objective of the MSP. These can contain binding limits and could be a stronger alternative to areas with *particular consideration to high nature values (n).*

By 2050, several areas are expected to be protected by marine area protection. Within the Convention on Biological Diversity, there is a target that 10% of coastal and marine areas shall be protected by marine area protection by 2020. In connection with the government decision on new Natura 2000 areas in December 2016, Sweden achieved the objective on a national level, but not in the Gulf of Bothnia, which currently has around 5% of its area protected (SwAM, 2016b).

The results from the sustainability assessment have identified a number of adjustments to the MSP that might mitigate the negative effects of wind power establishment. An expanded use of the indication *particular consideration to high nature values (n)* combined with *General use* and *Energy extraction* could potentially strengthen access to the ecosystem services that Commercial fisheries and a significant part of Attractive living environments (Tourism and recreation*)* are dependent on. The effect would partly or entirely be able to offset the local negative effect from the wind power expansion. Another proposed adjustment is to not indicate sea-based wind power closer than around 10 km from land in order to minimise the negative visual effect. These changes would probably also provide a more positive outcome in the

assessment of the plan's effect on goal attainment for the Swedish environmental objectives.

The MSP could work further to identify areas that are suitable for energy extraction at a greater depth and thereby reduce the impact on the shallow banks, and it could support long-term planning for technical development.

10 Monitoring and audit

10.1 Continued planning process and environmental assessment

The marine spatial planning process comprises the phases of discussion, consultation, review, and adoption. After the initial informal discussion phase, where drafts of proposed plans and SEAs were discussed, the planning process has continued with this formal consultation.

Consultation document
Consultation regarding the MSPs, including the SEAs and sustainability assessments, is being held for six months from 15 February to 15 August 2018. The Espoo consultation with neighbouring countries is being held for three months during this period.

Review document
After the consultation is completed on 15 August 2018, the preparations for the review will begin. This means that the proposed plan will be revised based on comments received and that the SEA and sustainability assessment will be updated as necessary. The actual review dialogue will begin in the spring of 2019, which is the last phase to obtain opinions before the proposals are submitted to the Government.

Adoption of the MSPs
SwAM's aim is for the MSP proposals to be submitted to the Government in December 2019. The Government will prepare the issue internally based on the proposed plan and other decision documentation. To fulfil the EU Maritime Spatial Planning Directive, Sweden should have adopted national MSPs before March 2021.

After the plans have been adopted and begun to be applied, a follow-up of the plans will be done continuously.

10.2 Evaluation and follow-up

Once the MSPs have been adopted, SwAM is responsible for follow-up of the plans' environmental impact and for evaluating the environmental impact that the plans' actually entail. This will be done to obtain knowledge early on of significant environmental impacts that were not previously identified in the process. The follow-up also aims to monitor the expected environmental impacts that this environmental assessment describes. A control programme will therefore be prepared that describes how the follow-up will be done and what parameters will be followed up. The control programme will be coordinated with other existing environmental follow-ups in order to ensure effective implementation.

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Appendices

Glossary

Term	Explanation
Abrasion	Abrasion of the seabed through, e.g. trawling.
Accumulation bottom	Seabed where sediment materials (particles that sink to the bottom) remain.
DDT	Dichlorodiphenyltrichloroethane (DDT) is an insecticide that was introduced in 1942.
Ecosystem service	A concept used to describe the sea's benefits, from food to recreation activities at, on, or in the sea.
Erosion bottom	Seabeds where sediment can easily erode, be dispersed, and carried away.
Green infrastructure	Green infrastructure is defined as how important marine habitats and processes are linked in time and space. Diversity and fragmentation of ecosystems are assessed in the environmental assessment within green infrastructure. Green infrastructure also refers to the ecological functional network of structures and habitats that contribute to the preservation of the biological diversity with a focus on functionality and the connectivity between them. The sea's green infrastructure is thereby comprised of habitats for various species, spreading routes, and migration routes for birds, fish, and other animal species, and this infrastructure is vital to be able to preserve the entire ecosystem.
Angiosperms	Plants characterised by having seeds enclosed in fruit (in contrast to gymnosperms).
HCH	Hexachlorocyclohexane (HCH)
HELCOM MPA	Marine Protected Areas, a marine protected area in the Baltic Sea established by HELCOM to protect marine ecosystems and habitats.
Hard seabeds	On hard seabeds, there are habitats such as mussel beds and seaweed forests.
Soft seabeds	The most commonly occurring type of seabed in Sweden's marine areas. Soft and shallow soft seabeds provide a good substrate for seaweed beds and for seed plants and charophyte green algae. These are also characterised in contrast to hard seabeds of digging animals, such as annelid worms, molluscs, crustaceans, and echinoderms.
MSFD	Marine Strategy Framework Directive, an EU initiative
PCB	Polychlorinated biphenyl (PCB) is a group of environmentally and health hazardous industrial chemicals.

Pelagic habitats	Pelagic habitats refer to the part of the marine habitat that is above the seabed or is not mainly affected by the bottom environment. It is in the pelagic zone that the majority of the sea's primary production takes place. This habitat is strongly affected by the photic (actually euphotic) one's extent, i.e. the upper sunlit part of a body of water in which photosynthesis can occur.
Plankton	Plankton is a collective name for organisms that live in the pelagic zone, and is an important part of the food chain because it is the main food for, among others, the endangered porpoise. Plankton consist of viruses, bacteria, protists, plants, and animals and are also food for seals and fish. They are a good indicator of changed water quality because they quickly react when nutrient salt concentrations and light change, especially plant plankton. The composition and amount of plankton also extensively affect the rest of the water environment through changed visual depth and food supply for animals that live in the water column or on the bottom.
Oxygen-free bottoms	Oxygen deficit leads to reduced biodiversity and altered species composition, and thereby has a negative impact on the ecosystems. Oxygen deficit refers to oxygen levels below 2 ml/l, which entails levels that make it difficult for most animals to survive (SwAM, 2015c). Oxygen deficit is defined on two levels: hypoxia entails levels of 2 mg/l, and anoxia means a total absence of oxygen. When all oxygen is consumed by various bottom processes, hydrogen sulphide (H_2S) is formed and is toxic to marine life. Under oxygen-free conditions, nutrients are also released, such as phosphate and silicate, from the sediment to the water, which upon vertical mixing can reach the surface layer and the photic zone and thereby contribute to the eutrophication problem. High levels of phosphate benefit the growth of plant plankton, especially cyanobacteria in the summer in the Baltic Sea, which can further increase the oxygen deficit as plankton ultimately sink to the bottom and require more oxygen to be broken down (SMHI, 2016). A higher spread of oxygen-free seabeds also contributes to a higher production and emission of methane gas, which is a greenhouse gas. The methane emissions are also affected by climate change because an increase in primary production resulting from a temperature increase can increase the production of methane gas. With warmer winters, the natural methane gas emissions can occur during longer periods every year. It is thereby of utmost importance to focus on reducing the oxygen-free seabeds, not only from a plant and animal life perspective, but also to not increase the methane emissions from the seabed.
Transport seabeds	Seabeds where sediment material is temporarily deposited until it is moved to accumulation bottoms.
Offshore banks	Offshore banks are elevations from the bedrock that differ from shallower coastal areas in that they are surrounded by deeper water. They are generally home to species and habitats that are characteristic for more unaffected marine environments. The offshore banks thereby often have high ecological and biological values because organisms that previously occurred in shallow coastal areas, but disappeared or decreased as a result of increased disturbances and pollution, often still exist. At the same time that offshore banks are home to high

	nature values, they are also attractive areas for installations of wind power due to their shallower conditions.