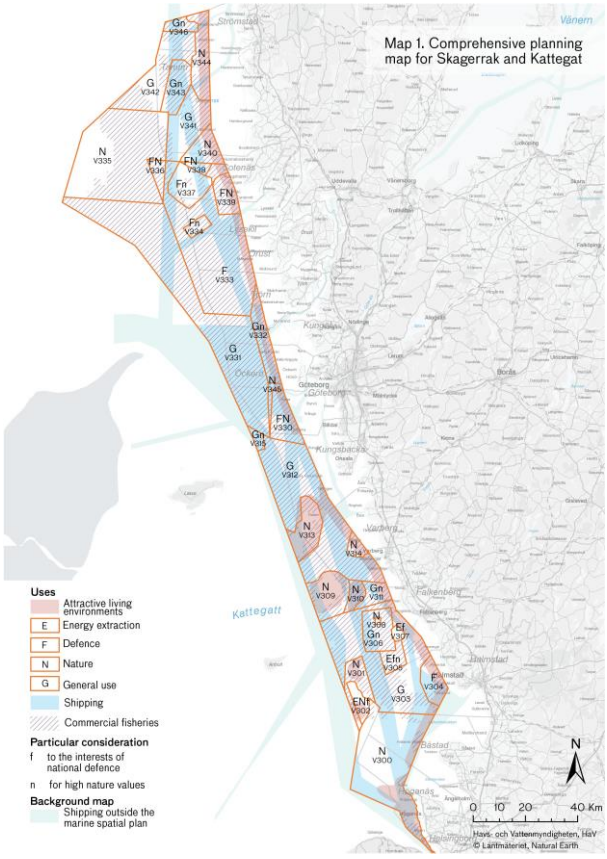
MARINE SPATIAL PLAN PROPOSAL

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 Skagerrak and Kattegat

Consultation document



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Box 11 930, SE-404 39 Gothenburg, Sweden

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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).

Consultant:
Mats Ivarsson, Assignment Manager COWI
Kristina Bernstén, Assignment Manager SEA
Selma Pacariz, Administrator Environment
Ulrika Roupé, Administrator Environment
Emelie von Bahr, Administrator Environment
Marian Ramos Garcia, Administrator GIS
Morten Hjorth and others

Strategic Environmental Assessment

Marine Spatial Plan - Skagerrak and Kattegat

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 with associated strategic environmental assessments (SEA) in broad collaboration. The marine spatial plans (MSP) 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 a sustainable development and be consistent with the objective of a good environmental status in the sea.

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

The SEA for the MSP draft for Skagerrak and Kattegat in the dialogue phase was prepared by the consulting firm WSP Sverige AB. Comments submitted during the dialogue phase were worked into the MSP proposals 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 sensitivity and impact from plan proposals. The revision was done in collaboration with SwAM, where COWI AB stood for the assessment of environmental effects and consequences, and 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 consultation phase's plan proposal prior to the review phase in spring 2019.

Gothenburg, 10 April 2018

Björn Sjöberg, Director,
Department for Marine and Water Management

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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 for the Gulf of Bothnia, the Baltic Sea and Skagerrak and Kattegat. The assignment is specified in the Marine Spatial Planning Ordinance (2015:400).

For each marine spatial plan (MSP), an environmental assessment and associated environmental impact assessment, the strategic environmental assessment (SEA), are also being done. This report is the SEA for the Skagerrak and Kattegat marine spatial planning area. It constitutes a consultation document together with the proposals on MSP that were prepared by SwAM for consultation in spring and summer 2018. In this SEA, the MSP's two marine sub-regions were analysed: Skagerrak and Kattegat.

The objective of the sustainability assessment and SEA is to integrate environmental aspects in the planning and decision-making so that a 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 and in addition to that stipulated in the Marine Spatial Planning Ordinance, a sustainability assessment was also done. The sustainability assessment is based on the three sustainability dimensions: *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.

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, 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 to relatively small environmental effects according to the analyses 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 effects that the MSP may 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 environmental impact 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, WATER	AIR, 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	Moderate negative	Small negative	Positive	Small negative	Positive
DEFENCE	None	None	None	None	None	Positive
STORAGE AND EXTRACTION OF MATERIALS	-	-	-	-	-	-
NATURE	Positive	Positive	Positive	None	None	Positive
TRANSPORTATION AND COMMUNICATIONS	None	None	Positive	None	None	None
AQUACULTURE AND BLUE BIOTECHNOLOGY	-	-	-	-	-	-
COMMERCIAL FISHERIES	None	Positive	None	None	None	Positive

Population and people's health

The MSP is deemed to provide a positive impact on the environmental aspect *Population and people's health*.

In the future, demand from both national and international tourism to participate in the archipelago life of Skagerrak and Kattegat and to use the sea for recreation is expected to increase. One of several conditions is that important nature values are preserved, which the MSP's introduction of areas with *particular consideration to high nature values (n)* is intended to do. The MSP's areas for energy extraction may entail restrictions for outdoor recreation.

The spatial changes that an approved MSP for Skagerrak and Kattegat entails are deemed to only marginally contribute to emissions to air or marine litter. However, the sectors' development up to 2030 may entail increased pressures compared with the present situation.

Animals, plants and biological diversity
Through proposals on areas with *particular consideration to high nature values (n)* and regulation of Commercial fisheries, the MSP is expected to have a positive impact regarding the environmental aspect *Animals, plants and biological diversity*. Energy extraction that is indicated in the MSP entails a moderate negative impact, even if energy extraction also entails some positive effects. In planning, establishment and operation of wind power establishment, extensive consideration must be taken to nature values. In a comprehensive assessment, the MSP overall is deemed to entail a small negative impact on the environmental aspect *Animals, plants and biological diversity*.

In the plan, the use Commercial fisheries is present in large parts of Skagerrak and Kattegat. The pressure from Commercial fisheries is expected to decrease up to 2030 in both the zero alternative and the plan alternative as a result of the regulation of equipment and fishing periods within fishing management. The plan alternative includes important spawning areas for cod in central and southern Kattegat with the use Nature or with protection through areas with *particular consideration to high nature values (n)*. Altogether, these standpoints in the MSP are assessed to contribute to the impact of Commercial fisheries being reduced in these areas.

Sea-based wind power primarily has an impact through *underwater noise* from construction work and the operation of the facilities, and the use of the seabed with *physical disruptions* and *physical losses*. Like habitats of interest for Commercial fisheries, energy extraction's use of seabed habitats for wind power foundations may create artificial reefs that can benefit biodiversity in general, at the same time that wind power limits access for fishing, shipping and recreational activities. The total environmental effect thereby generally decreases in these areas, but the assessment needs to be made specific for each area of consideration to the local nature values. In the plan, there are three areas with the use Energy extraction in Kattegat. Adaptation needs to take place so that sea-based wind power can co-exist with Kattegat's high nature values and in some areas also the local Commercial fisheries. Adaptation based on the interests of total defence is also necessary.

Land, soil, water, air, climate, landscape, built environment and cultural environment
For the environmental aspects of *Land, soil, water, air, climate, landscape, built environment* and *cultural environment,* the MSP is deemed to primarily entail local negative environmental effects in the areas where new establishment is proposed as energy extraction while a positive effect is expected to arise in the areas that *particular consideration to high nature values (n)* is to be taken through traffic regulation. The MSP is deemed to have

a positive consequence on the part of the environmental aspect that concerns *climate* such that the plan provides conditions for wind power extraction. For other parts of this environmental aspect, the plan entails no environmental impact. Altogether, the MSP is deemed to entail a positive impact for the environmental aspect *Land, soil, water, air, climate, landscape, built environment and cultural environment*.

Shipping in Skagerrak and Kattegat is very extensive, and in the zero alternative and plan alternative, shipping is assumed to increase by 50% in Skagerrak and Kattegat by 2030. Within the MSP, shipping received larger areas for its use compared with existing national interest claims to enable proposals on traffic separation systems and anchorages. An analysis has shown that traffic separation and broader shipping lanes altogether entail an improvement for the marine environment (SwAM, 2017b). Shipping contributes to environmental problems in several different ways. 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 areas with use energy extraction and areas in which *particular consideration to high nature values (n)* and to some extent also *to defence (f)* shall be taken. By 2030, the impact of total defence is expected to increase proportionally with the development of the sector. The interests of the Defence are deemed 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 cause technical disruptions that compete with the interests of total defence. Altogether, the MSP is not deemed to entail any change for emissions to air and sea from the different sectors (shipping, Commercial fisheries and defence) compared with the zero alternative.

Cultural heritage remains, such as shipwrecks, may be affected in an establishment of permanent constructions for wind power and must be taken into account in a permit process and adaptations must be made to minimise the impact on possible permanent remains. Establishment of wind power entails a local impact on the seabed and the marine environment. The plan entails a potential emission reduction of carbon dioxide in an establishment of renewable energy extraction and is thereby deemed to have a positive effect (COWI, 2018b).

Management of land, water and the physical environment otherwise and *Other management of materials, raw materials and energy*.
The MSP for Skagerrak and Kattegat overall is deemed to have a positive impact for the environmental aspects *Management of land, water and the physical environment otherwise* and *Other management with materials, raw materials and energy* and work for a good management of the marine spatial planning area through sectors/themes Energy extraction, Defence, Nature and Commercial fisheries. Energy extraction has a positive effect by contributing

energy from a renewable source and thereby a positive impact on the part of the environmental aspect that concerns *Other management of energy*. *Particular consideration to high nature values (n)* has a positive effect on fishing, but also other parts of ecosystems, which entails a positive impact on the part of the environmental aspect that concerns *Other management with raw materials*.

In the MSP for Skagerrak and Kattegat, there are three areas with the use Energy extraction. The wind power establishments that can be related to the areas of use are preceded by an environmental impact assessment process in which local impact and effects are analysed and assessed with the aim of minimising the environmental impact. Within Skagerrak and Kattegat, there is no sand extraction today and the MSP does not plan for any such use. In the MSP, some sectors are deemed to be able to coexist and also in areas where the plan recommends *particular consideration to high nature values (n)*, one or more other uses can coexist. In most cases, the areas, where *particular consideration to high nature values (n)* shall be taken, are important spawning grounds and recruiting areas for fish, which means that the MSP through these areas can have a positive effect on the fish stocks as a resource. It is therefore important in an establishment of other activities to take this into consideration and even in fish management discuss possible new or strengthened regulations of commercial fisheries based on the MSP.

Goal attainment and sustainability

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

Plan proposal and the Swedish environmental objectives

The proposed MSP concerns several of the Swedish environmental objectives. In the evaluation of the plan's contributions to goal attainment, focus is on the environmental objective of *A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos,* more specifically on the specification: *Ecosystem services - important ecosystem services of coasts and seas are preserved*. An overall assessment is that the plan does not entail any net effect on the possibility of achieving the environmental objective of *A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos* in Skagerrak and Kattegat. The negative impact on cultural ecosystem services as a result of the establishment of sea-based wind power is deemed to be able to be offset by positive effects on the planning area's ecosystem services from the proposed plan's guidance on *particular consideration to high nature values (n)*.

Proposed plan and good environmental status according to the Marine Strategy Framework Directive

The overall effect when it comes to the plan's impact on the possibility of achieving the environmental quality standard (EQS) of *Good environmental status* in the *North Sea* management area is difficult to assess as the plan proposal entails both negative and positive effects.

Further analyses are required to determine with certainty the combined effect of the plan proposal on the current environmental quality standards.

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 be able to potentially entail a negative effect due to guidance on wind power establishment in unaffected areas (Stora Middelgrund (V302)).

The sustainability assessment of the proposed MSP in Skagerrak and Kattegat indicates a slightly positive result compared with the zero alternative when no plan is applied (COWI, 2018b):

Economic sustainability
The combined result in terms of the plan proposal's economic effects show a slightly positive effect compared with the zero alternative. This is primarily due to expected positive economic effects from energy extraction from wind power and strengthened ecosystem services in the planning area as a result of increased consideration of nature through guidance on *particular consideration to high nature values*.

Ecological sustainability
For the ecological sustainability dimension, positive and negative effects are largely deemed to offset each other and result in an overall neutral assessment compared with the zero alternative. Negative environmental effects are deemed to be able to arise as a result of wind power establishment according to the plan proposal's guidance in the marine sub-region Kattegat, which is deemed to entail significant burdens on high nature values. At the same time, establishment of wind farms means that fishing with equipment associated with extensive environmental impact will be limited or end in affected areas. Such a limitation of Commercial fisheries in the concerned energy areas is deemed to be able to entail major positive environmental effects locally. On condition that the fishing has the possibility to move to other areas, the pressures are assumed to increase in surrounding areas, which is why the total environmental impact from Commercial fisheries as a result of energy establishment is deemed to be the same in the plan and zero alternatives. A positive environmental effect that is attributed to the energy establishment is the climate benefit deemed to be able to arise as a result of an expansion of sea-based wind power in the plan area. In addition, the plan proposal's guidance on *particular consideration to high nature values* is deemed to be able to entail reduced environmental impact.

Social sustainability
As for ecological sustainability, the overall result for the social dimension is deemed to be insignificant in relation to use in the zero alternative. Effects

within the social dimension are primarily deemed to be able to arise as a result of establishment of wind power according to guidance in the Kattegat marine sub-region. A substantial visual impact on the landscape is deemed to be able to lead to a decrease in perceived accessibility to the marine area. Wind power establishment according to guidance in the plan proposal is also deemed to potentially be able to entail a negative impact on identity creation factors, such as outdoor recreation, tourism and Commercial fisheries. Energy establishment also entails a risk of damage to possible cultural environments on the seabed, although there is extensive uncertainty in terms of the scope. The identified negative effects are partially offset by the energy establishment also being deemed to be able to lead to higher employment.

Cross-border environmental impact

For Skagerrak and Kattegat, the cross-border environmental impact is mainly about the effects from the sectors of Transportation and communications, Commercial fisheries and Energy. The cross-border impact deemed to be caused by the MSP mainly takes place in Kattegat close to the border with Denmark, and in northern Skagerrak towards Norway's border and is deemed to be limited and in some cases positive.

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 may need to be managed through cross-border cooperation, as these sectors are mobile and their environmental impact is cross border. Mobility also provides opportunities for improvements, where in especially impacted areas restrictions can be set on fishing and shipping in some areas through cross-border cooperation, such as in Skagerrak where the areas with a high impact according to the MSP are mainly in areas where Commercial fisheries is the most suitable use. Another activity that causes cross-border environmental impact is the establishment of wind farms in southern Kattegat, which also yields the effect that the area is limited for Commercial fisheries, and this can preserve nature values through reduced trawling and withdrawal of fishing stocks. Collaboration with, in this case, Denmark can ensure that the positive effect remains.

The analysis highlights that areas with *particular consideration to high nature values (n)* have positive effects in the MSP. At the same time from a cross-border perspective, cooperation with the neighbouring countries is required, mainly in terms of further concretisation of management measures within the plan's areas with *particular consideration to high nature values (n)* that are within the border areas. This is current in northern Skagerrak where Sweden and Norway are jointly responsible for valuable marine areas, such as off of the Koster islands. Another example is an area in northern Kattegat with *particular consideration to high nature values (n)*, where cooperation with Denmark will be needed to maintain the area's status.

Conclusions and future outlook

In general, areas with *particular consideration to high nature values (n)* contribute to reduced negative environmental effects. In the areas that have the use Energy in combination with *particular consideration to high nature values (n)*, the environmental effect will be even markedly better compared with the zero alternative. This is due to Commercial fisheries possibly being limited in the area and moving to neighbouring areas. A recommendation is that more areas be identified where *particular consideration to high nature values (n)* shall be taken.

The MSP can contribute to a good environmental status to a higher degree if the interest Nature is strengthened further and negative impact from other uses is limited. Moving or limiting the impact from Commercial fisheries entails a positive environmental effect, which should be further highlighted in the MSP. One such way is for the plan to more clearly take a standpoint for more marine protection that is a stronger protection than the current areas with high nature values compared with *particular consideration to high nature values (n)*. 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 where *particular consideration to high nature values (n)* shall be taken without it being a regulated marine protection area.

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 the Gulf of Bothnia, the Baltic Sea and Skagerrak and Kattegat that provide 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 marine spatial plans, the responsibility for preparation, consultation and cooperation in the proposal process, and monitoring and review.

According to the Ordinance, SwAM shall develop proposals for marine spatial plans 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 may 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. The Agency shall promote cooperation with other countries and the coordination of the Swedish marine spatial plans with those of other countries. Each MSP shall be environmentally assessed and a strategic environmental assessment (SEA) shall be prepared.

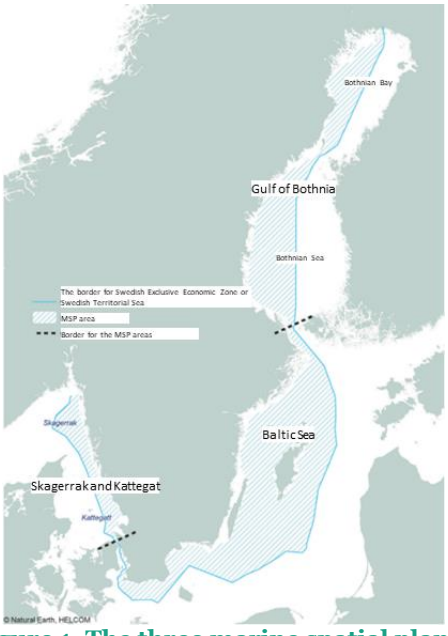

Figure 1. The three marine spatial planning areas. The municipal boundary between Östhammar and Norrtjälje forms the boundary between the Gulf of Bothnia's and the Baltic Sea's marine spatial planning areas. The municipal boundary between Helsingborg and Höganäs represents the boundary between the Baltic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

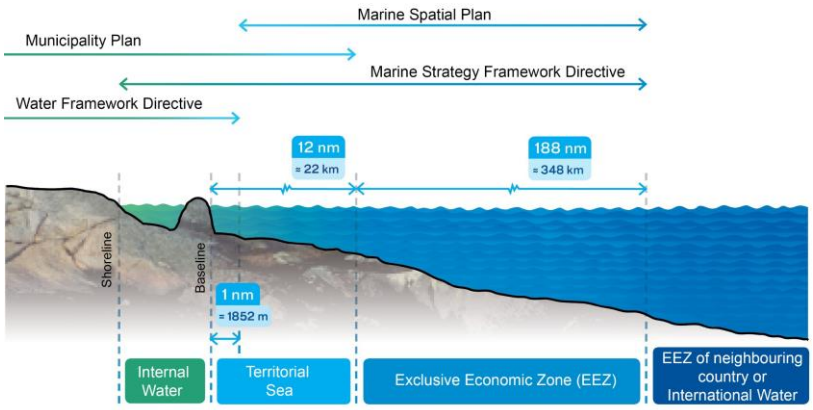

Figure 2. Illustration of the MSP's physical scope. This figure also indicates planning responsibility and environmental legislation for the sea.

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

A marine spatial plan should also provide the guidance necessary to be able to use the areas for the purposes that they are best suited to considering character, situation and needs[1]. The MSPs shall provide guidance to public

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

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 to the conditions of the ecosystems 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 that 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 rather are intended to serve as a guide. The planning should interact with both the international planning perspective, as well as 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 of the Skagerrak and Kattegat, Baltic Sea and Gulf of Bothnia also needs to be coordinated with each other (SwAM, 2015a). 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. A marine spatial plan 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 marine spatial plans. 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.

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 MSP 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 do not have 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 which may 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.
In the Skagerrak marine sub-region, municipal planning processes are under way in inter-municipal collaboration. In Northern Bohuslän, so-called Blue Master Plans were circulating for comment in 2017.

2.3.4 Interaction between land and sea

Developments in the sea are dependent on and governed by activities on land, and the marine spatial plans must therefore be placed in this context in the MSP proposal, the SEA and the sustainability assessment. Population and industry 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 high degree, an additional factor which the 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 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 (2017) have generated the MSP proposal for Skagerrak and Kattegat the environmental impact of which is being assessed in this strategic environmental assessment (SEA). The objective of the SEA is to integrate environmental aspects in the planning and decision-making so that a sustainable development is promoted[2]. With regard to the preparation of plans and programmes, the environmental assessment process is called a

[2]Act (2017:955).

strategic environmental assessment (SEA). An SEA shall be carried out when 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[3]. The work on the strategic environmental assessment is compiled in an SEA-document, the contents of which is listed in Chapter 6 Paragraph 11 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 may entail.

The proposal on the MSP for Skagerrak and Kattegat (plan map and plan description) will be out for consultation between 15 February and 15 August 2018. The SEA and sustainability assessment were added to the consultation on 10 April 2018. The consultation will take place with concerned authorities, organisations, etc. at a national, regional and municipal level. During this period, consultation will also be carried out with Sweden's neighbouring countries for the SEA, which is required in cross-border context 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 scoping for the environmental assessment and focus in the SEA. Marine spatial planning can briefly be described as a process of analysing and organising activities in marine areas to achieve environmental, social and economic policy objectives.

In the Road Map, 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.

[3] Marine Spatial Planning Ordinance (2015:400)

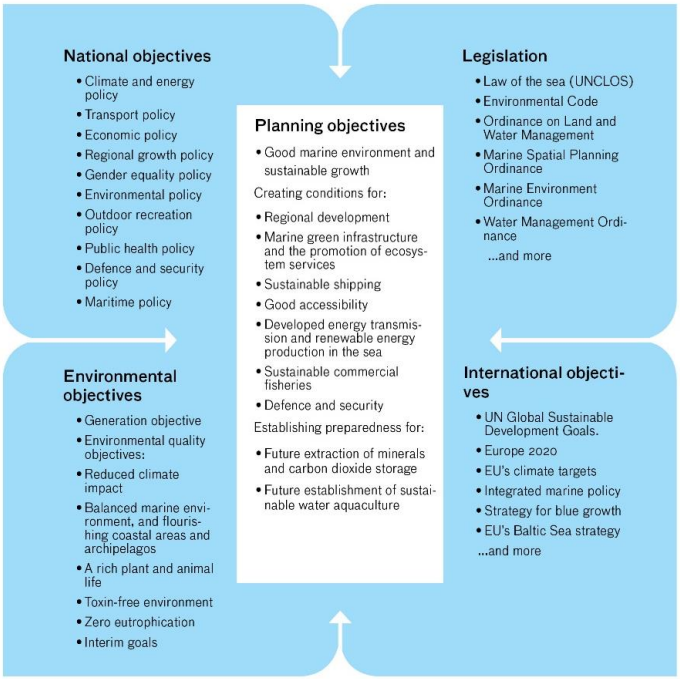

Figure 3 Identified planning objectives for the marine spatial planning, Marine Spatial Planning Roadmap, SwAM report 2016:21.

2.6 Sustainability assessment

In parallel with the SEA, a sustainability assessment is made of the MSP for Skagerrak and Kattegat. The sustainability assessment is based on the three sustainability dimensions: 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 maritime 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 the more general climate change. Marine ecosystem services and their fundamental role for the ecosystem's function are important points of departure as it is 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' nature and cultural values.

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

3 Marine Spatial Plan - Skagerrak and Kattegat.

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

The MSP also includes the areas where particular consideration shall be shown to high nature values and the interests of total 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 by all use of the area. *Particular consideration to high nature values (n)* is not a use in the plan, but a guide regarding consideration. *Particular consideration to total defence interests* (f) means that particular consideration shall be shown in all use of the area.

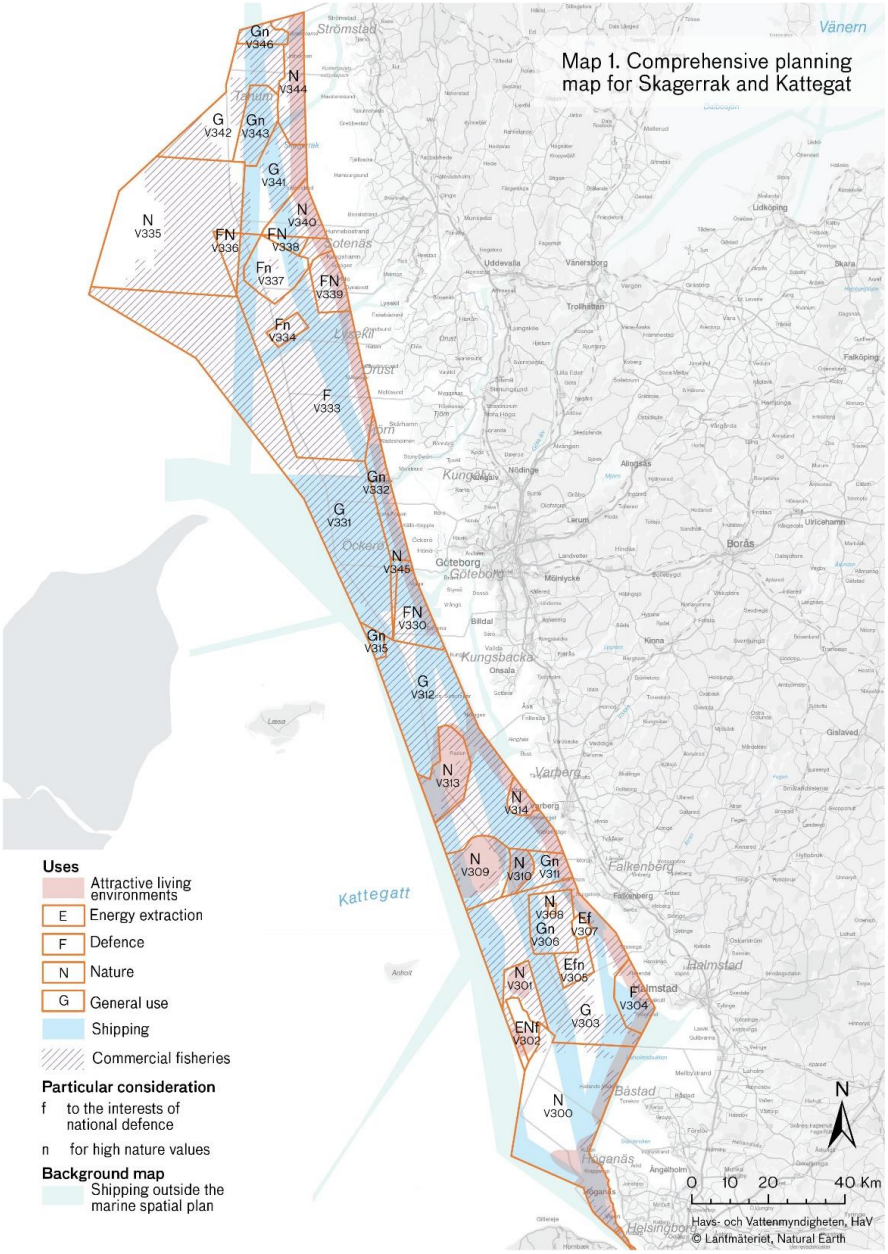

Figure 4 Comprehensive planning map for Skagerrak and Kattegat (SwAM, 2018b)

3.1 Summary of the MSP Skagerrak and Kattegat

In the Skagerrak and Kattegat marine spatial planning area, there are high nature values in many places and attractive living environments for people, where both outdoor recreation and tourism are important. Commercial fisheries in the area is extensive and includes both fish and shellfish that are caught with different methods. Some of the most important and largest Swedish ports are on the west coast and shipping routes between the North Sea and the Baltic Sea and to Denmark and Norway pass this area, which makes Transportation and communications a comprehensive theme, mainly through shipping. The Defence has marine training areas within the marine spatial planning area. The conditions for energy extraction are good, both with regard

to depth and wind conditions. Many activities coexist well in the marine spatial planning area. At the same time that there are good conditions for various activities, the environmental status in Skagerrak and Kattegat needs to be improved to be able to achieve a good environmental status.

Figure 5 Comprehensive map over the marine sub-regions in Skagerrak and Kattegat: 1: Skagerrak and 2: Kattegat.

3.2 Skagerrak

Besides the areas where the MSP has the use of nature (N), which entails an expansion in relation to the existing nature protection, there are also several areas where various activities shall show *particular consideration to high nature values (n).* From the theme Transportation and communications, shipping constitutes a larger area than existing national interest claims to enable proposals on traffic separation systems and anchorages (V330-333).

There is a rich and diverse biodiversity across the Skagerrak/Kattegat area, with a large share of Sweden's marine flora and fauna. Skagerrak shows a biological diversity and large fish stocks, which means that Commercial fisheries is an important activity in the marine area, with both diversity and unique species. Shrimp fishing is conducted to an large extent in Skagerrak, as well as fishing for Norway lobster. The use Commercial fisheries is therefore

present throughout the Skagerrak marine sub-region, except for a small area furthest west inside the Natura 2000 area Bratten.

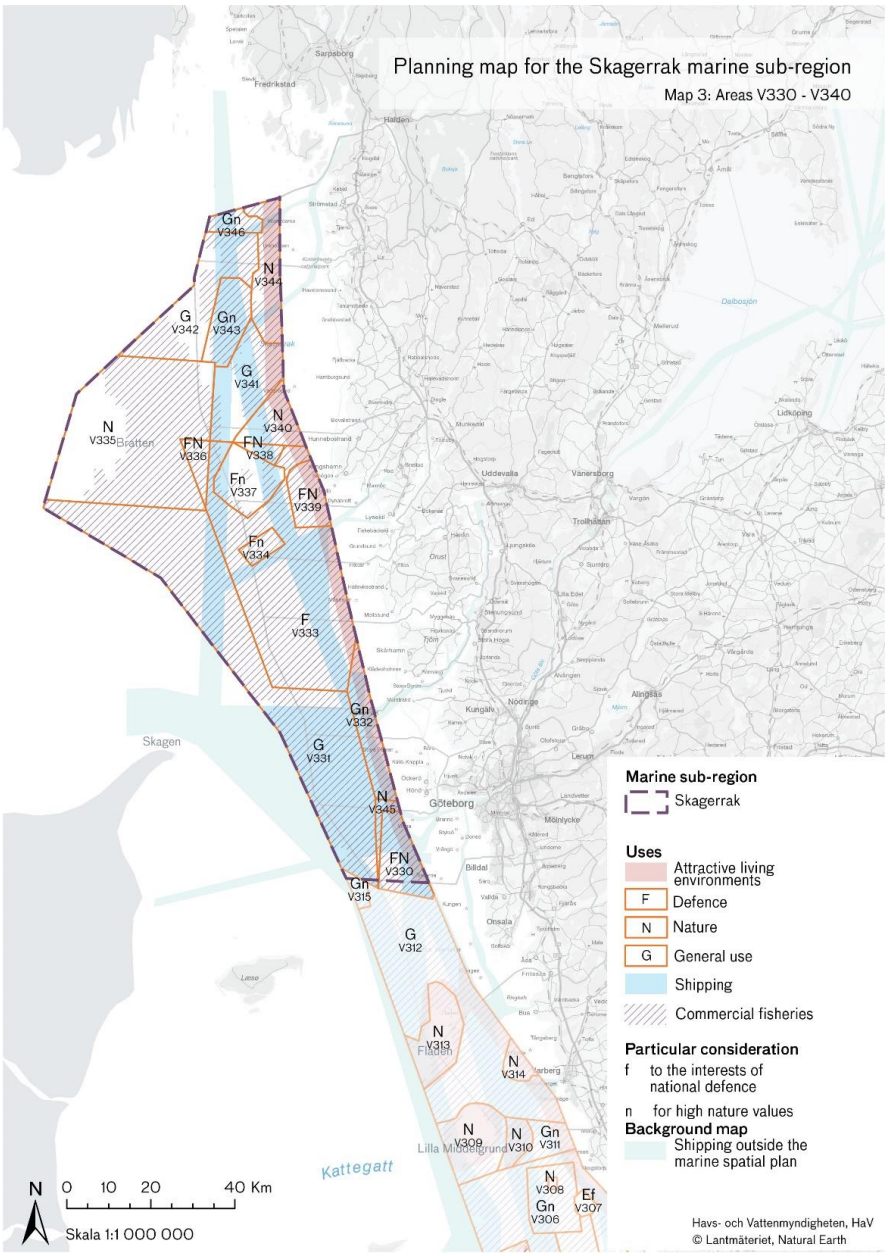

Figure 6 Planning map for the Skagerrak marine sub-region. Area numbers are on the map and areas with particular consideration to high nature values are marked with an n. (SwAM, 2018b)

3.3 Kattegat

Shipping is important and extensive in Kattegat since the way through the marine sub-region is one of only two ways into the Baltic Sea for large vessels. The shipping lanes are widespread in the entire marine area with several lanes from north to south and into the ports along the coasts, on both the Swedish and Danish sides. The use *shipping* therefore constitutes large areas that provide room for the proposed traffic separation systems necessary for safe shipping (V300, V303, V306, V309- 313, V315).

In the marine area, there are good prerequisites for wind power with high wind speeds and offshore banks with suitable depths. In Kattegat, there are three areas with the use Energy. In two of the areas (V305, V307), *particular consideration to high nature values (n)* is indicated. One area (V302) coincides with Natura 2000. The offshore banks that have the highest nature values according to the earlier inventory (Swedish Environmental Protection Agency, 2006) are withheld from energy extraction.

High values mainly for birds and porpoises and important spawning areas for fish and valuable bottom environments are safeguarded with the use Nature**.** These are mainly on the offshore banks, furthest to the south and along the coast. Several uses also need to show *particular consideration to high nature values (n)* in several areas in Kattegat.

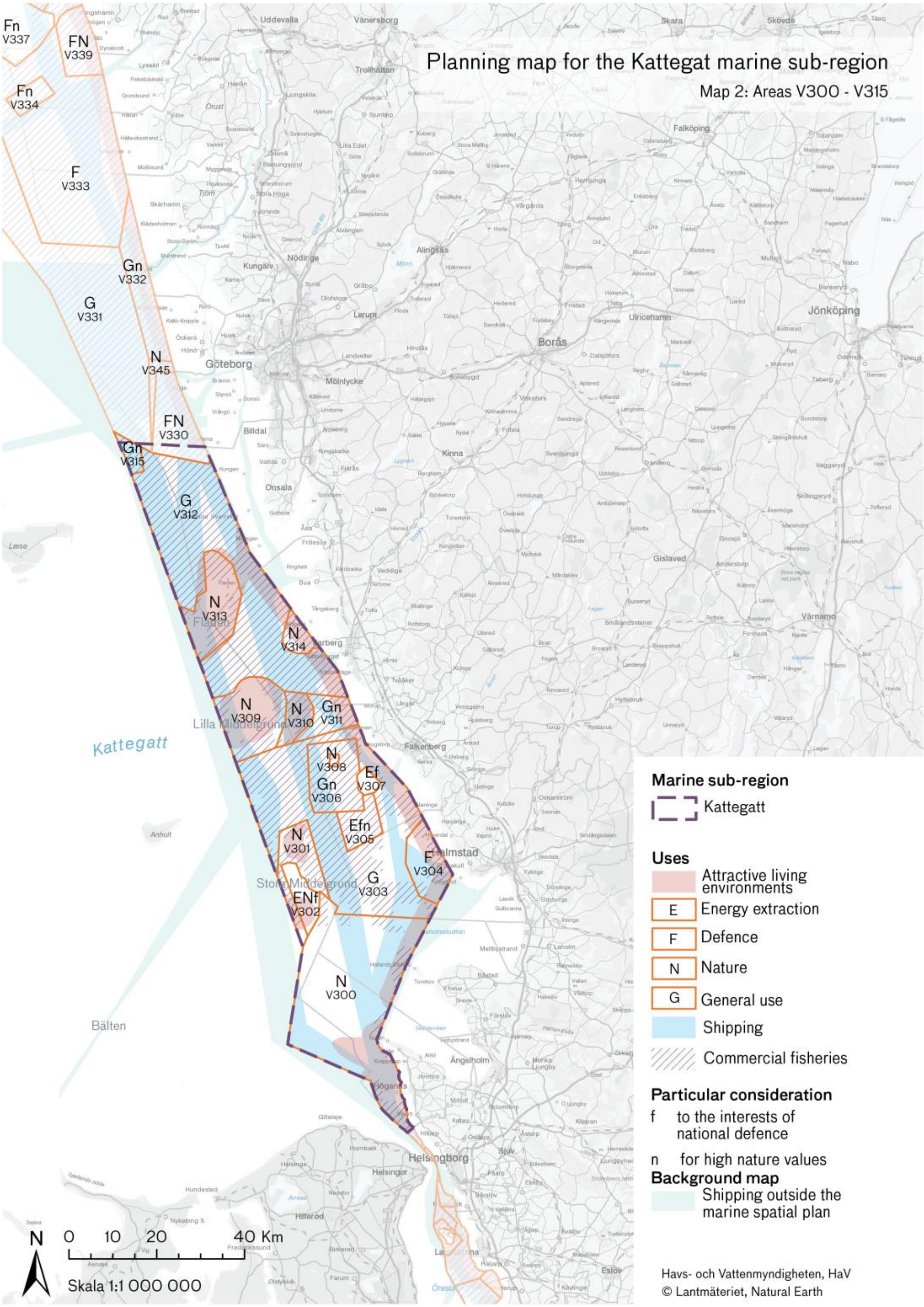

Figure 7 Planning map for the Kattegat marine sub-region. Area numbers are on the map and areas with particular consideration to high nature values are marked with an n. (SwAM, 2018b)

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 a sustainable development is promoted. This means that the environmental assessment needs to be an integrated part of the planning process so that the environmental impact of the plan has an adequate treatment in the planning work and is allowed to influence the plan's direction and standpoints.

A strategic environmental assessment (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 may arise as a result of the MSPs. The link between the marine areas and the coastal zone is important from an environmental perspective. 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. Several of the environmental quality standards 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 (applicable as of 1 January 2018) 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 overall the MSPs environmental impact compared with the zero alternative in 2030, i.e. if the plan was not applied. The environmental assessment was based on Symphony and expert investigations; Symphony is described in the following section. The effects of the plan have been assessed 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, and
- 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 fisheries, etc.

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

Environmental aspects are the aspects described in Chapter 6 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 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 x 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 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 a part of the marine ecosystems. To calculate the environmental effect, the values for ecosystem components are multiplied by the values for pressures and values for the sensitivity in each area (pixel). The result is an estimate of the combined environmental impact (here called the cumulative environmental effect).

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, 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. Resulting data shows the cumulative effect of the sectors' impact on the environment as it looks 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 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 8. 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. For example, there is good knowledge of ecosystem components in Kattegat (SwAM, 2018a).

Interpretation of results from Symphony must generally be made with caution and 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 it entails on another directly related ecosystem component. Symphony provides an illustration of the long-term environmental impact and individual short-term disruptive elements are not included since they would have an overrepresented impact on the results. The geographic resolution in Symphony is high, but measurement data does 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 within Symphony.

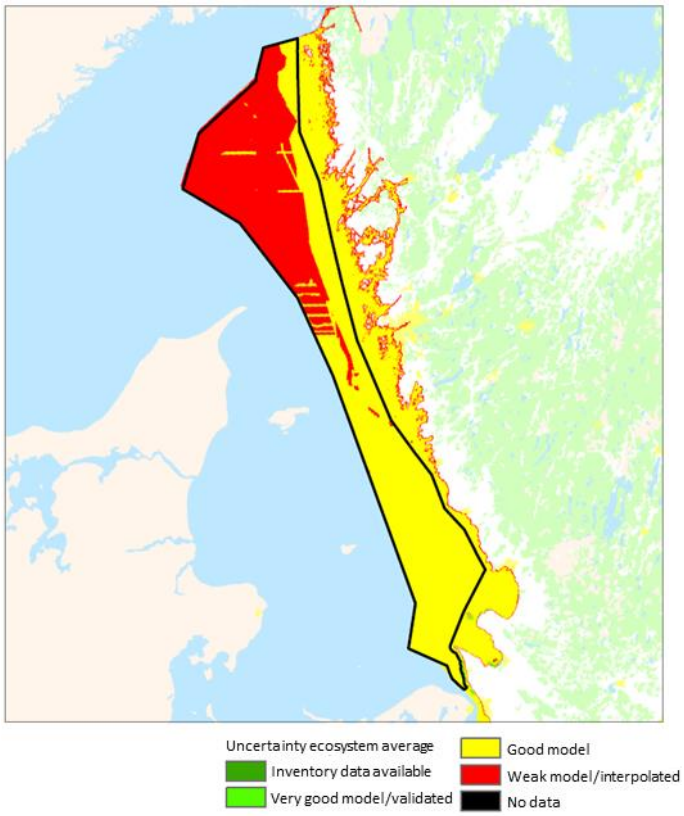

Figure 8 Aggregated uncertainty for Skagerrak and Kattegat. Spatial uncertainty based on data over ecosystem components. In the red areas, knowledge of nature values is low and the model is thereby weaker compared with e.g. coastal areas.

Further information on the planning support Symphony can be read 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 three steps.

Step 1. Identification of connection between sectors and pressures
The environmental assessment is based on the sectors defined in the MSPs within the themes. The sectors' impact is 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. Type of impact as defined in Symphony linked to the impact according to the Marine Strategy Framework Directive. 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 Connection 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 biotechnolo	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 in 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, considered 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 impact 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 will be 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 impact they entail. The sectors also entail some impact, 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 assessment 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 below Table 3.

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

OBJECT'S VALUE/SENSITIVITY	PRESSURE/IMPACT **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 west coast and the environment of Skagerrak and Kattegat have almost oceanic conditions that provide extensive species diversity, especially in Skagerrak. Prevailing conditions for winds and currents in Skagerrak and Kattegat mean that possible oil emissions are at risk of quickly reaching land, which is also true for marine litter. Between them, the Skagerrak and Kattegat marine sub-regions have different conditions regarding ecosystems, environmental problems, weather, the uses fishing and shipping. There is a rich and diverse biodiversity across the Skagerrak/Kattegat area, with a large share of Sweden's marine flora and fauna.

5.2 Physical and chemical conditions

5.2.1 Hydrographic conditions

Skagerrak has a good water turnover rate with a constant inflow from the North Sea. Kattegat is a transition zone and the turnover of deep water may be limited for short periods of time (Havet.nu, 2010), even if the turnover time is generally estimated at around three months. In Skagerrak, the salinity is relatively high due to a continuous inflow of salt water from the North Sea. The salinity of the surface water is around 30 psu (practical salinity unit) and around 34 psu in deep water. However, Kattegat is a transition zone with higher variation of salinity both between surface and bottom water, but also horizontally in surface water. The salt water flowing in from Skagerrak with a salinity of around 34 psu forms the bottom water in Kattegat. The surface layer consists of the water than flows out from the Baltic Sea and has a salinity of around 10 psu. On its way through Kattegat, the salty bottom water is mixed up in surface layers that in northern Kattegat and eastern Skagerrak have a salinity between 25 and 30 psu. The difference in salinity between the surface water and bottom water creates a layer, a halocline. In general, the vertical gradient in salinity over the layer is very large, which impedes the vertical mix between the layers.

5.2.2 Physiochemical composition

The conditions for the sea's temperature, salinity and oxygen conditions (which in turn also affect pH) are largely determined by the water circulation in the marine spatial planning area. A large impact factor 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 Skagerrak and Kattegat where the greenhouse effect of an elevated carbon dioxide content has caused the water temperature to increase since the beginning of the 1990s (Swedish Institute for the Marine Environment, 2014a). An elevated carbon dioxide content in the air also entails an addition of carbon dioxide to the water, which reduces its pH. The reduction of pH in Skagerrak

and Kattegat is also taking 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 temperature and pH vary between years and seasons. At higher temperatures, primary production that consumes carbon dioxide increases, thereby raising pH. The temperature itself also affects pH as carbon dioxide is less soluble in warmer water and is thereby emitted to the air. In the summer, the surface water is around 20°C in Skagerrak and Kattegat while in the winter it drops to nearly 2°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 wind also affects the water temperature. When the wind is blowing towards land, the warm surface water is pushed inwards and down. When the wind is blowing away from land, the warm surface water is forced out and cold water rises from below (upwelling). Upwelling is commonly occurring in Skagerrak at times of anticlockwise circulation (SwAM, 2015b), and means that water with a higher content of nutrient salts from the bottom can be carried up to the surface.

The salinity of the surface water varies sharply along Sweden's coast, from around 30-33 psu in eastern Skagerrak to 2-4 psu in the Bothnian Bay. The salinity of the sea sets limits for the ecosystems and affects the species' ranges, which is a basic explanation of the larger number of plant and animal species in Skagerrak and Kattegat (around 1500 species in Skagerrak, 800 species in Kattegat and around 70 species south of Gotland). With the gradual change in salinity, there is a transition from salt water species in Skagerrak to a predominance of freshwater species in the Gulf of Bothnia.

An important factor that affects the conditions for life in the sea is also the *halocline*, which primarily arises in Kattegat within the marine spatial planning area. The halocline prevents a remixing of the entire water mass and thereby oxygen transport down to the bottom (Swedish National Environmental Protection Agency, 2013b). Skagerrak is deeper with an average depth of 218 m and the salinity is stable with a good oxygen supply through the entire water column. Kattegat's average depth is 23 m (maximum depth of 130 m) with a lower water remix going down and a thermocline at 15 m. Thermoclines primarily arise in Kattegat, but can also arise in Skagerrak. Marine ecosystems in Skagerrak and Kattegat, especially Skagerrak, can be considered to be less sensitive to changes in salinity as there is a constant inflow of salt water that preserves the marine environment.

5.2.3 Nutrient levels and microbiological quality (Bacterial contamination, toxic algae blooms)

The amount of nutrients in the sea water that controls biological life in the seas as 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 algae blooms.

In HELCOM's report (2010a), the eutrophication level is classified for the various marine spatial planning areas where the four categories are translated in this case as: good, average, poor and substandard. Skagerrak has been classified as good to average in the entire marine area, while Kattegat is classified as average to poor.
The occurrence of algae blooms is mainly a result of a surplus of nutrients, but is also affected by the water's physiochemical composition and the occurrence of predatory fish and animal plankton. This is explained by animal plankton placing grazing pressure on primary producers and thereby being partly able to regulate their levels. Animal plankton is in turn eaten by smaller fish (such as herring in Skagerrak and Kattegat), which is prey for the larger predatory fish. Overfishing predatory fish thereby entails a smaller possibility for a regulation of the primary production from animal plankton. Algae blooms appear primarily, but not solely, at the height of the summer and in the autumn. A surplus of the nutrients of phosphorous and nitrogen in the water gives rise to eutrophication and algae blooms. Some algae produce toxins that are used against other algae to compete with them for nutrients. Toxins are also used to keep from being eaten by e.g. small crustaceans and are taken up by humans mainly by eating clams that have consumed these algae. This can be a problem in Skagerrak and Kattegat where the Swedish
mussel farms are concentrated. Algae blooms can also cause fish kills, through for instance the production of algae toxins or the low oxygen levels that arise after the algae bloom (SMHI, 2016a). In Skagerrak and Kattegat, some algae blooms have been harmful for fish, mainly farmed salmon, and others have affected entire ecosystems. Other algae produce toxins that are bio-accumulated in mussels.

The risk of microbial contamination increases with a higher nutrient supply and one can thereby assume that the risk of a toxic algae bloom is higher in areas with a higher level of nutrients. When cyanobacteria can bind nitrogen from the air, phosphorous therefore normally becomes limiting to the toxic algae bloom.

5.2.4 Pollution level in the sea

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, 2014). The amount of oil illegally released from ships mostly occurs in southern Skagerrak and northern Kattegat where the levels are high. These oil emissions are mostly unmonitored and the oil from propeller shafts is believed to contribute to even higher percentages of the total oil emissions than the illegal emissions (Swedish Institute for the Marine Environment, 2014b). Shipwrecks in central Skagerrak also release high levels of oil, and some lower emission points are also in southern and central Kattegat.

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 since they can cause illness in humans by affecting the nervous system, reproduction, kidneys and bones.

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 (1-12 nautical miles from land) within the marine spatial planning area (and also for all marine spatial planning areas) is that all areas achieve good chemical status "without pervasively exceeding substances" (mercury and brominated flame retardants), but that none of the MSP's areas achieves a good status if pervasively exceeding substances are included in the assessment (County Administrative Board VISS, 2016). According to HELCOM (2010b), the situation looks to be on an "average level" in both of the marine sub-regions. However, high levels of PCBs have been measured in sea mussel populations in Northern Skagerrak (highest levels measured in Swedish waters) and average levels of mercury and cadmium in fish and sea mussels in both Skagerrak and Kattegat. However, these substances seem to have a low occurrence in the sediments, which however contain average levels of Tributyltin (TBT) (2-50 $\mu g\ kg^{-1}$) (HELCOM, 2010b).

5.3 Biological conditions

5.3.1 Biodiversity and green infrastructure

The situation for marine biodiversity in Skagerrak and Kattegat is serious. HELCOM (2010a) has classified the status of biodiversity for Kattegat as *poor to substandard* and on the southern part of Skagerrak as *substandard*. Skagerrak and Kattegat comprise the Swedish marine area that is most impacted by anthropogenic pressure at present and the area north of Helsingborg in particular is one of the most affected areas in the entire Baltic Sea area (HELCOM, 2010a) and must therefore be prioritised higher as it is also an area of high biodiversity.

Biodiversity is vital to be able to preserve the ecosystem services people depend on and retain the unique population composition that exists. The Swedish Species Information Centre Red List (2011) clarifies that the percentage of red-listed species was higher in the marine environment than in any other habitat and 318 of the species that are on the 2015 red list are marine species (Sandström, 2015). The red list also shows that many species that were previously regularly encountered have become very uncommon or entirely disappeared from coastal environments due to more disruptions, pollutants, eutrophication and particle amounts. Many other species can currently be found only in small, isolated areas that have escaped trawling due to their inaccessibility (SwAM, 2015b). In the southern part of Kattegat, there are areas with marine eelgrass beds, but these have recently been reduced and marine eelgrass is currently endangered. But to benefit good growth opportunities and high biodiversity, the size of the eelgrass beds is important. The eelgrass beds' coherent size has proven to be the most important factor for the survival of fry that live in the beds (Staveley, Perry, Lindborg, & Gullström, 2016).

Skagerrak contains nearly twice as many species of macrofauna (larger animals) and plants than Kattegat. This has a lot to do with Skagerrak being deeper and the salinity being more stable with a good oxygen supply throughout the entire water column. Kattegat has a worse water mix moving deeper and a thermocline that makes it harder for species to survive as the salinity varies largely between surface and deep water, which induces stress in the animals.

It is of utmost importance to preserve and try to benefit the key species of sea mussels and Lophelia pertusa, which are two important biotope building species for survival of the ecosystems that are still in Skagerrak and Kattegat. Structure-forming species, such as Lophelia pertusa, often have a long lifespan and low reproduction, something that makes them sensitive to changes. Other species that have proven essential are small grazers, such as amphipods; with a high diversity in this group, the growth of periphyton on eelgrass can be kept down, which is an important function for maintaining eelgrass beds.
As Skagerrak and Kattegat have a much higher biological diversity than e.g. the Baltic Sea, the system can be assumed to be less sensitive to external disruptions and thereby be more resilient, which means that it can more easily recover from these disruptions. Skagerrak and Kattegat also have large sediment-dwelling organisms that can increase oxygenation of sediment and thereby increase binding of nitrogen, phosphorous and carbon. This process is missing in the Baltic Sea area and is a process that reduces effects from acidification and eutrophication.

5.3.2 Natural bottom environments

Skagerrak and Kattegat's offshore banks provide a very unique species composition. The offshore banks consist of rock that is overlaid with sediment of coarser materials such as gravel, stone and boulders. Many different attached algae are encountered in the area down to 15-20 m at the same time

with many animals, such as fish, porpoise and invertebrates. The concentration of red-listed species is relatively high at the places. Offshore banks are also especially important for sea birds that live on mussels, as the offshore banks' more visible bottom makes it easier for fishing for these species (Naturvårdsverket, 2006). In Skagerrak, there are the offshore banks Persgrundet, Grisbådarna, Svaberget and Vanguards grund and in Kattegatt, there are the offshore banks Kummelbank, Fladen, Lilla Middelgrund, Stora Middelgrund, Röde Bank and Morups bank (SwAM, 2015b).

Skagerrak largely consists of a soft seabed and the deepest area in the entire marine spatial planning area is in this sub-region. Persgrundet is the only inventories offshore bank within the marine area and consists of a crystalline rock foundation with large stone blocks and a high level of vegetation and species diversity (Naturvårdsverket, 2006). The rock foundation at the offshore banks in Kattegat is generally overlaid by sediments consisting of a mix of rough materials, such as gravel, stones and boulders. At Fladen, there is a bubbling reef of lime, where hydrogen sulphide and methane pass through the sediment, and there are submarine structures consisting of "sandstone slabs, pavements" and up to 4 m high pillars, formed through aggregation of carbonate cement caused by microbial oxidation of gas emissions, mainly methane. Animals seek protection in the large number of cavities, which further increases diversity.

Kattegat is matched by a relatively shallow area with an average depth of 23 m, which means that it has several photic areas that provide good conditions for eelgrass beds. However, these have decreased sharply in Skagerrak and Kattegat since 1995 (Havs- och vattenmyndigheten, 2013). Skagerrak is deeper with a maximum depth of 502 m and the marine spatial planning area has unique deep sea areas that provide a good basis for the unusual, sensitive and long-lived deep sea species that only thrive in deep sea ecosystems.

Dredging and dumping is done widely in the entire marine spatial planning area and is a human activity than can change bottom environments drastically by removing or adding large amounts of material. Shallow areas are often made deeper so that large ships can make their way to ports in the coastal areas. Dumped masses shall be dumped on accumulation bottoms to prevent the spread of particles to water and the masses shall have the same characteristics as the existing sediment, but unnaturally large amounts of sediment are often added in a short time, which changes the composition of the bottom substrate. Bottom trawling is also a human activity that changes the natural bottom structure. Within Skagerrak and Kattegat, bottom trawling takes place in large areas of the marine sub-region of Skagerrak and to a more limited extent in Kattegat, but within both areas, bottom trawling takes place on deep soft bottoms.

5.3.3 Pelagic habitats

Both in Kattegat and Skagerrak, the ecological status for plant plankton is high. The level of plant plankton biovolume is unchanged while the chlorophyll levels

have decreased somewhat, which indicates a better visual depth (Swedish Institute for the Marine Environment, 2016a) Measurements in Skagerrak and Kattegat (from a single measurement station) indicate a decrease in animal plankton, which is caused by a decrease in the normally dominant cyclops. This reduction may be attributable to the higher amount of the warty comb jellies, which is an effective predator of animal plankton (Swedish Institute for the Marine Environment, 2016a).
The pelagic zone in Skagerrak and Kattegat is strongly affected by nutrients emitted from various sources. The area has a large pressure from land and an explanation for this is that there is a lack of large lakes in the system, which otherwise function as sedimentation traps. For a long time, this has been a major problem in Kattegat and Skagerrak, which has the second largest pressure in the country after Öresund. In Kattegat, the emission of phosphorous and organic material is lower. While the emission of nitrogen has decreased, the emission of phosphorous and organic material has increased. Emissions of nutrients increase the production of plant plankton and filamentous algae, which has a negative impact on the pelagic photic zone.

5.3.4 Oxygen-free bottoms

The marine spatial planning area has no thresholds that obstruct the water currents and, consequently, the water turnover is good and there are few oxygen-free bottom areas, even if occasionally low oxygen levels caused by a limited turnover of deep water from Skagerrak can occasionally occur in Kattegat.

5.3.5 Marine plants

Seabeds lined with plants are amongst the most productive and species-rich. There is a great variety of species along all coastlines. 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. Charophyte green algae together with angiosperms fill the same function as macroalgae in terms of diversity. Eelgrass has root systems that can form beds that bind sediment that reduces effects on the bottom from erosion at the same time that they add oxygen and are important nursery areas for several fish species. Healthy eelgrass beds also bind a large amount of nutrients that can counteract algae blooms and carbon, which can reduce the carbon dioxide level and raise the pH in the water. In Bohuslän, the areal spread of eelgrass has decreased by more than 60% since the 1980s as a result of, among other things, eutrophication and overfishing, which corresponds to a loss of around 12,500 ha of eelgrass[4]. In Skagerrak and Kattegat, there are around 350 species of algae, while there are only a few marine angiosperms. Of the macroalgae that occur, a majority are very uncommon, as in the Baltic Sea. In Skagerrak and Kattegat, a large addition of nutrients has entailed major changes along the coast since the nutrient supply

[4] Source: https://www.havochvatten.se/downpressure/18.7bb4ad22156f6eab6165b769/1476861287991/hav-rapport-2016-8-restaurering-algras.pdf

increases the amount of plant plankton and organic particles in the water. More particles reduce the light supply for plants and an increased nutrient supply generally benefits rapid growth.

Long-term changes in the seaweed community vary
along Sweden's coast. The Swedish Environmental Protection Agency (2013a) has done studies of the offshore banks where 67 different algae groups (taxa) were found at one single offshore bank area in Skagerrak. Of these, 49 were red algae, 12 brown algae and 6 green algae, which corresponds to a typical distribution of different types of algae in Skagerrak and Kattegat. The offshore bank in Skagerrak Svaberget proved to contain more species in the deeper intervals up to 30 m compared with the offshore bank in Kattegat Vanguard, which indicates a higher light supply and water quality in Skagerrak.

5.3.6 Marine animals

Commercial fauna can be seen as a resource for people and for future generations and fishing is done by many as Commercial fisheries and for recreation. In terms of bottom fauna, there is an extensive lack of follow-up of the spatial spread of populations. Species on certain types of seabeds and of certain sizes are either imperfectly monitored or not monitored at all. There is also an uncertainty in terms of indicators for habitats and ecosystems, as well as for biological diversity (SwAM, 2015b).

Marine mammals

The marine mammals that live in Skagerrak and Kattegat are grey seals, harbour seals and porpoises. The grey seal is the largest of the seal species and is not as common in Skagerrak and Kattegat as the harbour seal, which is the marine spatial planning area's most common seal species. In terms of the species' status, the situation for the grey seal and the harbour seal is favourable for both marine sub-regions, which is also true of the species' ranges ("satisfactory"). The harbour seal is the only seal species that usually uses Skagerrak and Kattegat for reproduction as the grey seal prefers to give birth on ice (Havsmiljöinstitutet, 2011). The situation for the seal species has improved since the 1970s when they were severely threatened due to hunting and low fertility. However, the harbour seal strain was struck by PDV (Phocine distemper virus) in 1988, which led to half of the seals in Skagerrak and Kattegat dying. In Skagerrak and Kattegat, the stock of harbour seals is growing today at a normal pace.

The c*ritically endangered porpoise* is the only whale species that regularly occurs in Swedish waters and it is encountered in all areas in the marine spatial planning area. Distinction is made between three populations of porpoise in Swedish waters, which are called the *Baltic Sea population, the Skagerrak population* and *the Danish Straits population*. As the porpoise is a small whale, it has a high metabolism and is dependent on a large food supply, especially among the females. Porpoise mainly eat cod and sill and have proven to largely follow the herring's range, especially when the cod stock has been limited. The porpoise's food shifts to the species that has the largest nutrient content for the season and hagfish has proven to constitute a large share of the diet of full-

grown females. Today, the porpoise population is mainly affected by injuries caused by fishing, underwater noise, ecosystem changes and environmental toxins. There is today a strong protection system for the species as only a few of the marine protected areas are specifically designed to protect the porpoise. This entails a major risk of mainly the Baltic Sea population's continued existence as Swedish waters encompass its main range (AquaBiota, 2015). The Skagerrak population of porpoise is classified as *vulnerable* and has one large and several small important reproduction areas mainly in Skagerrak (Wijkmark, 2015).
Areas especially worthy of protection for this population are at Jutland's northern tip, which is a part of a large reproduction area. In Kattegat, the important areas for the porpoise are Fladen and Lilla and Stora Middelgrund, which is mainly used by the Danish Straits population, which is also classified as *vulnerable*.

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, (ArtDatabanken, 2015) 70 per cent are invertebrates, but many species are probably missing from the list as there is a large lack of knowledge in this particular group.
Blue (common) mussel banks constitute a substrate for other organisms and therefore indicate high biodiversity. These mussel banks also contribute a regulating ecosystem service in the form of filtration of particles in the water, which contributes to lower turbidity in the water column. The banks are therefore of high protective value, but soft seabeds that are also relatively unaffected by trawling can have a high protective value as 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 material. These mainly spread out on hard moraine bottoms.

The distribution and composition of invertebrate bottom dwellers has undergone a considerable change over the last hundred years. Today, the occurrence of the largest mussel communities in the deep water areas is limited to the shallower seabed in Kattegat's coastal area.
Many invertebrates are bottom dwelling organisms and have been affected to a high degree by bottom trawling. Trawler fishing is most intensive in the northern and southern part of Skagerrak's marine area and we can thereby also assume that the invertebrates in this marine area are the most vulnerable. The long-lived tall sea pen is endangered today (previously common in Skagerrak) as a result of large-scale fishing (Artdatabanken, 2011).

Crustaceans such as the northern prawn, brown crab, lobster and Norway lobster are invertebrates of major economic significance for humanity. Skagerrak and Kattegat comprise the highest occurrence of crustaceans in Swedish coastal areas, but this group has also been negatively impacted by bottom trawling. Stock of northern prawn has decreased sharply in recent years

and most red-listed crustaceans exist in both marine sub-regions, but with greater abundance in Skagerrak (SwAM, 2015b).
Corals in turn are negatively impacted by silted up sediment from bottom trawling. Live sponge can filter large amounts of water and thereby constitute an important ecosystem service, but the spread and knowledge of the various species in Swedish waters are very limited. In Skagerrak, brittle star communities are commonly occurring, but there are also bryozoan, soft coral, gorgonians, anemones and colony-forming ascidians with a greater occurrence of alcyonaria and hydroids than in other areas. In Kattegat, the species that exist in Skagerrak are most often found, but also plenty of echinoderms, sea pens, the annelid worms *Serpulidae*, and some Devonshire cup coral.

Many annelid worms, marine snails and mussels live in the marine spatial planning area, and many of them are currently red listed and occur in both marine sub-regions (ArtDatabanken, 2015). There are also three foreign species of annelid worms *Marenzellaria* in Kattegat. Their impact on the environment is not unambiguous as they oxygenate oxygen-poor sediment, but thereby contribute to the sediments releasing stored environmental toxins (Havs- och vattenmyndigheten, 2016c).

Fish
The composition of fish fauna in Skagerrak and Kattegat is roughly the same as in the rest of the North Sea. Around 80 marine fish species reproduce in Swedish waters and the number of fish species generally decreases from Skagerrak towards Öresund. Cod, herring, sprat and sand lance dominate, along with flatfish on sand and clay beds. Eel occurs along Sweden's entire west coast, but more generally in the southern areas (SwAM, 2015b). The largest eel population in Sweden is located at southern Skagerrak's inner coastal area, but is also large in the marine spatial planning area. The herring stock is high in southern Skagerrak together with the cod stock, which is also high in the other areas in both marine sub-regions.

Since the end of the 19th century, the fish community in Skagerrak and Kattegat has changed with a decrease of large adult predatory fish to an ecosystem where small and young individuals are dominant. Examples of species that have been seriously affected by the intensity of the fishing are cod, haddock, sole, plaice and pollack. The recovery is progressing slowly even though the trawling boundary has been moved out and other preservation measures have been implemented (SwAM, 2015b). The levels are not satisfactory, even if the amount of large fish is on the increase again. The number of cod is still at such a low level that they are deemed to have a reduced reproductive capacity.

The main human impact on the fish population is of course fishing, but the population is also affected by the supply of nutrients, exploitation and the physical impact on habitats, such as salinity, and environmental toxins. Large-scale sea fishing is the cause of more than 20 species of fish being red listed in 2015. Among other things, Swedish stocks of cod, haddock, ling and halibut are

still threatened. As of 2015, hake and starry ray are also red listed, where the latter is endangered (Swedish Institute for the Marine Environment, 2016a).

Birds
The predominating breeding birds in Skagerrak and Kattegat are eider and gulls such as the herring gull. The majority breed in the archipelagos of Bohuslän, but significant colonies also exist on islands in Kattegat. Among resting and wintering sea birds, eider, velvet scoters and common scoters are the most common, along with a significant number of goldeneyes and mute swans on inland waters. Fulmar and gannets occur mainly in connection with storms during the autumn and winter. Other species are also regularly seen, such as black-legged kittiwakes, which breed at Nidingen. As to the Swedish breeding stocks, the eider has decreased drastically since the mid-1990s and a decrease has also occurred for the velvet scoter since the 1950s (SwAM, 2015b).

Bats
In Sweden, there are 18 bat species and 15 of them occur in the marine spatial planning area for Skagerrak and Kattegat (Artdatabanken, 2004). The extent to which the bats move over the sea was previously unclear even if bat populations are often found in coastal areas. Studies from recent years have shown that bats not only migrate along the coasts, but can also go further out to sea hunting insects. This hunting is seasonally restricted to summer and late summer, but is dependent on good weather. Systematic mapping of bats in coastal and marine areas is yet to be conducted (Havs- och vattenmyndigheten, 2015c).

5.4 Protected areas

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.

The marine area protection in Skagerrak and Kattegat is currently around 32%. So far, the Kosterhavet national park in Skagerrak and Kattegat is the only example of a pure marine national park. The aim is to keep a distinctive, species-rich marine and archipelago area and adjacent land areas in an essentially unaltered condition (SwAM, 2015b). 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 are important in marine spatial planning. In Skagerrak and Kattegat, Lilla Middelgrund and Fladen in Kattegat are especially valuable and

important from a nature conservation perspective to protect from all forms of development (Swedish Environmental Protection Agency, 2006). These are also pointed out as Natura 2000 areas according to the EU Habitats Directive and are included in the OSPAR network of Marine Protected Areas (MPAs). The marine areas that are protected constitute a part of the green infrastructure in the marine areas that are currently only partly protected (Havs- och vattenmyndigheten, 2015c).

5.4.1 Skagerrak

Kosterfjorden-Väderöfjorden is a national park that contains the only coral reef area in Swedish waters. The area contains 200 unique animal species and nine algae species, which do not exist within any other Swedish marine areas and make the area the most species-rich marine area in Sweden. The area's deepest depth is 247 m and the reef is mostly located on deep, sloping seabed areas. Some types of bottom-impacting trawling occur in this area and the problem is noted and regulated today in the scope of the so-called Norra Bohuslän Joint Administration. *Bratten* is an area with a unique seabed topography with many geological formations, so-called pockmarks with steep and widespread cliff valleys, which provide protection for species sensitive to trawling. A large number of red listed and uncommon species is thereby encountered in the area, of which several have their only or primary occurrence here in Swedish waters, which is mainly true of coral and brittle stars (Naturvårdsverket, 2006).

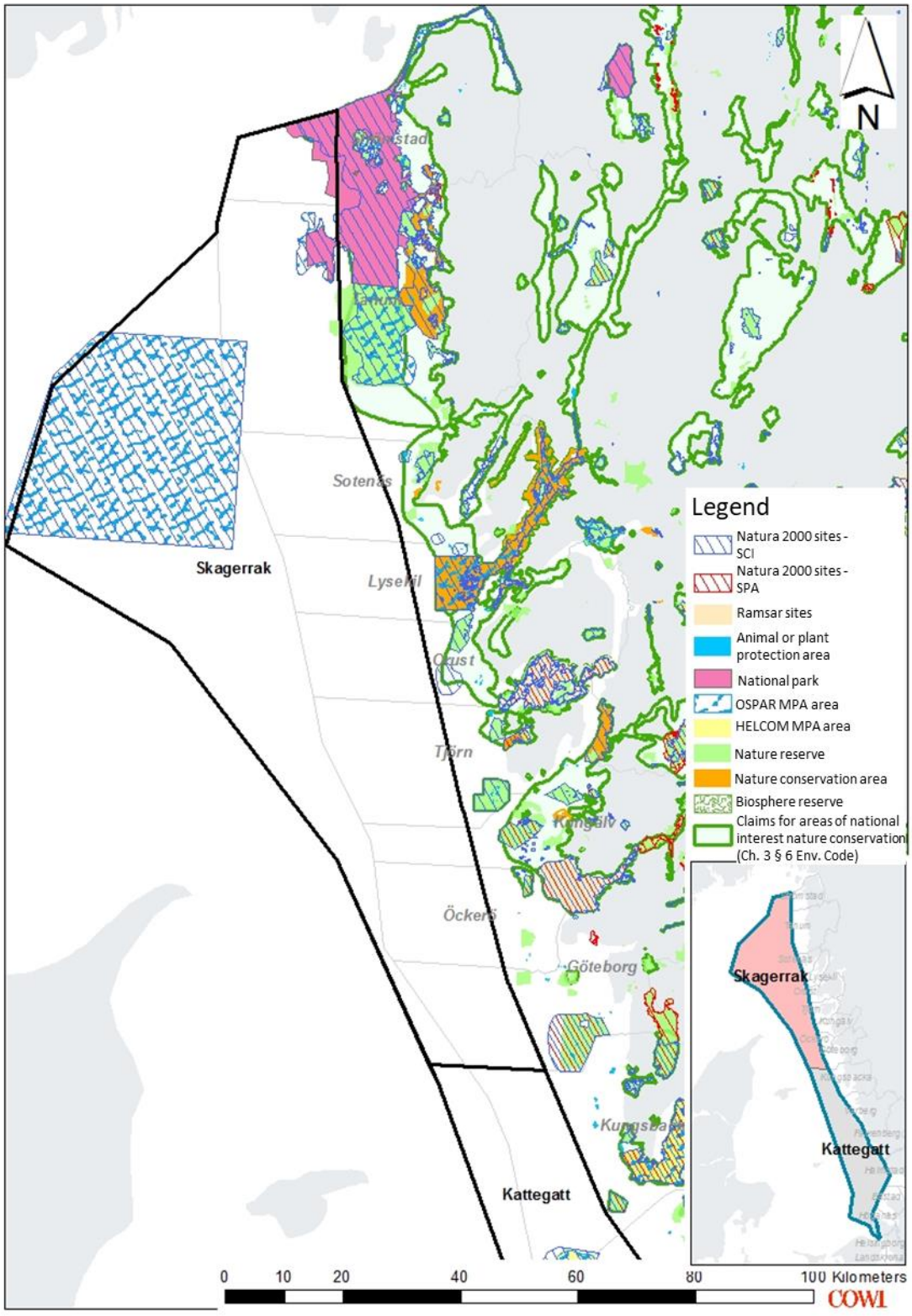

Figure 9. Natura 2000 areas, national interests for nature conservation and other potential protected areas for Skagerrak.

5.4.2 Kattegat

Stora Middelgrund and Röde bank are two connected banks of differing natures. Stora Middelgrund is a large bank where calcium encrusted algae are predominant and other leaf-shaped red algae can also be encountered while larger brown algae are encountered to a lesser extent. Several uncommon species are encountered often such as the masked crab, the pea urchin, the pea crab, Ocnus lacteus and the northern horse mussel. Röde Bank is a small bank that is deeper than Stora Middelgrund. Species such as the common sunstar and cod are observed to a greater extent. Both at Röde Bank and Stora Middelgrund, there are many species of starfish and porpoise that are encountered in both (Naturvårdsverket, 2006).

Lilla Middelgrund is a large bank with a varying environment containing a good bottom environment for digging animals. The area has a high species diversity of algae and animals and a large part of the seabed is covered by the red algae maerl, which is unique in Sweden. Many uncommon species for Kattegat live here, such as forests of various kelp species and Upogebia stellata. Scallops are often encountered, and several species of typical sea birds that are rarely seen closer to the coast, such as razorbills, common guillemots, black guillemots and fulmars. There are also porpoises in the area as well as pollack, which is red listed as critically endangered (Naturvårdsverket, 2006).

Fladen is an area that encompasses a diversity of environments with many habitats and a good water turnover, which entails clean and well oxygenated environments. There is a large amount of macro algae here, including maerl and also many species of digging crustaceans, fish and the two uncommon species of circular crab and Xenoturbella. The species diversity is mainly due to Fladen's unique bubbling reef of lime, where among other things methane gas and hydrogen sulphide pass up through the sediment. The bank has a high fish diversity with, among others, the leopard-spotted goby, which in Sweden has only been found at isolated sites, and the red-listed species cod, ling and porpoise. Several bird species less common for the west coast are also in the area, such as razorbills, common guillemots, black guillemots and fulmars (Naturvårdsverket, 2006).

Morups bank is a shallow offshore bank in the middle of Kattegat with a macro algae flora of high biodiversity. The seabed is varied and is covered to a significant extent by kelp forests.

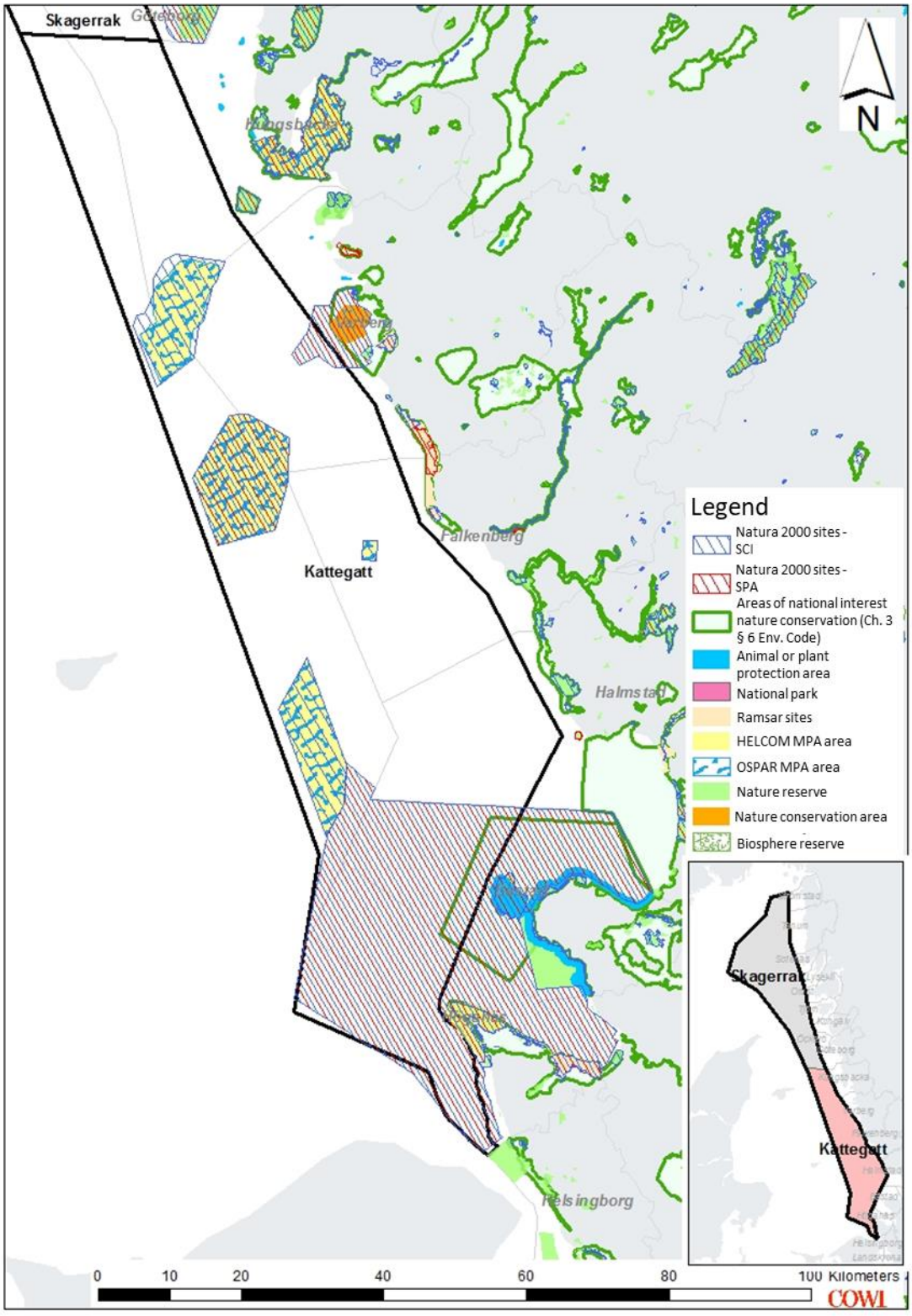

Figure 10. Natura 2000 areas, national interests for nature conservation and other potential protected areas for Kattegat.

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5.4.3 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* and shows which areas are valuable for many 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 components (Figure 11). 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 Skagerrak and Kattegat are presented in Figure 12.

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)* may need to be observed (see Chapter 3 and the MSP).

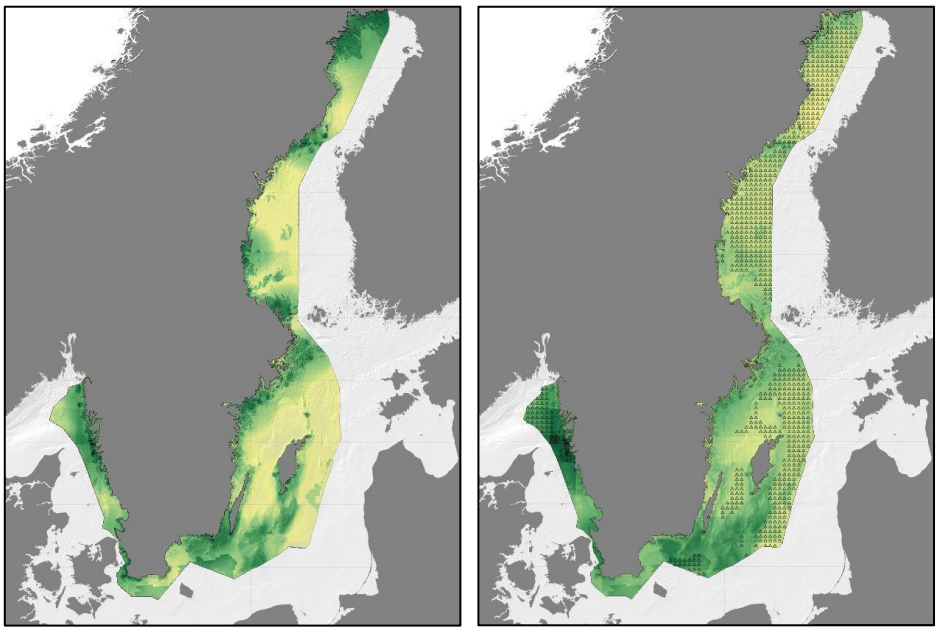

Figure 11 *The Green Map*. The picture at left shows the version of the *Green Map* used in the marine spatial planning, where normalisation has been done both according to the MSP and to groups of ecosystem components (habitats, fish, mammals and sea birds). The picture at right shows a simple aggregation of ecosystem components without normalisation or weighting; 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 at right shows areas with especially high uncertainty in data. Here, the knowledge of the nature values is low.

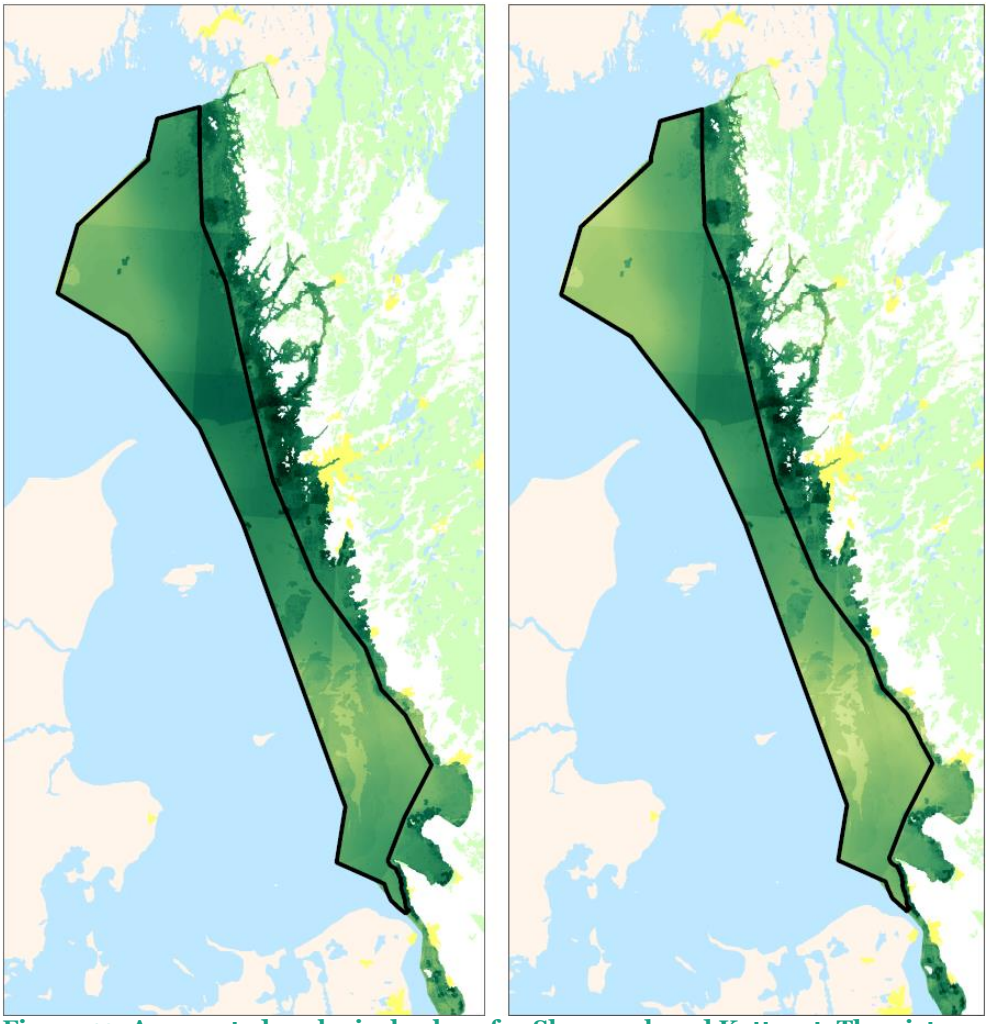

Figure 12. Aggregated ecological values for Skagerrak and Kattegat. The picture at left shows averages without weighting and at right shows four equally weighted groups (bottom environment, fish, mammals and birds) of ecosystem components and normalisation of the values. (Dark green – high value, light green – low value).

6 Current situation

6.1 Sectors and themes

6.1.1 General

An important issue is to protect marine areas with high biological values in Skagerrak and Kattegat. It includes the development of networks with good representativeness, and maintaining the productivity and functionality of shallow marine ecosystems. Strengthening the tourism is a part of the regional strategies to contribute to regional growth. The sea is identified here as a key factor.

In addition, the regional strategies emphasize the importance of municipal comprehensive planning to achieve a long-term and sustainable utilisation and protection of the coast and sea. Climate adaptation and the climate proofing of the coastal environment are primarily matters for the coastal zone planning, but can also affect the marine spatial planning in the form of impact on port operations and in terms of appropriate areas for sand extraction in the sea (SwAM, 2016b).

Development work in regions and county administrative boards along Skagerrak and Kattegat has resulted in regional goals and strategies/programmes that specify environmental goals and energy transition, which is partly related to marine spatial planning. For example, county administrative boards, regional planning bodies and researchers identify the marine sector as one of five areas of strength for Västra Götaland. Development possibilities in the maritime sector have also been specified in six focus areas where special efforts in innovative industries, such as sea-based energy, food production and biotechnology can be expected in the long term to have claims in the marine spatial planning area.

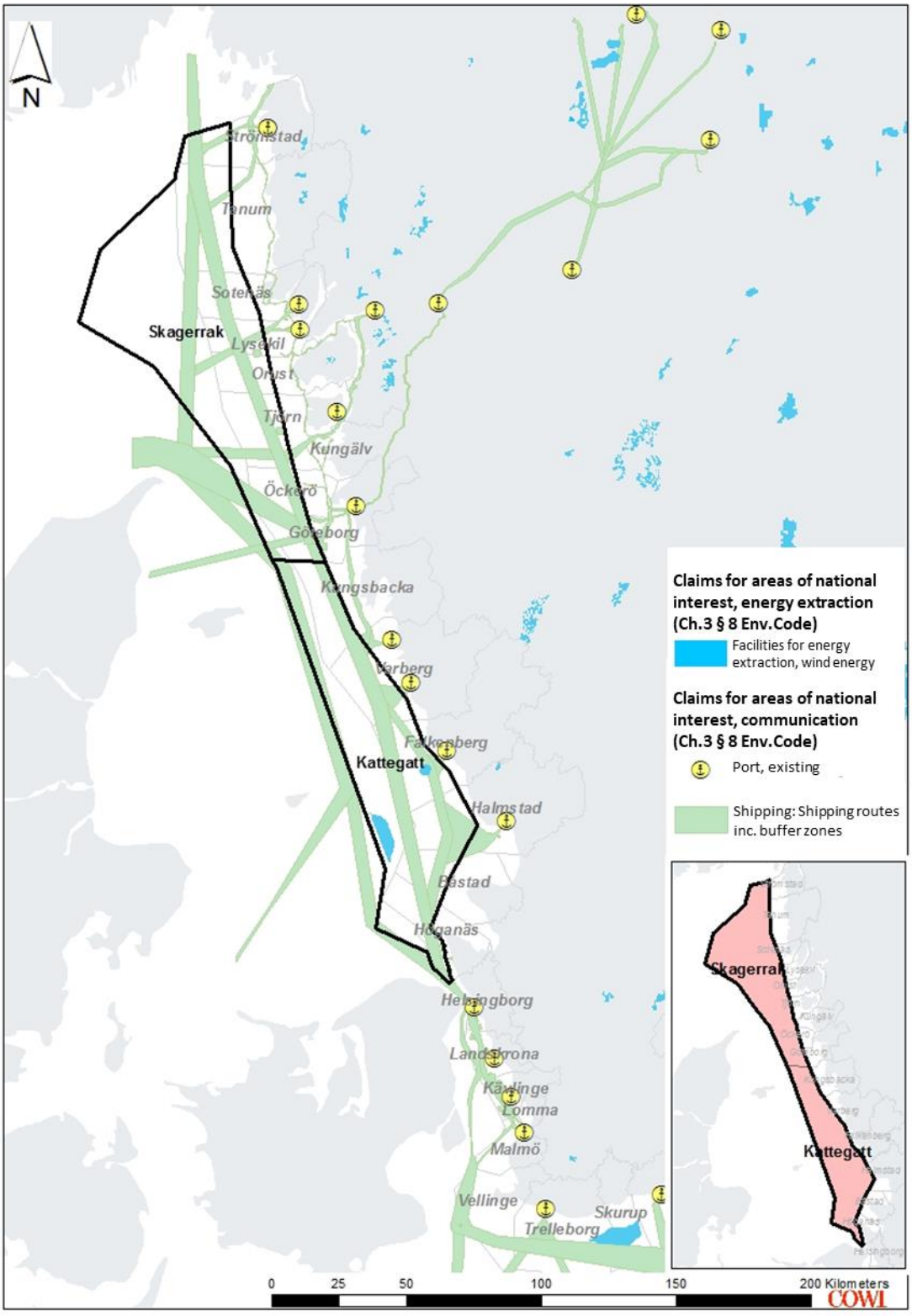

Figure 13 National interests for transportation and communications and energy in Skagerrak and Kattegat.

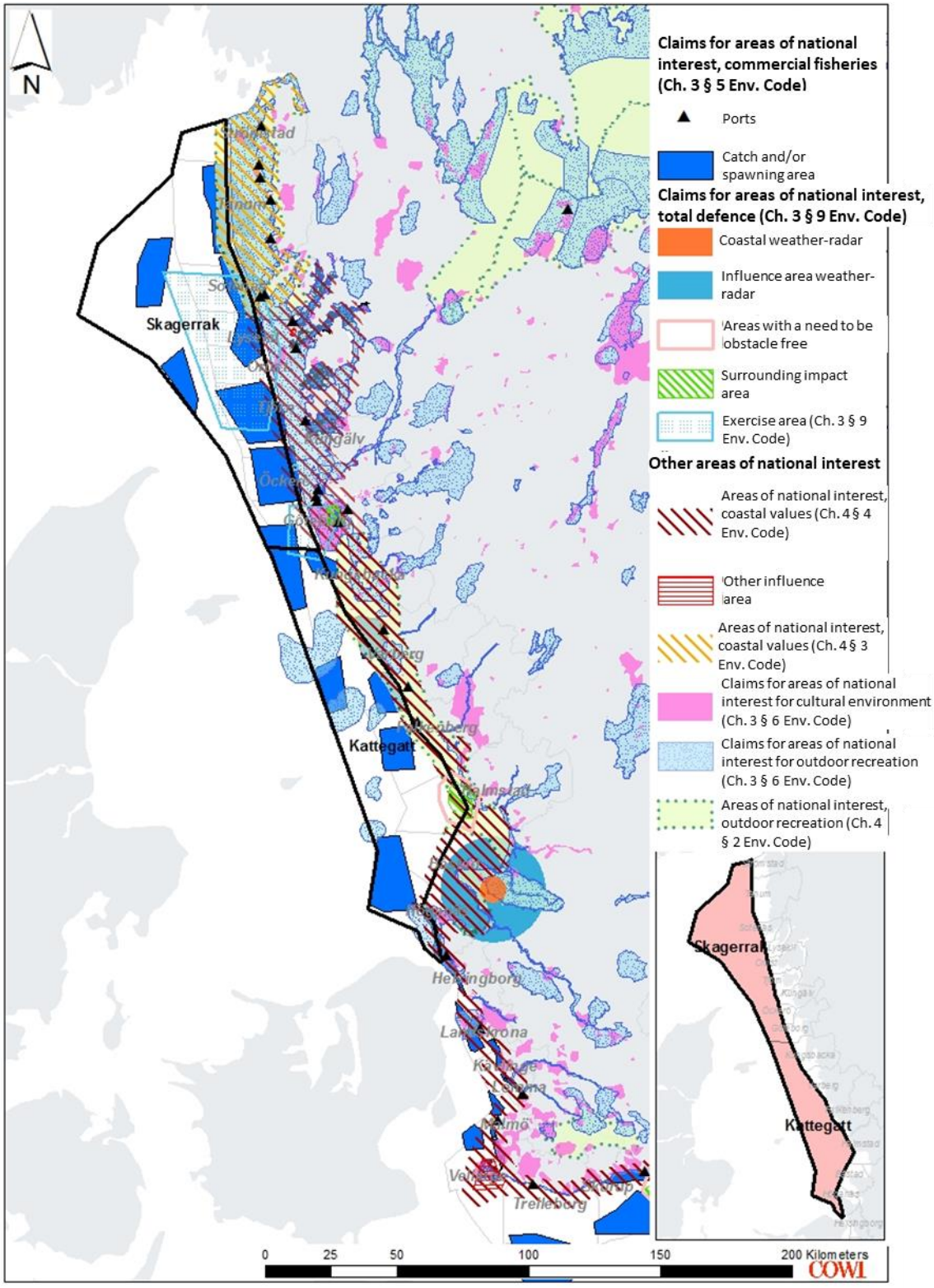

Figure 14 National interests for commercial fisheries, defence and other national interests in Skagerrak and Kattegat.

6.1.2 Attractive living environments

Outdoor recreation that depends on waters in the marine spatial planning areas mainly comprises recreational boating traffic and angling, but also cruise ships and ferry traffic, safaris, etc. Marine tourism is estimated in Sweden to have an extensive economic value of up to 50,000 employees and net sales of around SEK 70 billion (SwAM, 2017c). Aforementioned information 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 number of fishing days of 3.4 million (Statistics Sweden, 2017b). Statistics over recreational boats show that in 2015 there were around 200,000 recreational craft with their home port in Skagerrak and Kattegat (Swedish Transport Agency, 2016). Along almost the entire marine spatial planning area for Skagerrak and Kattegat, there is a strip closest to the coast that is appointed as a national interest for active outdoor recreation. There are also multiple areas pointed out for national interest claims for outdoor recreation (SwAM, 2017a).

Outdoor recreation and tourism contribute to environmental impact 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). In the marine spatial planning area, there are a number of ship wrecks, but the knowledge of other remains on the seabed is deficient. In the marine spatial planning areas, there are not any appointed national interests for cultural environments. At the Swedish National Heritage Board, work is under way 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 changed 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 the sea-based energy production touched upon in the plans, wind power is the absolutely largest part while production from other sources, such as waves, currents, tides and salinity gradient, only constitutes a limited component. Sea-based wind power has been in Sweden since the 1990s (Swedish Energy Agency, 2015). Today, there are four wind power parks at sea; none of them are in the Skagerrak and Kattegat marine spatial planning area. Seven parks have approved permits for production, but are not built yet, of

which one is in the current marine spatial planning area (Kattegatt Offshore) (WSP Sverige AB 2016). Wind power from the sea has 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, no production of sea-based wind power takes place in the Skagerrak and Kattegat marine spatial planning area. Today, there is a current permit for the preparation and production of wind power in Kattegat's marine sub-region, Kattegatt Offshore, off of Falkenberg. The permit process for wind power at Stora Middelgrund has also progressed far, but lacks a so-called Natura 2000 permit.

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, including in the Skagerrak marine sub-region, 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 commercialisability.

6.1.4 Defence

The activities of the Defence in the marine 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 especially 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. In the Skagerrak and Kattegat marine spatial planning area, there is one major and one minor artillery and training range. The major training range extends over the municipalities of Tjörn, Orust, Lysekil and Sotenäs. The minor range is located off of the City of Göteborg. The marine spatial planning area is also affected by a special need for obstacle clearance in the sea off of Halmstad.

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 cause technical disruptions that compete with the interests of total defence (SwAM, 2016c).

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 total defence exercises (SwAM, 2016a).

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 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, Sandhammar bank south of Ystad, in the Baltic Sea marine spatial planning area. 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 and one in the Gulf of Bothnia.

No carbon dioxide storage takes place today 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 process.

6.1.6 Nature

The nature and environment of Skagerrak and Kattegat are described under General Conditions, Chapter 5.

6.1.7 Transportation and communications

Shipping in Skagerrak and Kattegat is very extensive. Western Sweden handled 42% of Sweden's total amount of freight in 2016 (Traffic Analysis, 2017). Here, ships travel to the Port of Gothenburg, which is Scandinavia's largest port with the possibility of receiving very large container ships, but in the marine spatial planning area, transports also go to and from Denmark and on into the Baltic Sea. 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.

The air pollution includes a secondary impact on other assessed interests, where a relevant pressure is deemed to correspond to elevated nutrient levels and an impact on the water's physiochemical composition.

Within the marine spatial planning area, the amount of NO_X gases is the highest in southern Skagerrak where shipping is most extensive. The amount of nitrogen oxide that is released per year is less than half as much in Skagerrak and Kattegat as in the Baltic Sea, and in the Gulf of Bothnia, the amount is around one third that in Skagerrak and Kattegat. From a comparative perspective between the MSPs, the sulphur emissions from shipping are 2.5 times higher in the Baltic Sea than in Skagerrak and Kattegat, but nearly four times lower in the Gulf of Bothnia where the conditions for NO_X gases are similar. However, relatively more sulphur and nitrogen are deposited in the

Gulf of Bothnia, especially sulphur where the deposit is the highest per marine area (per m^2) (SMHI, 2016b).

Emissions of greenhouse gases from shipping are still increasing (Swedish Environmental Protection Agency, 2016) although there is a decrease of Sweden's total emissions of greenhouse gases. 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 as it among other things is in certain sea and lake beds and can thereby be freed upon e.g. 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. According to the Swedish Institute for the Marine Environment (2016b), 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 out compete native species with potentially major consequences for the ecosystems. Other consequences from shipping are systematic 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 in the greatest extent on the northern east coast (Statistics Sweden, 2017a). Mussel farming in the sea largely only takes place in Skagerrak and Kattegat with a few exceptions. Pressures on marine ecosystems from aquaculture can look different depending on what is farmed where farming of edible fish is associated with additions of nutrients that contribute to eutrophication, while farming of e.g. 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 the impact on the physical environment. In the Skagerrak and Kattegat 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 can become relevant 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, 2016d). A strong negative trend for the number of commercial fishermen has been under way since the mid-1990s (Swedish Environmental Protection Agency, 2017). A hard-driven Commercial fisheries has led to strained stocks. Overfishing of predatory fish affects the food chain with consequences for other parts of the ecosystem. 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 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 times of pressure as bottom trawling except the physical impact on the bottom environment (SwAM, 2016d). Skagerrak and Kattegat, with a relatively larger species richness and biodiversity, offers fishing for a larger number of species than the Baltic Sea, and the fishing is more diversified. Bottom trawling for Norwegian lobster and Northern prawn is important in this marine spatial planning area (SwAM, 2016d). These types of fishing for shellfish have it in common that they spatially are more bound to the location of their catch areas than Commercial fisheries for fish as the shellfish have less mobility. The ecosystems' sensitivity to disruptions from withdrawals of species and other pressures is lower compared with the Baltic Sea and the Gulf of Bothnia.

6.2 Cumulative effects - present situation

The cumulative effect for the marine spatial planning area of Skagerrak and Kattegat 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 Skagerrak and Kattegat

The total cumulative environmental effect is highest close to the coast and mainly around Gothenburg (SwAM, 2018b). Here, there are industries and coastal development (built environments and recreation) that affect valuable green areas. Within the marine spatial planning area of Skagerrak and Kattegat, the cumulative environmental effect is the highest in central and southern Skagerrak, which is due to a combination of intensive trawler fishing and a high background pressure in the sediments, see Figure 15. In these areas, there are relatively large amounts of fish and porpoise. In the north-western parts of Skagerrak and in all of southern Kattegat, the environmental effect is lower than in the rest of Skagerrak and Kattegat. The lower environmental effect in north-western Skagerrak, see Figure 16, is due to trawler fishing being less intensive here at the same time that the ecological values are high and the seabeds are relatively clean from pollutants and are oxygenated. The low environmental effect in southern Kattegat is partly due to earlier measures that reduced trawler fishing and to the ecological values being lower compared with e.g. Skagerrak, see Figure 17. The offshore banks in Kattegat show a relatively low cumulative environmental effect.

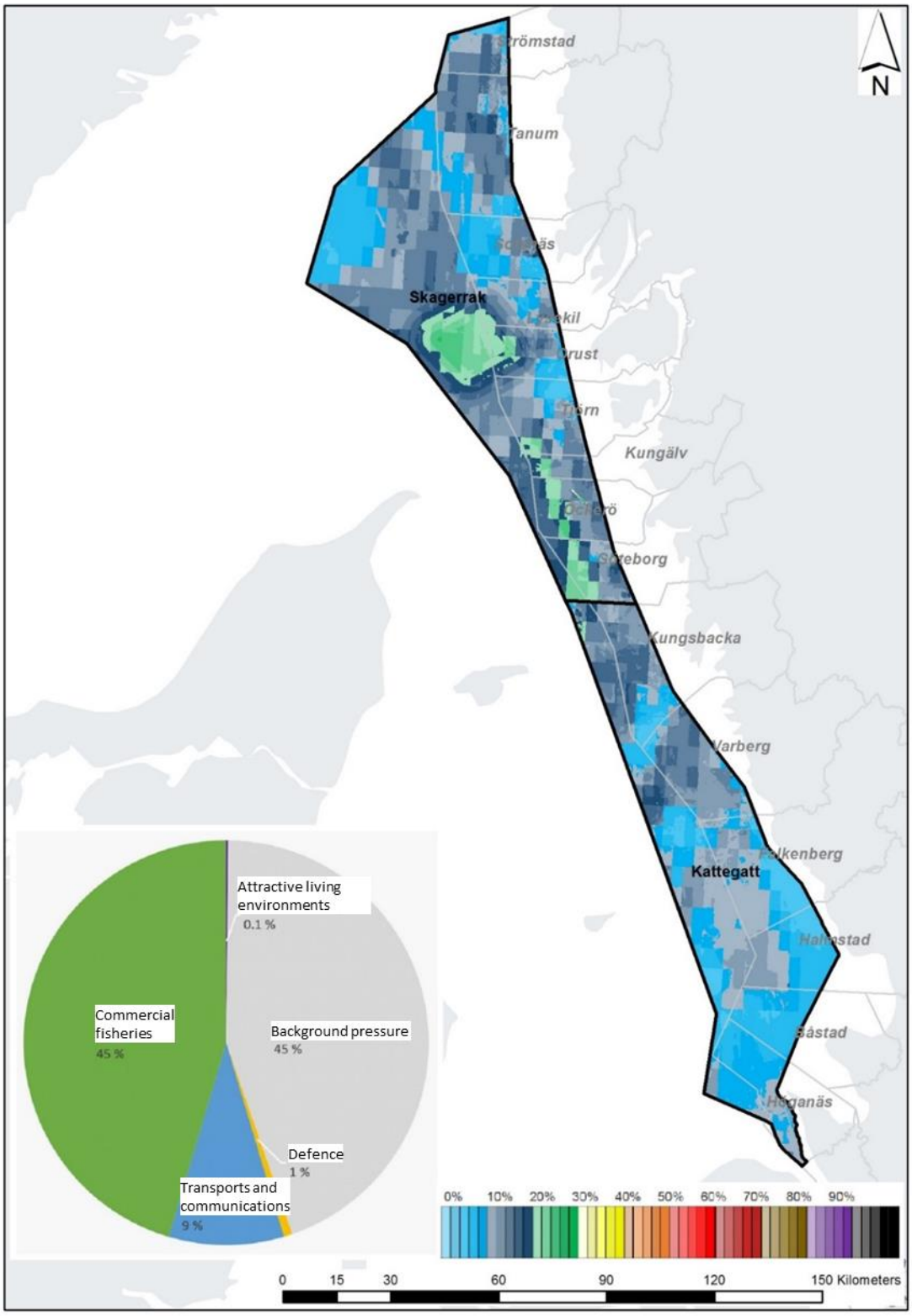

Figure 15 The total cumulative environmental effect in the Skagerrak and Kattegat marine spatial planning area. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat including coastal areas. The pie chart shows the relative percentage distribution of the sectors' contribution to the cumulative effect at present. The colours in the pie chart indicate sectors.

For the entire Skagerrak and Kattegat marine spatial planning area, the sectors of Commercial fisheries, Transportation and communications and Defence contribute to the cumulative effects. Commercial fisheries mainly contributes through *selective withdrawals of species* and *physical disturbance* from bottom trawling and is the sector that has the most effect in the marine spatial planning area, around 45% in total. Pelagic fishing and net fishing (*selective withdrawals of species*) have a relatively small effect. Defence activities contribute around 1% through *underwater noise* from explosions and *introduction of pollutants* (spread of chemical substances). Transportation and communications contribute 9% through *underwater noise* and *introduction of pollutants* through oil spills, but also emissions to air and spread of invasive species, which are not included in Symphony. *Introduction of pollutants* from recreational craft in the Attractive living environments sector accounts for only 0.1% of the cumulative effect. In Skagerrak and Kattegat, there is no sand extraction or sea-based wind power and the pressure from underwater cables is only marginal in the total environmental effect. A large part of the effect comes from background pressures, around 45%. This pressure consists of nitrogen (approx. 21%), pollutants in sediment (synthetics approx. 11%, heavy metals approx. 2%), pollutants from military activity from World War II (organic/inorganic approx. 4%), oxygen-free seabeds (approx. 3%), phosphorous (approx. 2%), and a very small percentage (< 1%) can be linked to oil spills that cannot be tied to any specific sector and heavy metals from mines from World War II.

The effects are mainly noticed on deep soft seabeds, spawning fish, cod, aphotic soft seabeds, plankton and porpoises. Some effect is also seen on herring, harbour seals, sprat, photic soft seabeds, and photic and aphotic transport seabeds.

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 litters*. 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.

<u>Air quality</u>

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 a way to go to achieve the environmental quality objective for

2020. In the assessment of air emissions of acidifying substances in the marine spatial planning area, the sulphur emissions are deemed to be the most crucial. Within the marine spatial planning area, the amount of NO_X gases is the highest in southern Skagerrak where shipping is most extensive. The amount of nitrogen oxide that is released per year is less than half as much in Skagerrak and Kattegat as in the Baltic Sea. From a comparative perspective between the MSPs along Sweden's coast, the sulphur emissions from shipping are 2.5 times higher in the Baltic Sea than in Skagerrak and Kattegat, but nearly four times lower in the Gulf of Bothnia where the conditions for NO_X gases are similar. However, relatively more sulphur and nitrogen are deposited in the Gulf of Bothnia, especially sulphur where the deposit is the highest per marine area (per m^2) (SMHI, 2016b).

The air quality generally seems to be on the way to improving, but the levels of nitrogen oxides are still increasing and emissions of nitrogen and sulphur are still somewhat high. Since air quality in Skagerrak and Kattegat does not seem sensitive to further impact from emissions to air, the marine area is given a low value (1) (WSP Sverige AB, 2016), see Table 4.

Greenhouse gases

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 as it among other things is in certain sea and lake beds and can thereby be freed upon e.g. resource extraction. 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 as the greenhouse gas emissions of shipping are increasing year on year. These emissions must, however, be put into 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 interest is set at high (3) for both of the marine sub-regions.

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 assessments thereof is that the sensitivity value is high (3). As foreign annelid worms, plant plankton, fish, oysters, crabs and diatom species occur in both marine sub-regions, the sensitivity is not considered to be high since the occurrence of invasive species is abundant (WSP Sverige AB, 2016). However, today, there are only indications of a real threat to biological diversity from the American lobster.

The value is deemed to be moderate (2) for both marine sub-regions as the differences based on this aspect are not significant, see Table 4.

Marine litter

Littering negatively affects the value for outdoor recreation as the sea landscape's quality decreases. Benefits from reducing marine littering include higher aesthetic values and improved possibilities for recreation and tourism (SwAM, 2012b). There is currently little data on marine litter in the open sea. Compared with litter on beaches, the litter at sea is spread over a wider area, which makes it harder to collect and measure. Based on the dominant surface currents in the Baltic Sea and the North Sea, it can be assumed that the Bohus coast is most affected by marine litter and this litter is often gathered in the oxygen-poor deep depressions (Havsmiljöinstitutet, 2016a). Lost and forgotten equipment and nets, such as cages and traps, are left in the sea and animals and objects can get stuck in them. These so-called ghost nets kill fish, birds and marine mammals in our seas every year. Ghost nets affect people when they are visible on the surface, but otherwise mostly only affect the marine bottom dwellers (SwAM, 2015b).

Macro plastics occur to the greatest extent in Skagerrak's coastal areas (outside the marine spatial planning area) where the level is high. In the larger part of the area, the occurrence is on a moderate level, although somewhat higher in the southern and western areas. Ghost nets extensively occur in Skagerrak's southern section and in the outer areas in the north while the occurrence is lower along the northern coast. In Kattegat, the occurrence of macroplastics is lower than in Skagerrak and varies from low in the outer areas to moderate in more coastal areas. However, the amount of ghost net is very large in Kattegat and is classed as high to very high in nearly the entire marine sub-region (Wijkmark, 2015).

The environmental objective "A Balanced Marine Environment, Flourishing Coastal Areas 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. Outdoor recreation is considered to not be especially impacted by marine litter in the offshore areas, but at the same time, all marine areas have a high occurrence of marine litter and the interest is thereby highly affected. The marine areas are therefore given a low value (1), see Table 4.

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

ASSESSED VALUE[5] 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, TOURISM)
SKAGERRAK	1	3	2	1
KATTEGAT	1	3	2	1

6.2.2 Skagerrak

Half of the cumulative effect that is caused by the sectors in Skagerrak comes from Commercial fisheries (approx. 50%), which mainly affects through *selective withdrawals of species* and *physical disturbance* mainly bottom trawling. Transportation and communications account for around 7% of the cumulative effect, mainly through *underwater noise* and *introduction of pollutants* (oil spills), and Defence accounts for around 1% from *introduction of pollutants* (heavy metals), *underwater noise* (explosion impact). The environmental effect linked to the background pressure accounts for around 42%. This effect consists of nitrogen (approx. 20%), pollutants in sediment (synthetics approx. 11%, heavy metals approx. 2%), pollutants from military activity from World War II (organic/inorganic approx. 6%), phosphorous (approx. 2%), oxygen-free seabeds (approx. 1%) and a very small percentage (< 1%) can be linked to oil spills and heavy metals from mines from World War II. Defence and Attractive living environments contribute less than 1%.

[5] Assessed sensitivity value in accordance with the SEA in the discussion phase (WSP Sverige AB, 2017)

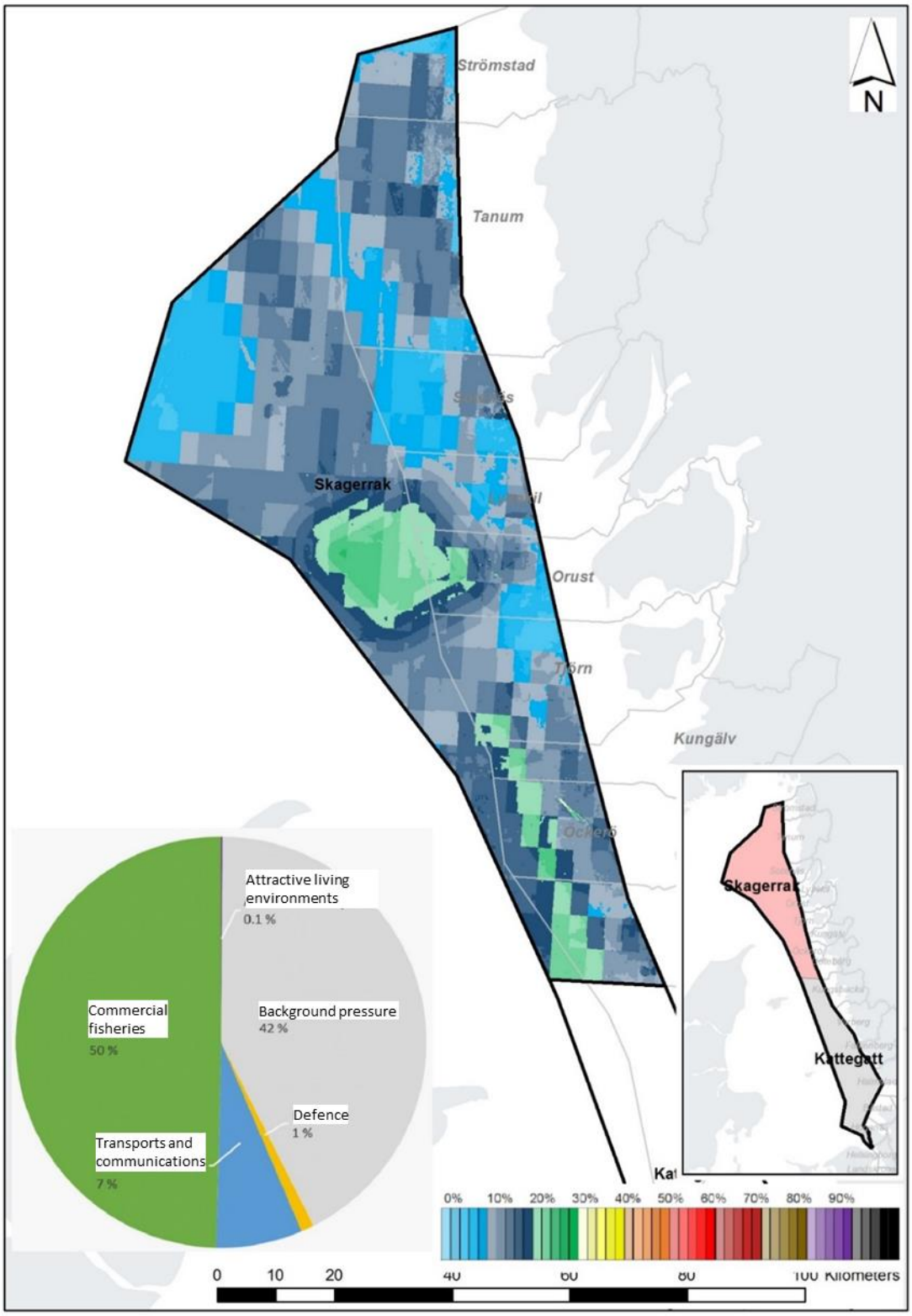

Figure 16 The total cumulative environmental effect in Skagerrak. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat including coastal areas. The pie chart shows the relative percentage distribution of the sectors' contribution to the cumulative effect at present. The colours in the pie chart indicate sectors.

The effects are mainly visible on deep soft seabeds, spawning fish, cod, porpoise, herring, sprat, harbour seal and plankton. Some impact also takes place on deep hard and transport seabeds, as well as aphotic transport bottoms. The largest impact comes from bottom trawling.

6.2.3 Kattegat

The cumulative effects in Kattegat are partly traced from Commercial fisheries, which accounts for around 38% of the effects, and Transportation and communications, around 14%. Commercial fisheries's effects mainly take place through *selective withdrawals of species* and *physical disturbance* in bottom trawling. Transportation and communications cause effects through *underwater noise*, and to a lesser part *introduction of pollutants* (oil spills). A largest part of the effects comes from background pressure, around 49%. This is rooted in nitrogen (approx. 24%), pollutants in sediment (synthetics approx. 9%, heavy metals approx. 3%), oxygen-free seabeds (approx. 8%), phosphorous (approx. 3%) and a very small percentage (< 1%) can be linked to oil spills and heavy metals from mines from World War II. Defence and Attractive living environments contribute less than 1%.

The effects in Kattegat mainly take place on aphotic soft seabeds, spawning fish, cod, plankton, porpoise, harbour seals and photic soft seabeds. Some effect can also be seen on herring, sprat, deep soft seabed, sea birds offshore wintertime, eel migration and aphotic and photic transport seabeds. It is mainly bottom trawling that affects them.

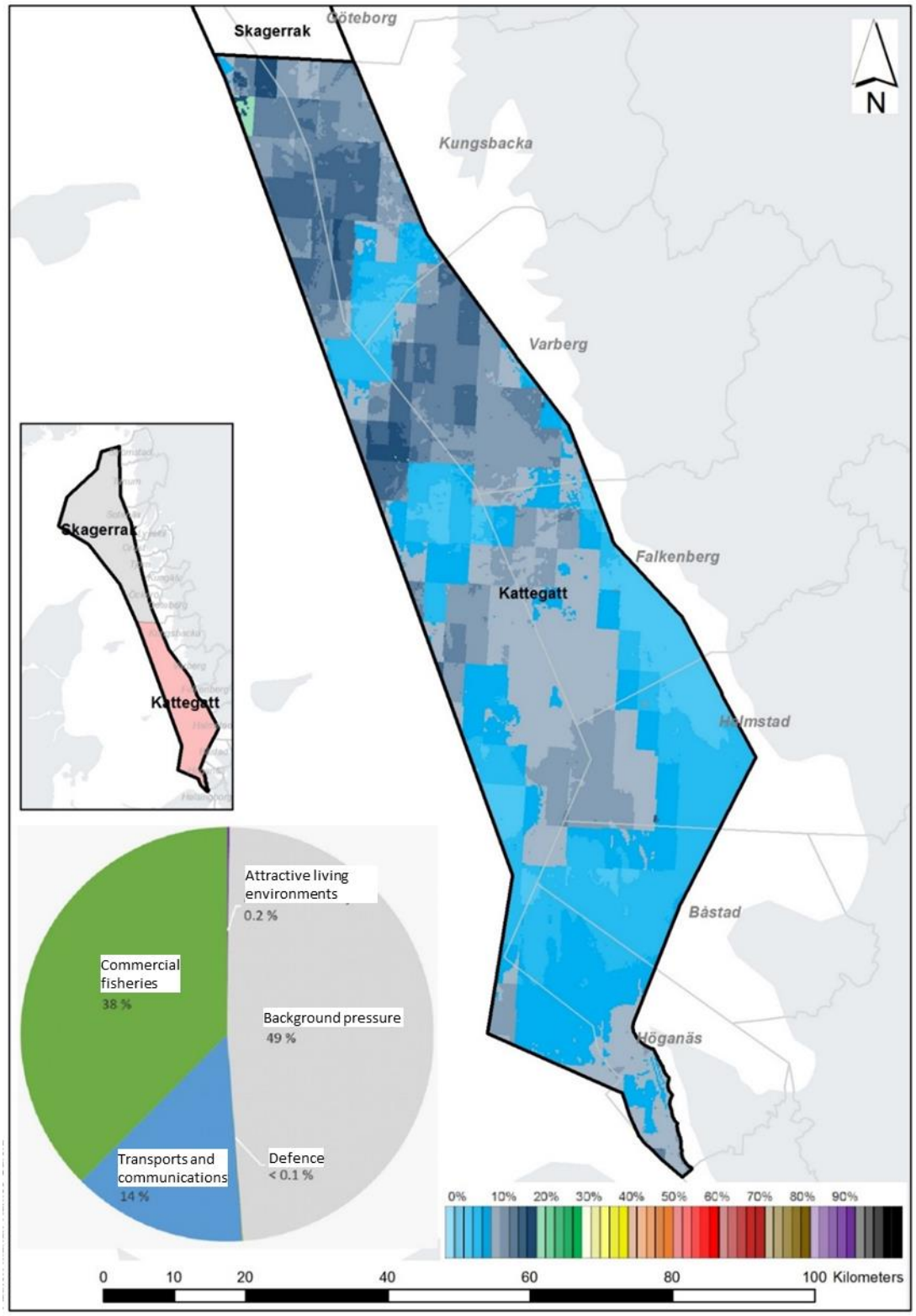

Figure 17 The total cumulative environmental effect in Kattegat. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat including coastal areas. The pie chart shows the relative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

7 Zero alternative

7.1 Sectors and themes

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 changes in the pressures. An upwards and increasing trend in the table accordingly means an increased pressure and thereby a negative effect.

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. Marine tourism is expected to continue an upward trend (SwAM, 2017d). 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 of 5% by 2030 with reference to uncertainty in the estimates and the lack of a clear trend in the actual numbers (SwAM, 2017d). However, recreational fishing is assessed to be relatively constant in scope until 2030 (SwAM, 2017d).

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, 2017d). Air pollution can also be expected to increase with the development of the 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 (2015c) regarding the collection of litter and lost fishing equipment and the initiation of prevention measures, littering is expected to decrease (SwAM, 2017d).

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 pollutants	Littering
ANGLING	→	→	→	→	↘
RECREATIONAL CRAFT	↗	-	↗	↗	↘
CRUISE TRAFFIC	↗	-	↗	↗	↘
FERRY TRAFFIC	↗	-	↗	↗	↘

* ↑ strong 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 for 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 entail a significant reduction in cost[6] (Swedish Energy Agency, 2018), and 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 the implementation of incentive funding. The Swedish Energy Agency (2017a) assesses that limited establishment will take place by 2030 and that the development will not gain speed until after 2030. Referring to a strong political desire to speed the transition to renewable energy production and on-going investigations in this area, the assumption is made that some establishment of wind power will take place in the marine spatial planning area. In the zero alternative, the assumption is made that wind power will be conducted according to existing permits, which in the Skagerrak and Kattegat marine spatial planning area entails production for Kattegatt Offshore off of Falkenberg. The permit comprises 50 wind turbines spread over 22 km².

Trends identified for technical development are that the wind turbines are becoming taller and the rotor blades longer and that the foundation technology

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

is developing (WSP Sverige AB 2016, the Swedish Energy Agency 2017a, SwAM 2017e). The development towards larger rotor blades is going quickly (SwAM, 2017e), 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 turbines will make it possible to place wind farms at a deeper depth than today and with potentially lower conflict with other interests. Establishment of floating turbines is not expected until after 2030 (Swedish Energy Agency 2017a, SwAM 2017e).

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	→	→	→	→	→

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

7.1.3 Defence

The Government bill on the direction of defence policy (Government bill 2014/15:109) describes a changed defence policy situation that motivates increases in the activities of the Swedish Defence. 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 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 proportionally 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 pollutants
ARTILLERY RANGE/TRAINING AREA	↗	↗	↗
DUMPED AMMUNITION	↗	↗	↗

* ↑ strong 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 Skagerrak and Kattegat, there are a few deposits with sand and gravel with geological conditions for extraction (SGU, 2017). The Gothenburg and Skåne regions are growth regions with extensive demand for construction materials that currently use relatively large shares of natural gravel in the production of ballast, which might entail higher demand for marine sand and gravel as replacement material for, among other things, reduced impact on ground water resources. This is on the condition that it is financially advantageous, which depends on several different factors, such as the supply of natural gravel on land, prices for the production of replacement material from crushed rock, and a political will that is demonstrated through, among other things, incentives for the respective forms of extraction. In the zero alternative, extraction is expected to take place solely in existing establishments and in areas pointed out as suitable by SGU (2017) in an even longer term. In the current marine spatial planning area, there are no areas pointed out as suitable, which is why extraction in the zero alternative is not assumed to take place in Skagerrak and Kattegat by 2030.

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	→	→	→

* ↑ strong 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 sand extraction. 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 expected to increase by 2030, and taken together are expected to cause the marine ecosystems further stress from, among other things, acidification, changes in the water's salinity, and a greater risk for the spread of invasive species.

The introduction of nutrients is decreasing, which contributes to a positive eutrophication trend in Skagerrak and Kattegat (Swedish Institute for the Marine Environment, 2016a). Thus the situation for Kattegat, which is affected by eutrophication problems, can be expected to improve by 2030.

The objective for expanded introduction of marine area protection will probably lead to more protected areas in 2030 than today (SwAM 2016e). 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 (IMO's Sulphur Convention and the 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. WWF (2010) describes a higher growth rate and a doubling of the number of vessels from 2010 to 2030. Based on these two sources, the zero alternative is expected to provide an increase in the pressure from the sector of 50% until 2030.

The general trend where the ships are becoming larger is expected to continue. The greater amount of transported goods might be captured by larger ships, and thus the number of passages might not increase. The total surface area for shipping lanes is not expected to have to increase, but risks in the form of collisions and associated risks for spills of oil and pollutants are expected to increase with the use of larger ships. Assumptions are made that dredging of existing shipping lanes might need to increase to enable the passage of larger ships.

With more activity in existing shipping lanes, the risk of collision increases, as well as the risk of running aground with associated risks to people and the environment (WSP Sverige AB, 2016). Shipping emissions into the air are regulated by several national and international regulations, such as the EU Sulphur Directive. Through the implementation of the Ballast Water

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

Table 9. Transportation and communications - 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	↗	↗	-	-	-	-

* ↑ strong 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 such farming might potentially become relevant in the marine spatial planning areas by 2030. Considering uncertainty in development, however, it is assumed that aquaculture will not 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	↗	→	→

* ↑ strong 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 that is already under way from smaller boats and one-man companies to larger units with higher capacity is expected to continue (SwAM, 2016d). The trend for a smaller 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 for catches in the long term (SwAM, 2017d). 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 acidification in the seas will affect marine environments and fishing.

The establishment of marine area protection with fully or partly regulated fishing is a measure 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 methods 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, 2016d). 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 Withdrawal of fish. 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)
BENTHIC TRAWLING	→	↘	↘
PELAGIC TRAWLING	→	↘	↘
OTHER FISHING	→	↘	↘

* ↑ strong 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 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 new uses of the sea than today with a potential increased pressure 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 new and 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 have gained speed. By 2050, development of floating wind

turbines might also have made this 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 disturbances increasing to a lesser extent than the increase of sector development.

7.2.3 Defence

Technical development and changes in the defence policy situation make it very difficult to assess the total 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, which might possibly 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 are important to preserve. By 2050, it is expected that demand and technology will have developed 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, an even greater pressure on the marine environment is expected compared to 2030. A probable development is that energy production at sea will have become more profitable and that establishment of wind farms will have gained speed along with, at least to some extent, 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 developments will lead to 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 into Skagerrak and Kattegat probably will have positive effects on eutrophication problems. However, recovery of ecosystems is a complex process and takes place slowly, and the status of Skagerrak and Kattegat 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 expected to continue to increase until 2050. A potential scenario is that in 2050 the common use of automatically controlled and unmanned vessels 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 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 areas developed for use, for example, algae for the production of food, feed, and biogas. It is likely that an increased demand will contribute to a greater 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, e.g., energy production. To reduce nutrient leakage into 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 such activities' pressures on the marine environment and fish stocks, the possibilities of future withdrawals are also affected by other pressures and by the seas' environmental status. The ecosystems' health, effects from climate change, etc., are uncertainties that make it difficult to forecast the pressure from Commercial fisheries in 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 Skagerrak and Kattegat 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 Skagerrak and Kattegat

In the zero alternative, the environmental impact and the cumulative environmental effect will increase in the Skagerrak and Kattegat marine spatial planning area compared with the present situation. The increase (2%) will mainly be within Kattegat and around Gothenburg, while the northern areas in Skagerrak will likely show an improvement. The geographic distribution of environmental effects will likely be similar to that of the current situation, i.e. the highest environmental effect will be in central and southern Skagerrak and in Gothenburg, see Figure 18.

The cumulative environmental effect in Skagerrak and Kattegat comes mostly from the sectors of Commercial fisheries and Transportation and communications with a smaller share from Defence, Attractive living environments, and Energy, see Figure 18. Commercial fisheries accounts for the largest share, around 42%, which includes disturbances from bottom trawling, including *selective withdrawals of species* and *physical disturbances*, as well as from pelagic fishing. This is a small decrease compared with the present situation because the impact from Commercial fisheries is expected to decrease through the regulation of equipment and fishing periods. Transportation and communications account for around 13% of the cumulative effect, and this includes *underwater noise* and the *introduction of pollutants* (oil spills) from shipping. Through the *introduction of pollutants*, the sector Defence contributes by around 1%. Attractive living environments and Energy contribute with less than 1%, and this includes the *introduction of pollutants* from recreational craft and *underwater noise* and *biological disturbance*. The background pressure contributes around 44% to the cumulative effects. This mainly consists of nitrogen (approx. 21%), but also pollutants in sediment (synthetics approx. 11%, heavy metals approx. 2%), heavy metals from World War II (approx. 4%), oxygen-free seabeds (approx. 3%), and phosphorous (approx. 2%), and a relatively small portion from oil spills from wrecks (<1%).

The cumulative effects appear mainly on deep soft seabeds, spawning fish, cod, aphotic soft seabeds, North Sea porpoises, plankton, and herring, but also on

harbour seals, sprat, Danish Straits porpoises, and photic soft seabeds.

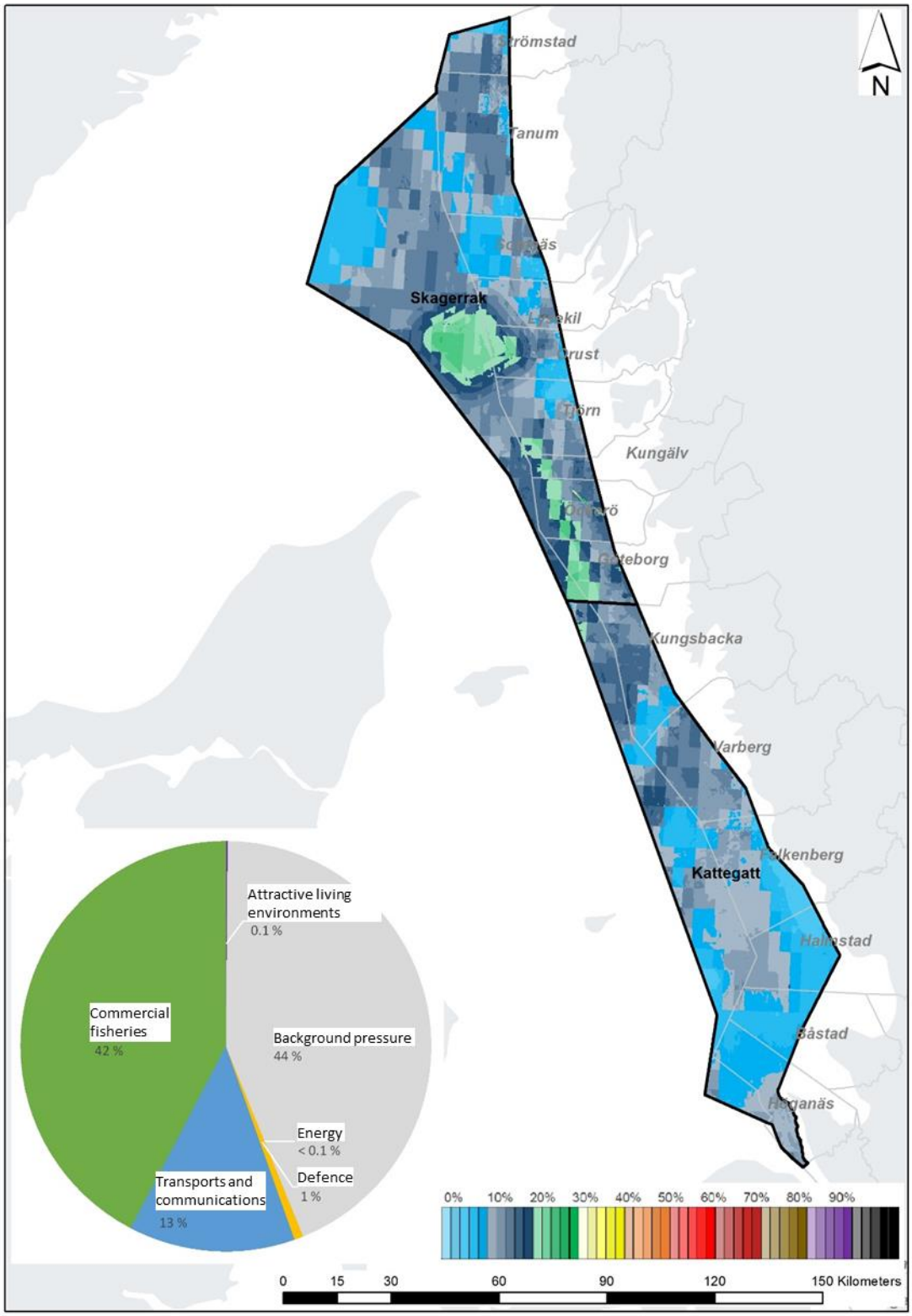

Figure 18 The total cumulative environmental effect in the Skagerrak and Kattegat marine spatial planning area. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat, including coastal areas. 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.

Other pressures that are not analysed in Symphony
Tourism and recreation are expected to increase in Skagerrak and Kattegat, which entails, among other things, more ferry and cruise traffic, which will result in a greater pressure from emissions into the 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 the introduction of preventative measures. Commercial fisheries is expected to be stable up to 2030 and is not expected to entail any change in the pressures (emissions into the air) compared with the current situation. Shipping is expected to increase by 50% until 2030 and to entail an increase in pressures. Emissions into the air from shipping are regulated with several national and international regulations, e.g. the IMO and EU's Sulphur Directive. Through the implementation of the IMO's 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 in Skagerrak and Kattegat is expected to have moderate to large 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 result in small to moderate effects, and the effect of marine litter is deemed to be small.

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

ASSESSED ENVIRONMENTAL EFFECT	AIR QUALITY (NO_X OR PARTICLES)	GREENHOUSE GASES (CO_2 AND OTHER GREENHOUSE GASES)	INVASIVE SPECIES (EXTENSIVE UNCERTAINTY - LACK OF KNOWLEDGE)	MARINE LITTER (LITTER FROM FISHING, SHIPPING, TOURISM)
SKAGERRAK	Small-moderate effects	Moderate-large effects	Small-moderate effects	Small effects
KATTEGAT	Small-moderate effects	Moderate-large effects	Small-moderate effects	Small effects

7.3.2 Skagerrak

The cumulative effects in Skagerrak come from the sectors Commercial fisheries, Transportation and communications, Defence, and Attractive living environments. Commercial fisheries, which accounts for around 47%, mainly results in *physical disturbance* and *selective withdrawals of species* (bottom trawling and pelagic fishing). Transportation and communications, which account for around 10%, causes mainly *underwater noise* and to some extent the *introduction of pollutants* (oil spills from shipping). The sector Defence mainly causes a pressure (approx. 1%) through *introduction of pollutants* (heavy metals and other substances) and some risk for the spread of *underwater noise* from explosions. Attractive living environments account for less than 1% and result in *introduction of pollutants* from recreational craft. The background pressure accounts for around 42% of the cumulative effect in

Skagerrak, and consists of a large share of nitrogen (approx. 20%) and pollutants in sediment (synthetics approx. 11%, heavy metals approx. 2%), heavy metals from World War II (approx. 6%), and phosphorous (approx. 2%). A relatively small part comes from oil spills from wrecks (approx. 1%) and oxygen-free seabeds (approx. 1%).

The cumulative effects appear mainly on deep soft seabeds, spawning fish, cod, North Sea porpoises, plankton, and herring, but also some effects on harbour seals, aphotic soft seabeds, and sprat.

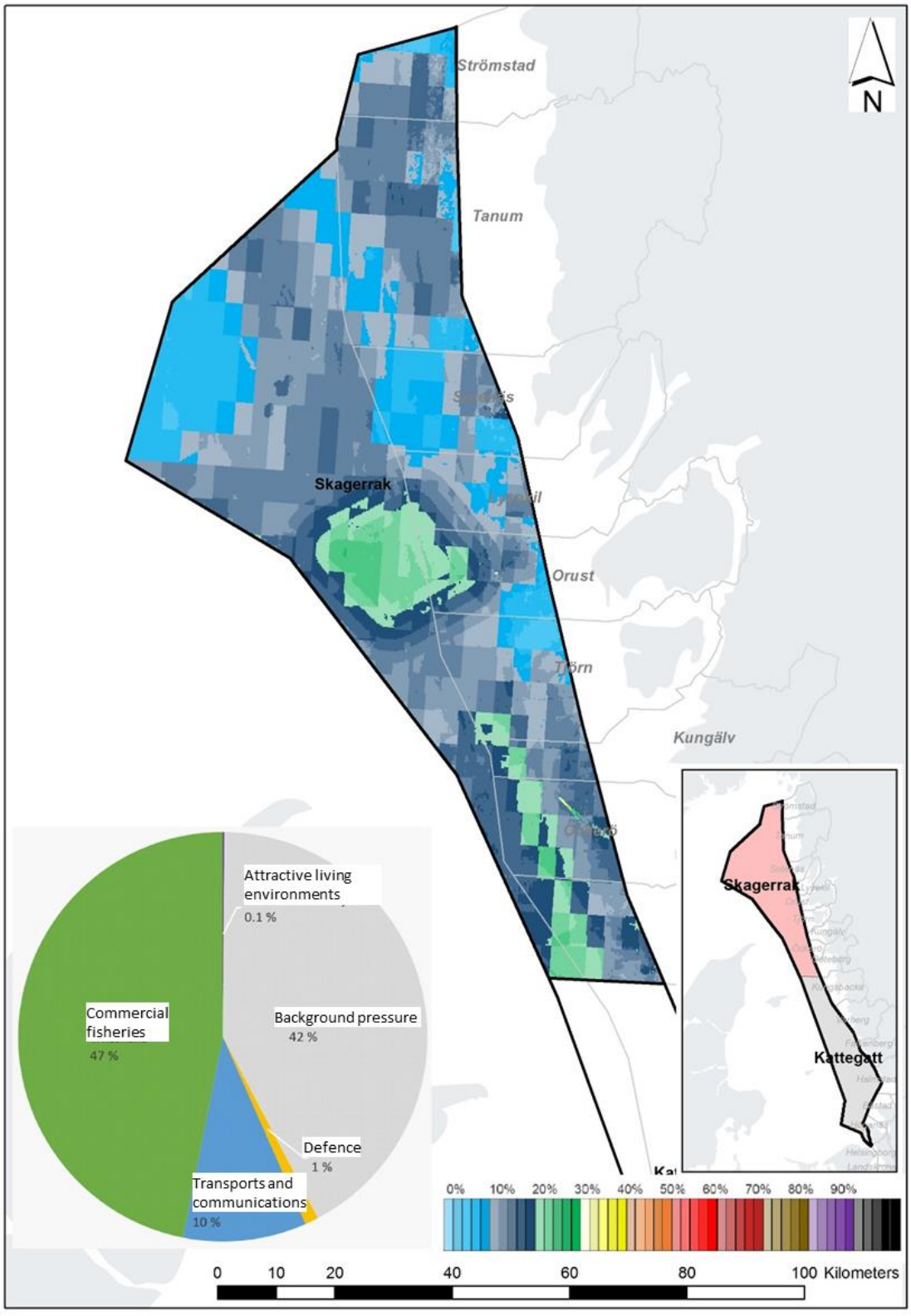

Figure 19 The total cumulative environmental effect in Skagerrak. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat, including coastal areas. The pie chart shows the relative percentage distribution of the sectors' contribution to the cumulative effect for the zero alternative. The colours in the pie chart indicate sectors.

Compared with the present situation, the cumulative environmental effect in the zero alternative is expected to increase by around 1%. An increase can be seen geographically in the eastern parts of the marine area, and the largest environmental effect is seen in the area around Gothenburg, see Figure 20. It is above all the shipping sector's development that provides a larger pressure, which has an effect on the cumulative environmental effect. In the north-western parts of the marine area, the cumulative environmental effect is expected to decrease in the zero alternative compared with the current situation. A continued reduction in fishing and the method development that is taking place in the sector is expected to lead to a smaller pressure and lower environmental effect in the northern and north-western parts of this marine area.

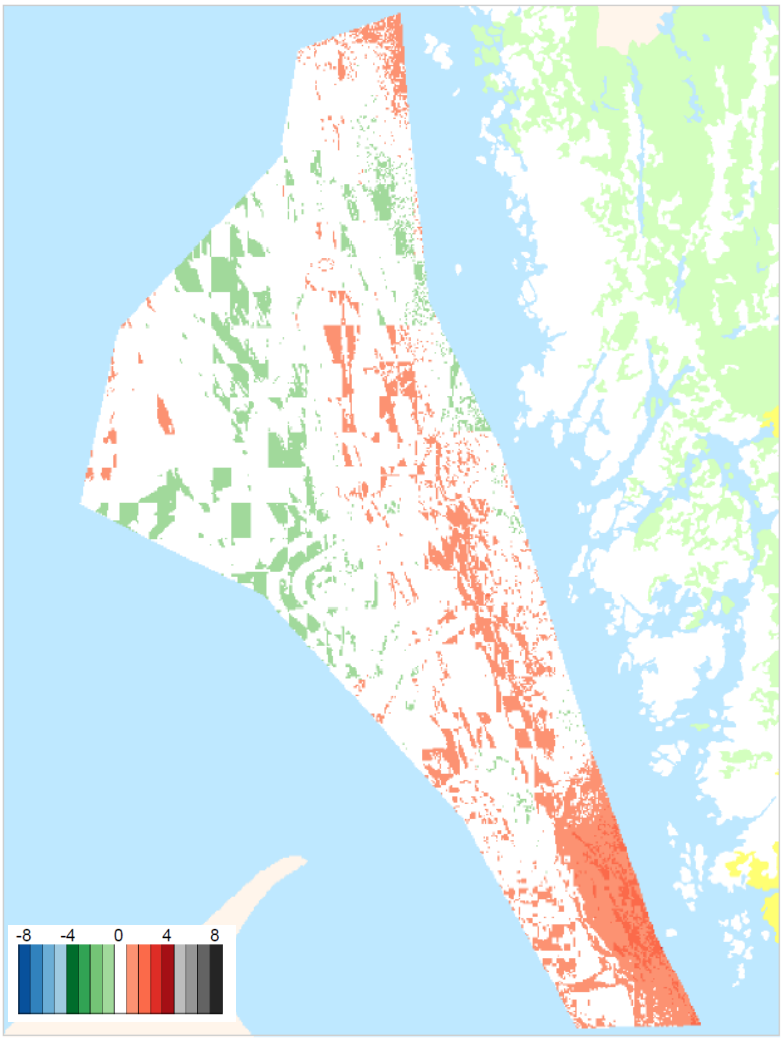

Figure 20 Change in the cumulative environmental effect as a percentage in the Skagerrak marine spatial planning area. Positive values, in red and grey, result in a larger cumulative environmental effect in the zero alternative compared with the present situation. Negative values, in blue and green, result in a smaller cumulative environmental effect compared with the present situation.

7.3.3 Kattegat

The cumulative effects from sectors in Kattegat come mostly from Commercial fisheries and Transportation and communications with small percentages from Attractive living environments and Defence. Commercial fisheries contributes around 34% and consists of effects from bottom trawling, including *physical disturbance* and *selective withdrawal of species*, which includes pelagic fishing. Transportation and communications contribute around 19% through

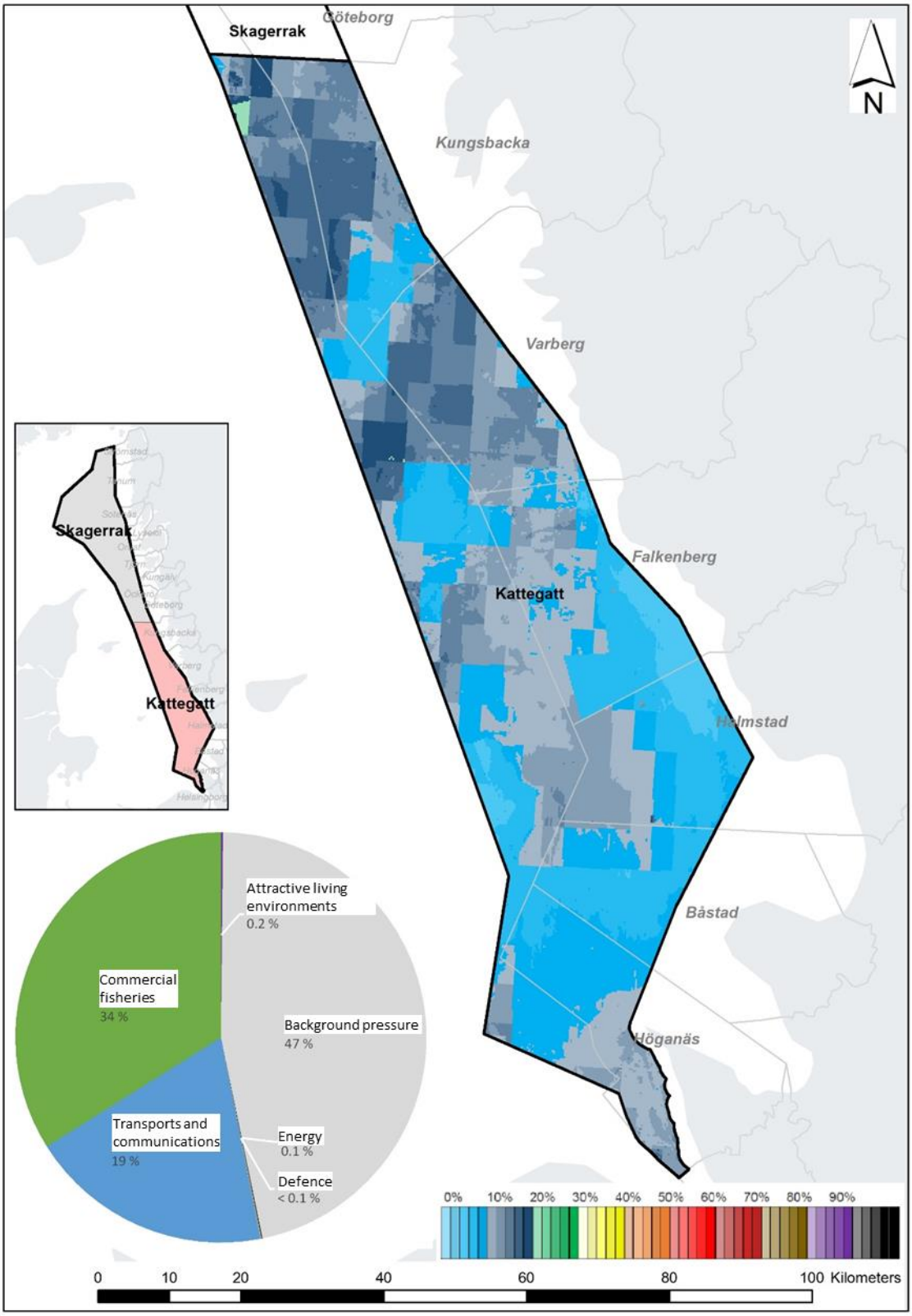

Figure 21 The total cumulative environmental effect in Kattegat. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat, including coastal areas. The pie chart shows the relative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

underwater noise, *physical disturbance* (sediment spread), and the *introduction of pollutants* (oil spills from shipping). Defence contributes a very small share through the *introduction of pollutants*. A very small percentage also results from Attractive living environments through the *introduction of pollutants* (synthetic environmental toxins) from recreational craft and bird hunting as well as from Energy through *underwater noise* and *biological disturbance*. The background pressure accounts for around 47% of the cumulative effects and consists mainly of nitrogen (approx. 23%), but also oxygen-free seabeds (approx. 8%), phosphorous (approx. 3%), and pollutants in the sediment (heavy metals approx. 3%, synthetics approx. 9%). A very small percentage is also contributed by oil spills from shipwrecks and heavy metals from mines from World War II.

The cumulative effects are visible in Kattegat mainly on aphotic soft seabeds, spawning fish, cod, and plankton, but also on photic soft seabeds, North Sea porpoises, Danish Straits porpoises, harbour seals, herring, sprat, deep soft seabeds, and aphotic and photic transport seabeds.

In a comparison between the zero alternative and the present situation, the environmental effect is expected to increase by around 4%, see Figure 22, which is due to the sectors' development. It is primarily the shipping sector that is expected to increase until 2030, which results in a higher pressure and in turn entails a greater cumulative environmental effect.

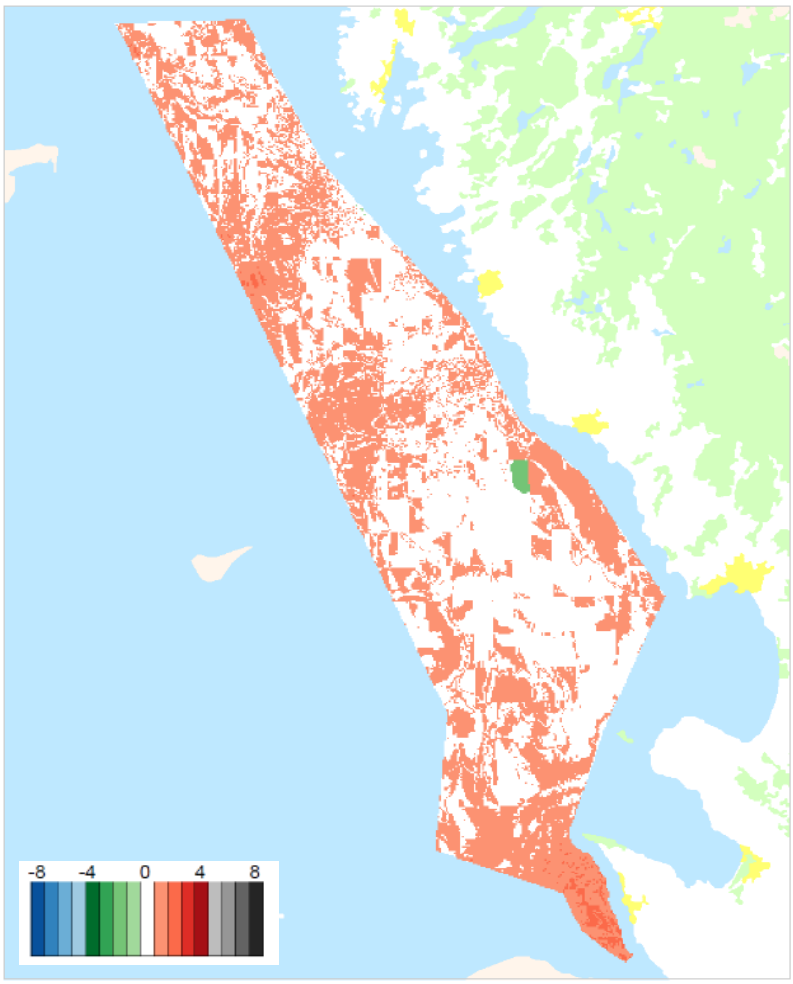

Figure 22 Change in the cumulative environmental effect as a percentage in the Kattegat marine spatial planning area. Positive values, in red and grey, result in a larger cumulative environmental effect in the zero alternative compared with the present situation. Negative values, in blue and green, result in a smaller cumulative environmental effect compared with the present situation.

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 estimates of the cumulative effect, the Symphony planning method and its included values were used as a base.

8.1.1 **Attractive living environments**

A comprehensive and valuable coastal and archipelago landscape extends along the entire coast where there are also many sunken shipwrecks. The archipelago is one of Sweden's most heavily visited with many natural harbours and marinas. Recreation and angling are extensive, and the use Attractive living environments is present in several parts of the marine area, both along the coast and on the offshore banks. Consequently, the use Attractive living environments is widespread in the entire marine spatial planning area.

8.1.2 **Energy**

In the marine spatial planning area, there are good prerequisites for wind power with high wind speeds and offshore banks with suitable depths. Good connection points for electricity are available on land, and the grid is well developed because the Ringhals nuclear power plant is on the Halland coast. Adaptation needs to take place so that wind power can co-exist with Kattegat's high nature values and local Commercial fisheries. Fishing that cannot be combined with the use Energy can be conducted in surrounding areas.

In Kattegat, there are three areas with the use Energy for sea-based wind power located at three sites off of Falkenberg and Halmstad. In the marine spatial planning area, there is a current permit for Kattegatt Offshore, located off of Falkenberg in Halmstad Municipality, to build 50 stations with a total installed capacity of 282 MW.

In two of the areas (V305, V307), *particular consideration to high nature values (n)* is indicated. One area (V302) coincides with Natura 2000. The offshore banks that have the highest nature values according to the earlier inventory are withheld from energy extraction (Swedish Environmental Protection Agency, 2006).

The marine spatial planning process shows that the areas that the Swedish Energy Agency has pointed out as national interest claims for wind power will not be enough to reach the target, due in part to competing interests. Therefore, further areas of interest for energy extraction have been worked out in the marine spatial planning process, which are not included in the zero alternative's estimates made with Symphony as a base. The zero alternative estimates of the cumulative effect, based on the Symphony planning method, include existing establishments (which do not exist in the Skagerrak and

Kattegat marine spatial planning area) and wind power establishments with granted permits (Kattegatt Offshore).

8.1.3 Defence

The Skagen marine training area extends from Sotenäs in the north to Tjörn in the south and out across the entire territorial sea and into the exclusive economic zone. Farther south, almost entirely within the city of Göteborg, is the Känsö marine training area. The areas are both indicated with the use Defence. Within the areas, there are several smaller areas with valuable nature that are expected to be able to co-exist with defence-related activities.

The Ringenäs artillery range is located off of Halmstad, and the plan indicates the use Defence there. The MSP also indicates that *particular consideration to total defence interests (f)* shall be taken in some locations.

8.1.4 Storage and extraction of materials

Today, no carbon dioxide storage takes place in Sweden, but the potential for future storage is being investigated. In a report, the Geological Survey of Sweden pointed out areas for further investigation of the suitability for carbon dioxide storage. The report shows that there might be a significant potential for storage in southern Sweden. The most and largest possible storage places have been found in the southern Baltic Sea, but an interesting storage unit designated the Höganäs-Rya formation also extends into southern Kattegat. This formation, which has its centre in Öresund, has an estimated storage capacity of 543 megatons of carbon dioxide. Continued studies and greater interest are required to determine this in the long term and if so, where storage might be of interest (SwAM, 2018b).

No sand extraction currently takes place within the marine spatial planning area. Nine different areas have been proposed as being of interest for the extraction of marine sand and gravel in the Government assignment that the Geological Survey of Sweden conducted together with SwAM in 2017. One of these areas is in Skagerrak and Kattegat, at Stora Middelgrund, and the area is located within the offshore bank's Natura 2000 area. Four of the nine areas are considered to be most suitable from a sustainability perspective. None of these areas are in Skagerrak and Kattegat.

The marine spatial planning area therefore contains no areas for Storage and extraction of materials.

8.1.5 Nature

The Skagerrak marine sub-region has high nature values, including birds, fish, mammals, and valuable seabed environments that also extend beyond the marine spatial planning area into international waters and in towards the coast. The area has almost oceanic conditions and a large variation of different types of seabeds at different depths, which entails a very high biological diversity that is unique for Sweden.

Within the marine training areas in Skagerrak, there are several smaller areas with valuable nature, which are protected through the use *Nature* or through *particular consideration to high nature values (n)*.

High values – mainly for birds and porpoises and important spawning areas for fish and valuable bottom environments – are safeguarded with the use *Nature*. These are mainly on the offshore banks, farthest to the south and along the coast. The offshore banks Fladen and Lilla Middelgrund have been pointed out as especially valuable by the Swedish Environmental Protection Agency with very high nature values that are protected through the use *Nature*. At the same time, the areas constitute the use Attractive living environments because they are appointed as national interests for outdoor recreation. On-going management measures might lead to some limitations to recreational fishing on the banks. This contributes to co-existence between both of the uses.

High nature values are also found on the Danish side. Several uses also need to show *particular consideration to high nature values (n)* in several areas in Kattegat.

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

- V332 – Reef and soft bottom environment with high biodiversity
- V334 – Soft bottom environment with high biodiversity with especially high environmental impact
- V337 – Reef and soft bottom environment and spawning area with especially low environmental impact
- V342 – Reef and soft bottom environment and spawning area with high biodiversity.
- V343 – Reef and soft bottom environment and spawning area with high biodiversity and the presence of porpoises

8.1.6 Transportation and communications

Shipping traffic routes between the North Sea, Norway, Denmark, and the Baltic Sea pass through Skagerrak and Kattegat. The shipping traffic is important and extensive because the route through Kattegat is one of only two ways into the Baltic Sea for large vessels with the route choice of Öresund or the Great Belt in the south, off of Stora and Lilla Middelgrund. Both routes limit the ships in height because both have bridges. The other way into the Baltic Sea is the Kiel canal, which also has limits on the width, length, and depth of the vessels. To guarantee safe shipping through the shallow waters in Kattegat, there are proposals for new traffic separation regulations on both sides of the offshore banks. An analysis has shown that the regulations, which entail broader shipping lanes, altogether entail an improvement for the marine environment (SwAM, 2017b). Sweden's two largest ports are also located in Gothenburg and Lysekil.

The shipping lanes are widespread in the entire marine spatial planning area with several lanes from north to south and into the ports along the coasts on both the Swedish and Danish sides. The use *Shipping* therefore covers large areas in order to provide room for the proposed traffic separation systems that are necessary for safe shipping (V300, V303, V306, V309–313, V315).

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 important and extensive in Skagerrak and Kattegat. Shrimp fishing is conducted to a large extent in the northern part of the area. Fishing for Norway lobster is conducted throughout the marine spatial planning area except for farthest west. Closer to the coast, there is cage fishing for Norway lobster. Sparser fishing with passive equipment takes place throughout the area and is somewhat more intensive in the south. Pelagic fishing is conducted from Sotenäs and to the south. The use Commercial fisheries is therefore present throughout the Skagerrak marine sub-region, except for a small area farthest west inside the Natura 2000 area Bratten, and in large parts of Kattegat. Important spawning areas for cod in central and southern Kattegat are included in the use *Nature* or are protected with *particular consideration to high nature values (n).*

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 in order to be adapted to new knowledge, new needs, and sector development.

8.3 Cumulative effects - plan alternative

The cumulative effect for the MSP alternative for both marine sub-regions of Skagerrak and Kattegat has been identified using Symphony, among other things. 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 types of impacts that the sectors contribute are linked to the pressures of the Marine Strategy Framework Directive.

8.3.1 Skagerrak and Kattegat

The proposed MSP entails no clear change to the cumulative environmental effect compared with the zero alternative, see Figure 23. The MSP entails a

lower cumulative environmental effect in the areas pointed out as areas in which *particular consideration to high nature values (n)* shall be taken. Within these areas, the decrease will be the largest where there is the largest concentration of nature values. In Kattegat, the environmental effect is reduced markedly in areas pointed out for energy extraction (wind power), which depends on some of the fishing being moved out from these areas to surrounding areas where the environmental effect instead increases slightly. This means that the net effect of the MSP is marginally positive (approx. 1% lower on average compared with the zero alternative).

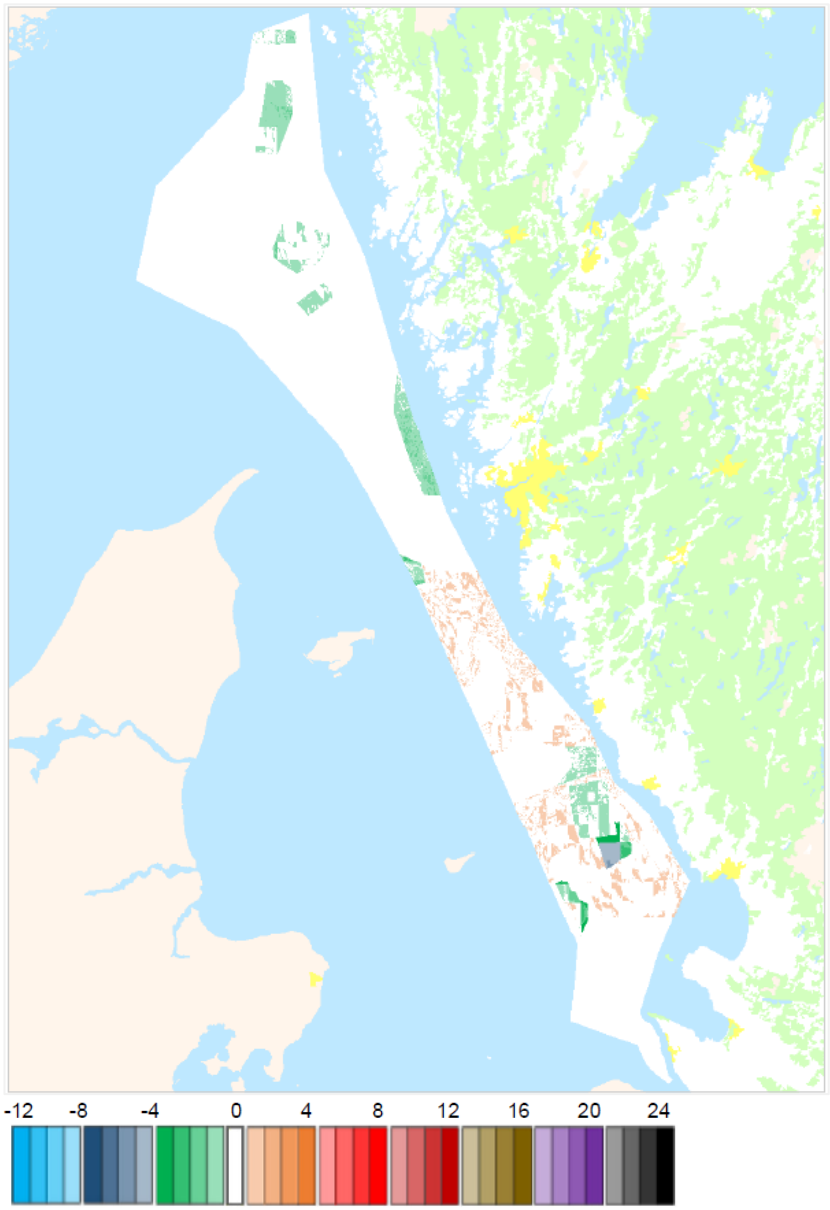

Figure 23 Change in the cumulative environmental effect in per cent in the Skagerrak and Kattegat marine spatial planning area compared with the zero alternative. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the zero alternative. Negative values, in blue and green, result in a smaller cumulative environmental effect compared with the zero alternative.

The cumulative effects in Skagerrak and Kattegat in the plan alternative come from the sectors Commercial fisheries, Transportation and communications, Defence, and Attractive living environments. Commercial fisheries contributes around 42% and consists mostly of effects from bottom trawling through *physical disturbance* and *selective withdrawal of species*, but includes some effect from pelagic fishing. Transportation and communications account for around 13% and consist of *underwater noise* and *introduction of pollutants* (oil spills) from shipping. The Defence sector, which contributes around 1%, consists of *introduction of pollutants* and *underwater noise* as effects from explosives. Attractive living environments contribute less than 1% with *introduction of pollutants* from recreational craft. Energy contributes less than 1% with *underwater noise* and *biological disturbance*.

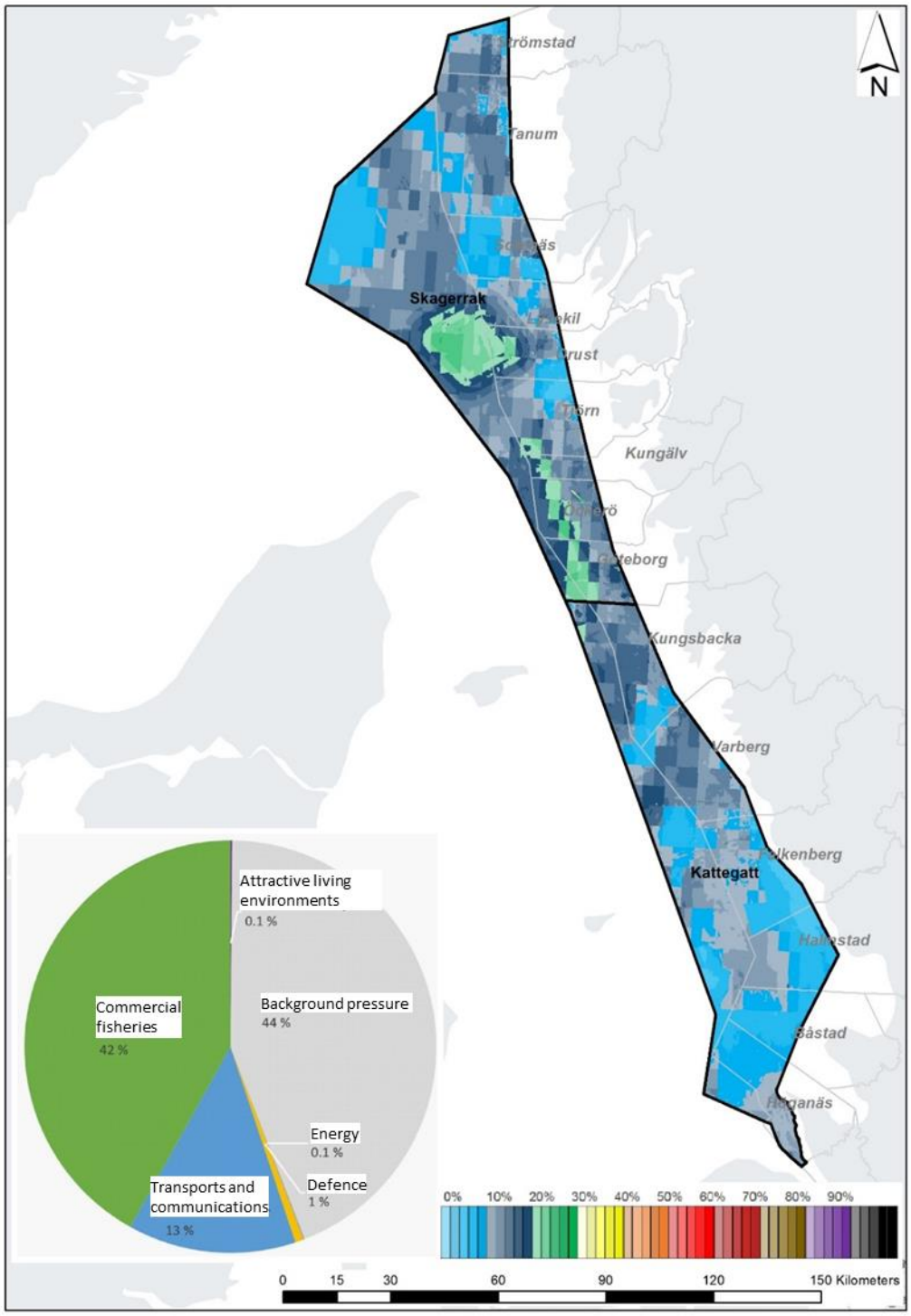

Figure 24 The total cumulative environmental effect in the Skagerrak and Kattegat marine spatial planning area. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat, including coastal areas. The pie chart shows the relative percentage distribution of the sectors' contribution to the cumulative effect. The colours in the pie chart indicate sectors.

The background pressure contributes to the cumulative effect by about 44% and mainly consists of nitrogen (approx. 21%) and pollutants in sediment (synthetics approx. 11%, heavy metals approx. 2%), but also heavy metals and

pollutants from World War II (approx. 4%), oxygen-free seabeds (approx. 3%), phosphorous (approx. 2%), and oil leakage from shipwrecks (approx. 1%).

The cumulative effects appear mainly on deep soft seabeds, spawning fish, cod, aphotic soft seabeds, North Sea porpoises, and plankton, but also on herring, harbour seals, sprat, photic soft seabeds, and Danish Straits porpoises.

Kattegat has three areas for Energy, which contribute to the total cumulative environmental effect through the impacts of *physical disturbance* and *biological disturbance*. The use Energy might also affect Attractive living environments (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 the conditions shall exist for continued preservation and development of these values. A further specification is that the status shall remain 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. Skagerrak has a moderate number of cultural heritage remains under water (see Figure 25), while Kattegat has relatively few known remains (data on underwater remains from the Swedish National Heritage Board's database for archaeological sites and monuments (FMIS)). In the areas in Kattegat that are planned for Energy, there might be a conflict. In detailed development plans of the wind power farms and other energy extraction in these areas, a study of marine archaeology needs to be carried out to minimise the impact on the cultural environment.

Another aspect of the areas designated for Energy is the landscape appearance. Here, landscape appearance refers to the perception of the landscape when at sea and the perception of the landscape from a point on land with a view towards the sea. Only the landscape appearance above the surface is addressed because knowledge of the submarine landscape view is deficient.

For the plan alternative, the areas for wind farms are deemed to result in a small environmental effect on cultural environments and landscape appearance.

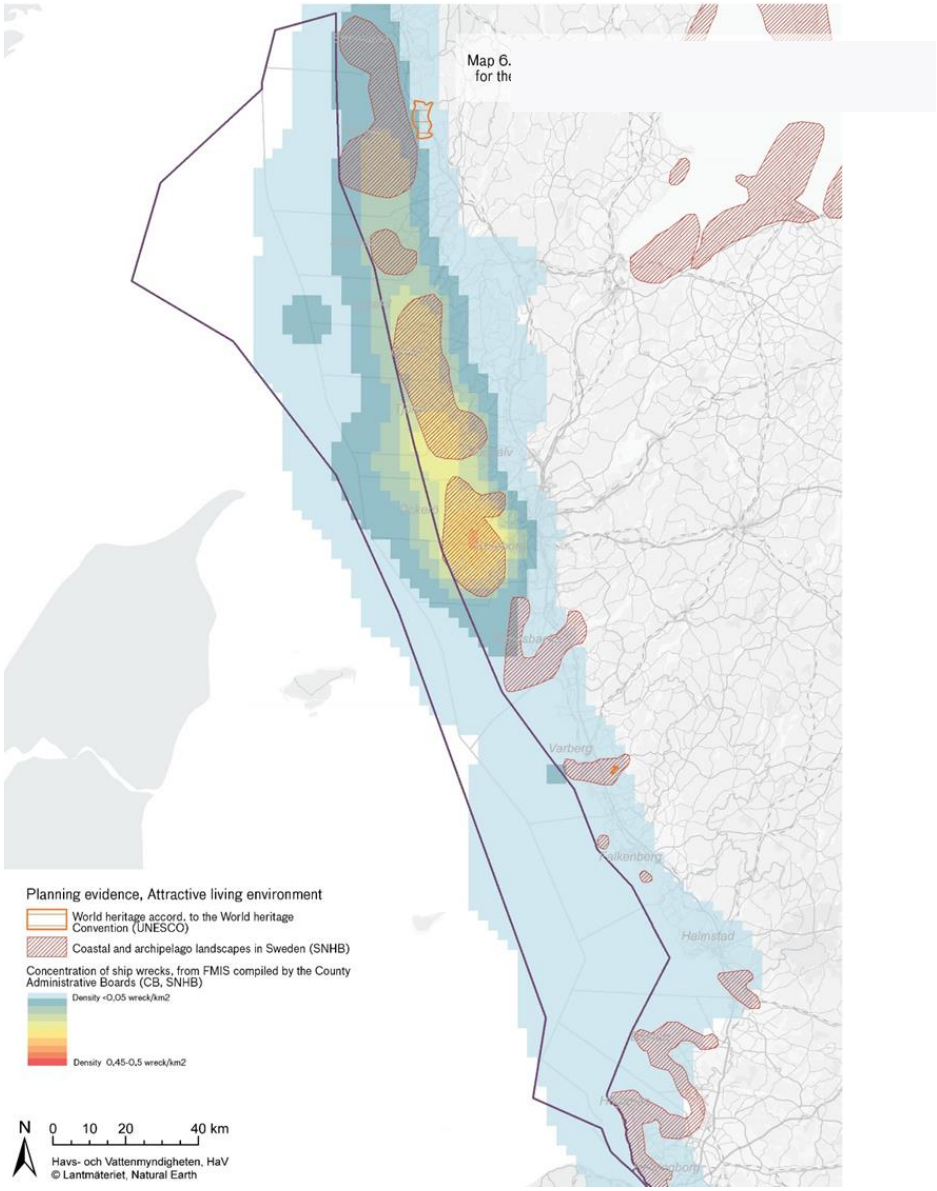

Figure 25 Public interests and other prerequisites for the theme Attractive living environments in the marine spatial planning area (SwAM, 2018b).

For every marine area in the Skagerrak and Kattegat marine spatial planning area, the environmental effects for the pressures of air emissions, invasive species, and marine litter were assessed. The MSP in 2030 entails only a small increase in the pressures for air quality and greenhouse gases. There are changes in the theme Transportation and communications (shipping) that contribute to these pressures, and these entail small environmental effects that are additional with the MSP guidance in 2030 compared with the effects that the zero alternative in 2030 entails (text in light grey).

Table 13 Assessed environmental effects in the respective marine area for the pressures of 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, TOURISM)
SKAGERRAK	Plan alternative: Small effects *Zero alternative: Small-moderate effects*	Plan alternative: Small effects *Zero alternative: Moderate-large effects*	Plan alternative: *Zero alternative: Small effects*	Plan alternative: - *Zero alternative: Moderate effects*
KATTEGAT	Plan alternative: Small effects *Zero alternative: Small-moderate effects*	Plan alternative: Small effects *Zero alternative: Moderate-large effects*	Plan alternative: - *Zero alternative: Small-moderate effects*	Plan alternative: - *Zero alternative: Moderate effects*

8.3.2 Skagerrak

Within the Skagerrak marine spatial planning area, the MSP's areas with *particular consideration to high nature values (n)* provide a positive effect compared with the zero alternative (approx. 1% lower on average compared with the zero alternative), see Figure 26. In these areas, the impact decreases mainly from Defence and Commercial fisheries. Within other areas, no effect of the MSP is seen compared with the zero alternative.

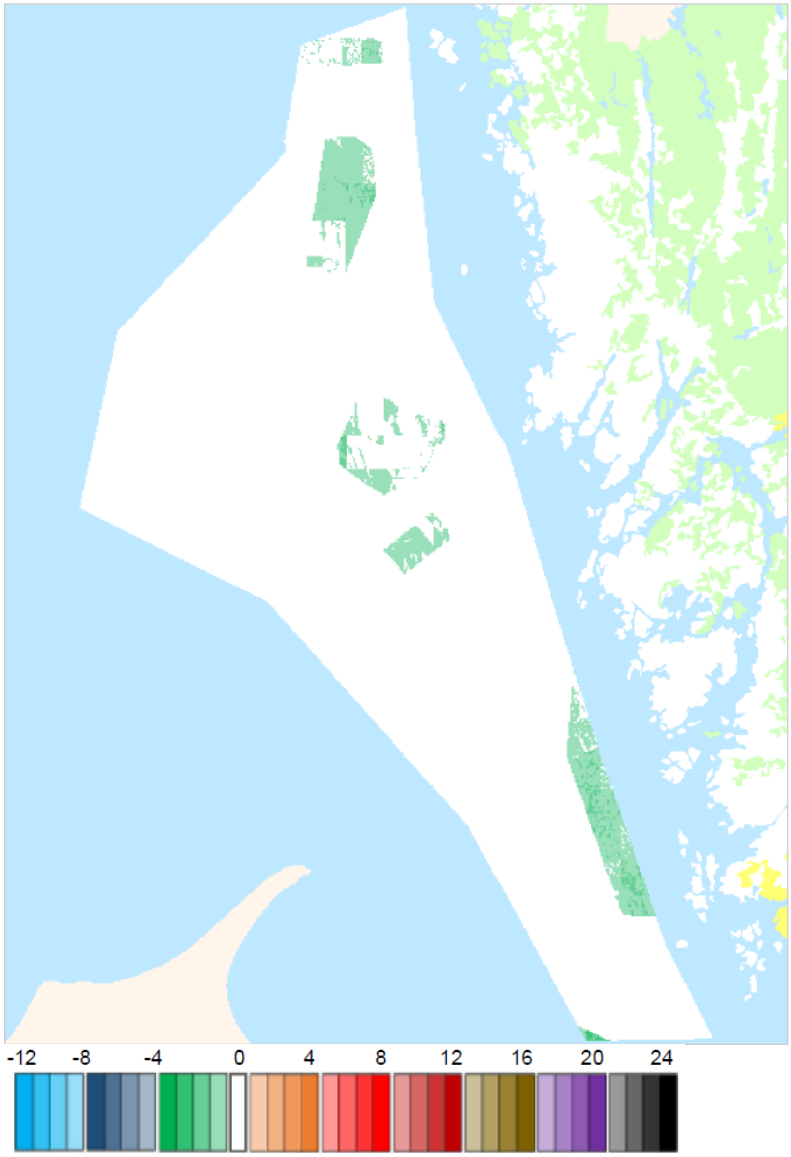

Figure 26 Change in the cumulative environmental effect in percent in the Skagerrak marine sub-region compared with the zero alternative. Positive values, in red and grey, result in a larger cumulative environmental effect compared with the zero alternative. Negative values, in blue and green, result in a smaller cumulative environmental effect compared with the zero alternative.

The cumulative effects in Skagerrak in the plan alternative come from the sectors Commercial fisheries, Transportation and communications, Defence, and Attractive living environments. Commercial fisheries contributes around 47% and consists mainly of effects from *physical disturbance* and *selective withdrawal of species* from bottom trawling and some effect from pelagic fishing. Transportation and communications account for around 10% and consist of *underwater noise* and *introduction of pollutants* (oil spills) from shipping. Defence contributes around 1% and consists mainly of *introduction of pollutants*. Attractive living environments consists of effects from *introduction of pollutants* from recreational craft and accounts for less than 1%.

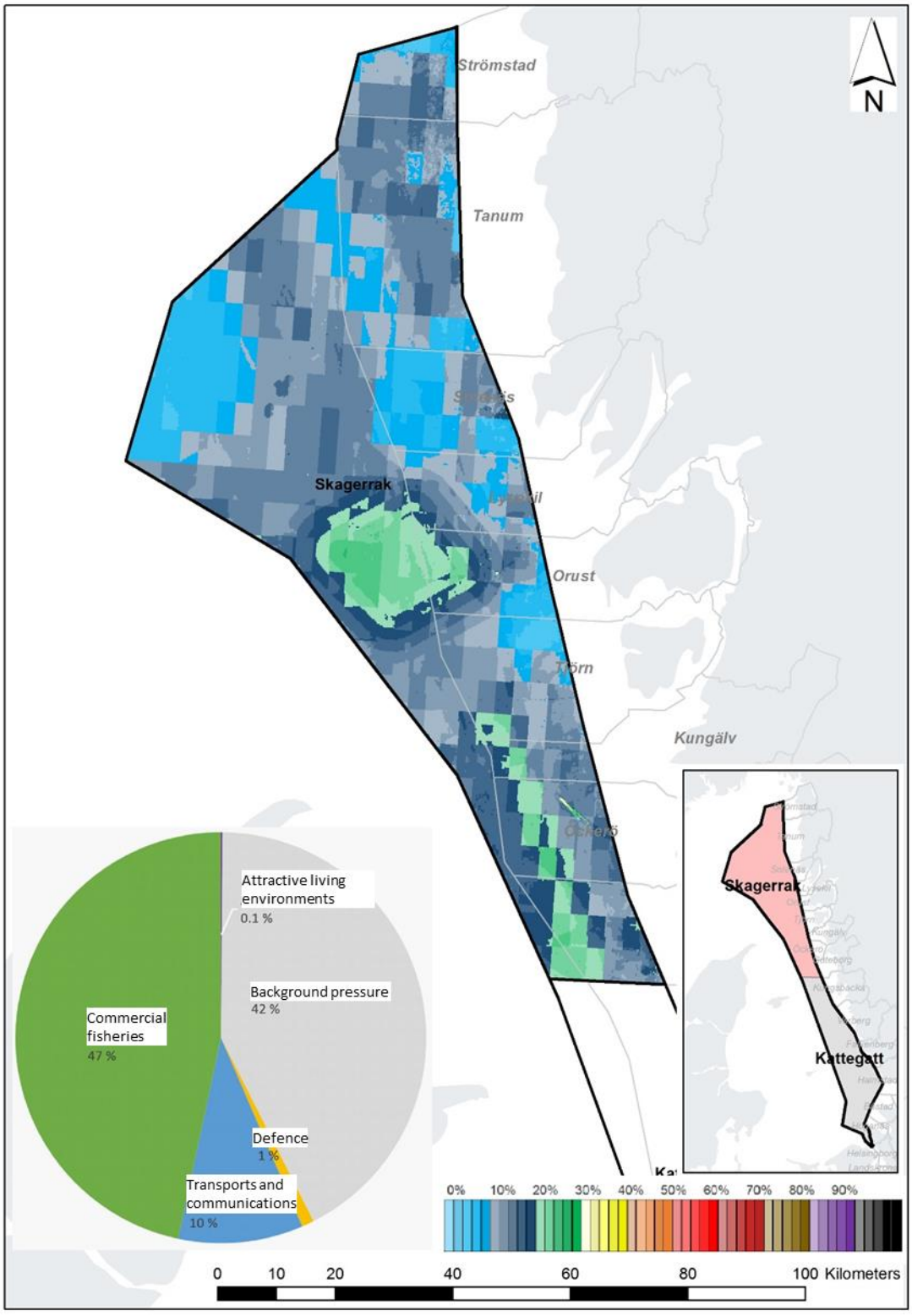

Figure 27 The total cumulative environmental effect in Skagerrak. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat, including coastal areas. The pie chart shows the relative percentage distribution of the sectors' contribution to the cumulative effect. The colours in the pie chart indicate sectors.

The background pressure contributes by about 42% and mainly consists of nitrogen (approx. 20%) and pollutants in sediment (synthetics approx. 11%, heavy metals approx. 2%), but also heavy metals and pollutants from World War II (approx. 6%), oxygen-free seabeds (approx. 1%), phosphorous (approx. 2%), and oil leakage from shipwrecks (approx. 1%).
The cumulative effects appear mainly on deep soft seabeds, spawning fish, cod, and North Sea porpoises, but also on plankton, herring, harbour seals, aphotic soft seabeds, and sprat.

8.3.3 Kattegat

Also in the Kattegat marine sub-region, the areas with *particular consideration to high nature values (n)* provide a positive change and a total reduced environmental effect (approx. 1% lower on average compared with the zero alternative), see Figure 28. In the areas planned for energy extraction, south-west of Falkenberg, the environmental effect is reduced compared with the zero alternative (around 60–80% of the zero alternative). Also, a positive effect of the planning is seen on Stora Middelgrund (84% of the zero alternative). The decrease in the environmental effect is due to some of the fishing being moved from these areas to nearby areas. This move means that surrounding areas get a higher pressure and a greater cumulative environmental effect. In five areas, there is *particular consideration to high nature values (n)* where fisheries and also to some extent recreational activities are regulated, which contributes to the positive effect from the MSP.

The cumulative effects in Kattegat in the plan alternative come mainly from the sectors Commercial fisheries and Transportation and communications, but also from the sectors Energy, Defence, and Attractive living environments, see Figure 29. Commercial fisheries contributes around 34% and mainly consists of *physical disturbance* and *selective withdrawals of species*, which are effects from bottom trawling, and a small share of effects from pelagic fishing. Transportation and communications account for around 19% and consist of *underwater noise* and *introduction of pollutants* (oil spills) from shipping. Energy contributes less than 1% and consists of *underwater noise* from wind power. Defence contributes less than 1% and consists of *introduction of pollutants*. Attractive living environments consists of *introduction of pollutants* from recreational craft and bird hunting and contributes less than 1%. The background pressure contributes around 46% and consists mainly of nitrogen (approx. 23%) and pollutants in sediment (synthetics approx. 9%, heavy metals approx. 3%), but also oxygen-free seabeds (approx. 8%), phosphorous (approx. 3%), oil leakage from shipwrecks (approx. 1%), and heavy metals from mines from World War II (<1%).

The cumulative effects are mainly exhibited on aphotic soft seabeds, spawning fish, cod, and plankton, but also on photic soft seabeds, North Sea porpoises, Danish Straits porpoises, harbour seals, herring, sprat, aphotic and photic transport seabeds, eel migration, and sea birds' offshore overwintering grounds.

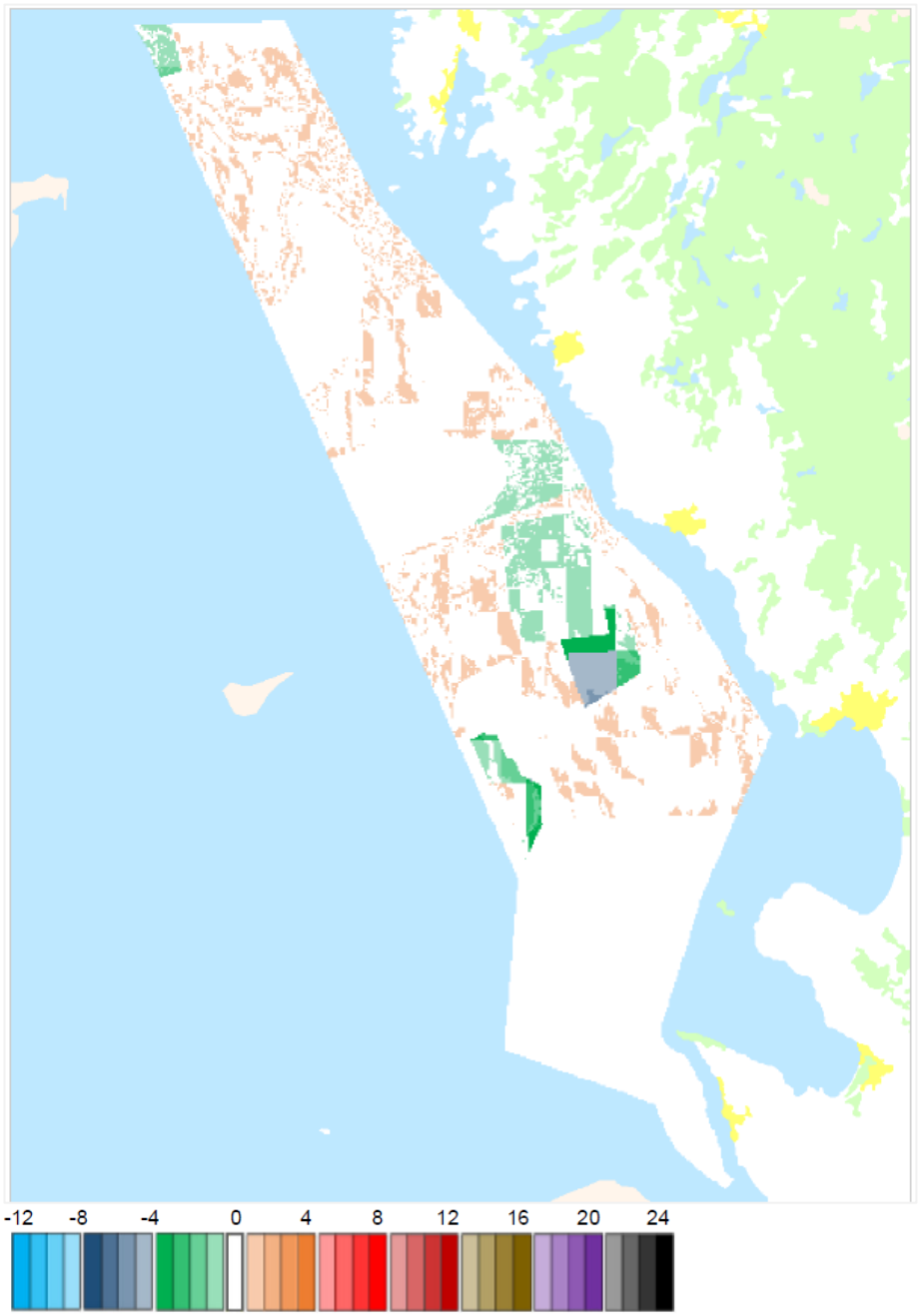

Figure 28 Change in the cumulative environmental effect in per cent in the Kattegat marine sub-region compared with the zero alternative. Positive values, in red and grey, result in a positive cumulative environmental effect compared with the zero alternative. Negative values, in blue and green, result in a negative cumulative environmental effect compared with the zero alternative.

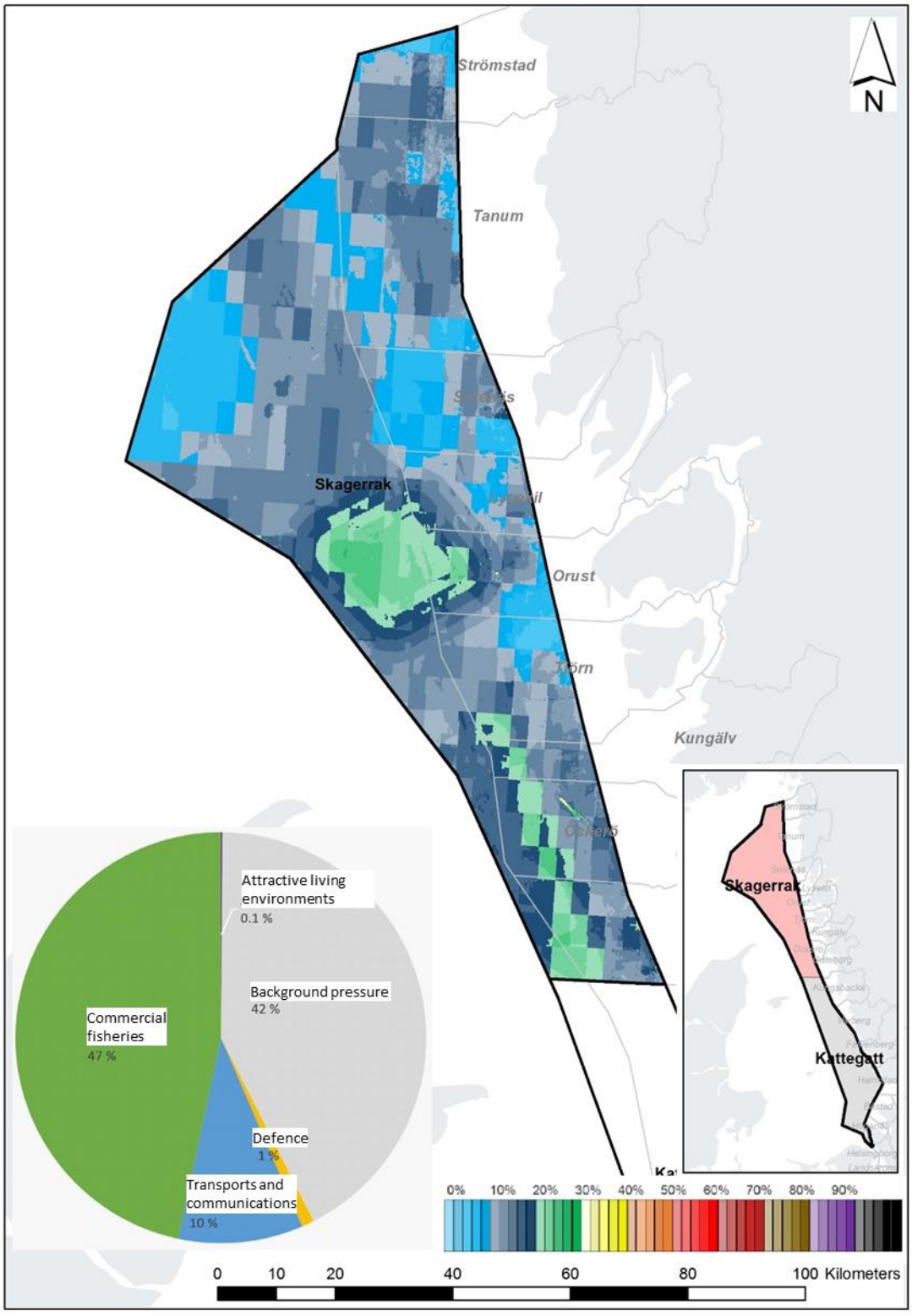

Figure 29 The total cumulative environmental effect in Kattegat. The colour scale in the map applies to all of Skagerrak and Kattegat, including coastal areas, and shows the percentage of the maximal cumulative effect in Skagerrak and Kattegat, including coastal areas. The pie chart shows the relative percentage distribution of the sectors' contribution 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 the environmental impact 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	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	Moderate negative	Small negative	Positive	Small negative	Positive
DEFENCE	None	None	None	None	None	Positive
STORAGE AND EXTRACTION OF MATERIALS	-	-	-	-	-	-
NATURE	Positive	Positive	Positive	None	None	Positive
TRANSPORTATION AND COMMUNICATIONS	None	None	Positive	None	None	None
AQUACULTURE AND BLUE BIOTECHNOLOGY	-	-	-	-	-	-
COMMERCIAL FISHERIES	None	Positive	None	None	None	Positive

This chapter summarises the cumulative environmental effect for the respective environmental aspect that is taken up in Chapter 6 of the environmental code. In parallel with the environmental assessment of the MSP for Skagerrak and Kattegat, a sustainability assessment was done, which is summarised below in the following Section 9.2.

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, 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 though they contribute relatively small environmental effects according to the analyses in Symphony. Below is a summary of the SEA's collective assessment.

9.1.1 Population and people's health

The seas contribute in various ways to human welfare and well-being from food to conditions for various recreation activities. Through trade and fishing, the seas have also played a crucial historical role in Sweden's development up to today's modern society 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. These services, often exemplified as fish, crops, or timber, are benefits that contribute to society's well-being or that hold a financial or other value for people.

In the sustainability assessment for Skagerrak and Kattegat (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 (tourism and recreation).

The archipelago along the west coast is one of Sweden's most heavily visited with many natural harbours and marinas. Recreation and angling are extensive and are widespread in several parts of the marine spatial planning area, both along the coast and on the offshore banks. 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 nature values are preserved, which the MSP's areas with *particular consideration to high nature values (n)* are intended to do. The MSP's areas for energy extraction might entail restrictions to outdoor recreation.

The spatial changes that an approved MSP for Skagerrak and Kattegat entail are deemed to only marginally contribute to emissions into the air or to marine litter. However, the sectors' development up to 2030 independent of the MSP might entail increased pressures compared with the present situation.

The MSP is deemed to provide 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 in general

The Skagerrak marine sub-region has high nature values, including birds, fish, mammals, and valuable seabed environments that also extend beyond the marine spatial planning area into international waters and in towards the coast. This marine sub-region has almost oceanic conditions and a large variation of different types of seabeds at different depths, which entails a very high biological diversity that is unique for Sweden. The offshore banks farthest to the south and along the coast have nature values worthy of protection in both Skagerrak and Kattegat.

Commercial fisheries is widespread throughout almost all of Skagerrak and in large parts of Kattegat. Bottom trawling for Norway lobster and Northern prawn is important in Skagerrak and Kattegat. Bottom trawling is the fishing method that causes the most damage to the marine environment, mainly in the form of *physical disturbance* to the bottom environment from abrasion and increased turbidity from sediment, but also from withdrawals of species, including by-catch. In the latter, there is a development towards more selective equipment. Pelagic fishing also entails pressures, but no physical impact on the bottom. In the plan alternative, the use Commercial fisheries is present in large parts of Skagerrak and Kattegat. The pressure from Commercial fisheries is expected to decrease in both the zero alternative and the plan alternative as a result of the regulation of equipment and fishing periods through fishing management. The plan alternative includes important spawning areas for cod in central and southern Kattegat that are designated for the use Nature or are protected through areas with *particular consideration to high nature values (n)*. Altogether, these standpoints in the MSP are assessed to contribute to the impact of Commercial fisheries being reduced in these areas.

With the prevailing political objectives in the energy and climate area, there is pressure for the expansion of renewable energy in which sea-based wind power plays a significant role. 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 the cumulative effects of *underwater noise* is a pressure that must be taken into consideration. Use of the seabed entails some *physical disturbance* and *physical loss*, i.e. habitat loss, as a result of such activities. 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 the 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 coexistence can be achieved through the energy extraction areas being provided with a designation for *particular consideration to high nature values (n)* as well as *total 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 will need to be 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 plan, there are three areas with the use Energy extraction in Kattegat. Adaptation needs to take place so that sea-based wind power can coexist with Kattegat's high nature values and in some areas also the local Commercial fisheries. Coexistence with Defence is also necessary. The offshore banks that have the highest nature values have been withheld from energy extraction in the plan. Stora Middelgrund is an important area for porpoises, which can be very sensitive to disruptions from the establishment of wind turbines (Naturvårdsverket, 2006). Within the areas where energy extraction has been pointed out, the environmental effect is reduced markedly by the fishing in the areas being limited. At the same time, the fishing can increase somewhat in surrounding areas where the environmental effect instead increases slightly, but altogether such areas are deemed to have lower nature values.

Through proposals on areas with *particular consideration to high nature values (n)* and regulation of Commercial fisheries, the MSP is expected to have a positive impact regarding the environmental aspect *Animals, plants, and biological diversity*. Energy extraction that is indicated in the MSP entails a moderate negative impact, even if energy extraction also entails some positive effects. In the planning, establishment, and operation of wind power, extensive consideration must be taken to nature values. In a comprehensive assessment, the MSP overall is deemed to entail a small negative impact on the environmental aspect *Animals, plants, and biological diversity*.

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

Shipping in Skagerrak and Kattegat is very extensive. Here, ships travel to the Port of Gothenburg, which is Scandinavia's largest port with the possibility of receiving very large container ships, but transports also go through the marine spatial planning area to and from Denmark and on into the Baltic Sea. The general trend where the ships are becoming larger is expected to continue. In

the zero alternative and plan alternative, shipping is assumed to increase by 50% in Skagerrak and Kattegat by 2030. Within the MSP, shipping has obtained larger areas for its use compared with existing national interest claims. The expanded use areas are based on documentation from the transport authorities and are motivated in part by enabling proposals for traffic separation systems and anchorages. To guarantee safe shipping through the shallow waters in Kattegat, there are proposals for new traffic separation regulations on both sides of the offshore banks. An analysis has shown that the regulations, which entail broader shipping lanes, altogether entail an improvement for the marine environment (SwAM, 2017b). Shipping contributes to environmental problems in several different ways. Combustion of fuel results in emissions into the air that contribute to climate change and to 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 energy extraction and the introduction of areas in which *particular consideration to high nature values (n)* and to some extent *to defence (f)* shall be taken.

In the Skagerrak and Kattegat marine spatial planning area, there is one large and one small artillery and training range that affect the marine environment through emissions of metals from ammunition that can cause large local concentrations. The activities of the Defence in the area also generate underwater noise. The MSP is also affected by the appointed area for national defence's special need for obstacle clearance in the sea off of Halmstad. A possible development in defence activities according to the SwAM thematic work might be the increased use of virtual methods that to some extent might replace the need for physical artillery exercises. An effect of this can probably be expected only after 2030. By 2030, the impact of national defence is expected to increase proportionally with the development of the sector. The interests of the Swedish Defence are deemed 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 cause technical disruptions that compete with the interests of national defence. Altogether, the MSP is not deemed to entail any change in emissions into the air and sea from the different sectors (shipping, Commercial fisheries, and defence) compared with the zero alternative.

Cultural heritage remains, such as shipwrecks, might be affected in the establishment of permanent constructions for wind power, which must be taken into account in a permit process, and the construction must be adapted to minimise the impact on possible permanent remains. The establishment of wind power entails a local impact on the seabed and the marine environment. The plan entails a potential emission reduction of carbon dioxide in the establishment of renewable energy extraction and is thereby deemed to have a positive effect (COWI, 2018b).

For the environmental aspects of *Land, soil, water, air, landscape, built environment*, and *cultural environment,* the MSP is deemed to primarily entail local negative environmental effects in the areas where new establishment is proposed for energy extraction, while a positive effect is expected to arise in the areas where *particular consideration to high nature values (n)* is to be taken through traffic regulation. The MSP is deemed to have a positive consequence on the part of the environmental aspect that concerns *Climate* such that the plan provides conditions for wind power extraction. For other parts of this environmental aspect, the plan entails no environmental impact.

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

The objective of the MSP is to plan the marine spatial planning area such that different areas are used for the purposes that they are best suited for considering their character, situation, and needs. In the MSP for Skagerrak and Kattegat, there are three areas designated with the use Energy. The wind power establishments are preceded by an environmental impact assessment process in which local impacts and effects are analysed and assessed with the aim of minimising such impacts. Within Skagerrak and Kattegat, there is no sand extraction today, and it is not included in the MSP.

In the MSP, some sectors are expected to be able to coexist, and areas with *particular consideration to high nature values (n)* have been pointed out in coexistence with one or more other uses. Adaptations will need to be made to minimise the impact and effects in these areas that are worth protecting in order to achieve the aim of having appointing these areas as such, especially when it comes to the establishment of wind power. In most cases, the areas where *particular consideration to high nature values (n)* shall be taken are important spawning grounds and recruiting areas for fish, which means that the MSP, through these areas, can have a positive effect on the fish stocks as a resource. This might also entail a geographically large effect. It is therefore important in the establishment of other activities that this is taken into consideration and that possible regulation of Commercial fisheries is discussed.

The MSP for Skagerrak and Kattegat overall is deemed to have a positive impact for the environmental aspects *Management of land, water, and the physical environment* and *Management of materials, raw materials, and energy* and to work towards good management of the marine spatial planning area through the sectors/themes Energy extraction, Defence, Nature, and Commercial fisheries. Energy extraction has a positive effect by contributing energy from a renewable source and thereby has a positive impact on the part of the environmental aspect that concerns *Management of energy*. *Particular consideration to high nature values (n)* has a positive effect on fishing, but also parts of other ecosystems, and this entails a positive impact on the part of the environmental aspect that concerns *Management of raw materials*.

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 thematic parts that are mainly affected by climate change are Transportation and communications, Commercial fisheries, Energy, and Nature. Changed salinity is assumed to not create problems in Skagerrak and Kattegat because it is assumed not to create problems in the other two marine spatial planning areas. However, an increase in nutrient pressure might remain as a problem, and eutrophication might affect marine ecosystems to an increasing degree. For Skagerrak and Kattegat, climate change will probably affect the introduction of invasive species to a greater degree. This is mainly because Skagerrak and Kattegat borders on other marine areas and because international shipping is expected to increase. Limiting the establishment of invasive species in a climate scenario might be difficult if not impossible.

Shipping might be affected by climate change causing harsher weather conditions and flooding, which will affect ports, coasts, and marine structures. Commercial fisheries is mainly affected in that eutrophication might limit growth in some ecosystems, and action plans that extend over both land and sea will be necessary, as well as the creation of climate refuges for threatened species (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.

The 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 followed. In the marine spatial planning process, it must be specified what a good environmental status means in a spatial perspective, and the ways in which various activities can affect the marine environment must be analysed.

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 and the fulfilment of environmental quality standards have also been included.

9.2.1 Plan steering towards the guiding objectives

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

The proposed MSP for Skagerrak and Kattegat 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 Directive

Good environmental status 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 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 taken into account both impact and pressure. Environmental quality standards along with their indicators constitute an important part of the assessment and monitoring of the sea. The environmental quality standards shall not be violated, which is why the marine environmental management needs to take into account different aspects and to formulate action programmes so that environmental quality standards are met and that a 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 where environmental status is described using 11 descriptors.

Table 15. The 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	Production 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 as well as 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 the 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 material (one standard: A1)
B. Introduction of hazardous substances (two standards: B1 and B2)
C. Biological disturbance (four standards: C1–C4)
D. Physical disturbance (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 proposed MSP for Skagerrak and Kattegat is assessed to be able to have significant environmental effects with regard to the Energy sector as a result of the potential expansion of wind power in Kattegat. The pressures from the sector are expected to increase, mainly *physical loss* and *physical disturbance* on the seabed areas that are used, but also through *underwater noise* and *electromagnetic disturbance*. One of the affected areas (V305) is covered by guidance on *particular consideration to high nature values (n)*, which is deemed to be able to lead to a reduction in the negative effects as a result of detailed project planning of wind turbines in which the most important food-seeking areas for sea birds are avoided (SwAM, 2018a). However, it is unclear what significance the area has as a food-seeking area for sea birds.

In terms of Defence, the proposed plan is deemed to be able to entail a marginal pressure reduction with regard to underwater noise in Skagerrak. The effect is linked to the designation *particular consideration to high nature values (n)* and the adaptations of explosives activities that are deemed to result from this.

The plan is also deemed to be able to entail changes regarding environmental pressures in Commercial fisheries as well. By trawler fishing being impeded or ceasing in areas designated for energy extraction, the pressure on the seabeds through abrasion is also expected to decrease in the areas concerned (V302 and V305, see Figure 4). The effect is especially distinct in an area (V305) where extensive fishing is conducted with bottom trawling in the zero alternative. The guidance on energy extraction in this area can in the long term entail a combined reduction of physical impact on the bottoms after they have recovered from the pressure from the wind power construction phase. The proposed plan's guidance means at the same time that the on-going fishing in affected energy areas is moved to surrounding areas where the pressure on the seabeds increases instead. From a pressure perspective, the significance of the relocation is difficult to assess because the effect is dependent on the sensitivity of the ecosystem components (bottom habitats and species) outside the energy areas that are affected by the relocated fishing. The relocation of fishing from the energy areas also entails a potential risk that the affected fishing boats need to travel a longer distance to their catch areas. The result might be increased air emissions, but this effect is deemed to be marginal.

The plan proposal is deemed to be able to entail a positive effect through guidance on *particular consideration to high nature values (n)* in combination with *General use* (Gn). For Commercial fisheries, the guidance is deemed to entail a reduced environmental pressure as a result of reduced by-catches (use of trawlers with high catch selectivity in pelagic fishing, porpoise deterrent pingers, by-catch minimisation panels for net fishing, etc. (SwAM, 2018)).

The plan's consequences for the environmental status in Skagerrak and Kattegat are difficult to assess because both positive and negative consequences

are deemed to be able to arise. The following environmental quality standards are deemed to be affected:

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

  Through impact from energy extraction (*Physical loss, Physical disturbance*, and *Underwater noise)* on the descriptors D1, D6, and D11 in Kattegat, the plan proposal potentially contributes negatively to achieving the environmental quality standard *Good environmental status* in the management area of the North Sea.

  In terms of the pressure linked to energy extraction, the negative effects are deemed to be linked mostly 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.

  At the same time, the guidance on energy extraction in the long term entails a general decrease in the pressure in one of the energy areas (V305) where fishing is currently conducted mainly with bottom trawling. This is deemed to be able to entail a reduced physical pressure on the seabed and a positive effect on D6 and thereby the possibility of achieving *Good environmental status* in the North Sea management area. At the same time, the on-going fishing in affected energy areas is moved to surrounding areas where the pressure on the seabed increases instead. The net effect with regard to meeting the standard is uncertain.

  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 have a positive effect on the descriptors D1, D3, and D4. In the areas with the guidance on energy extraction with *particular consideration to high nature values (n)* (V305), detailed project planning of wind turbines is expected to take place to minimise the impact on sea birds (descriptor D1). In this respect, the plan entails a positive contribution to the possibility of achieving *Good environmental status* in the *North Sea* management area.

- *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 impacts (*Physical loss* and *Physical disturbance*) on the descriptor D6 in Kattegat as a result of guidance on energy extraction on the unaffected seabed in the Natura 2000 area Stora Middelgrund (V302), the proposed plan potentially contributes negatively to achieving the *environmental quality standard D1* in Kattegat's offshore waters.

The overall effect when it comes to the plan's impact on the possibility of achieving the environmental quality norm of *Good environmental status* in the *North Sea* management area is difficult to assess because the plan proposal entails both negative and positive effects.
Further analyses are required to determine the combined effect of the plan proposal on the current environmental quality standard.

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 be able to potentially entail a negative effect due to guidance on wind power establishment in an unaffected area (Stora Middelgrund (V302)).

Sweden's environmental quality objectives
For the evaluation of the Swedish national environmental quality objectives, both the environmental assessment and the sustainability assessment are 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 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**
  The coasts' and the seas' important ecosystem services are maintained.

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)*. This positive effect must, however, be taken into account in the planning of sea-based wind power and the 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 for outdoor recreation (limited accessibility) and landscape appearance (visual impact).

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 comes through the areas with *particular consideration to high nature values (n)*, while the negative effect is mainly tied to potential expansion of sea-based wind power.

An overall assessment is that the plan does not entail any net effect on the possibility of achieving the environmental objective of *A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos* in Skagerrak and Kattegat. The negative impact on cultural ecosystem services as a result of the establishment of sea-based wind power is deemed to be offset by positive effects on the planning area's ecosystem services from the proposed plan's guidance on *particular consideration to high nature values (n).*

9.2.2 MSP 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 in Skagerrak and Kattegat indicates a slightly positive result compared with the zero alternative when no plan is applied (COWI, 2018b).

Economic sustainability
The combined result in terms of the plan proposal's economic effects show a slightly positive effect compared with the zero alternative. This is primarily due to expected positive economic effects from energy extraction from wind power and strengthened ecosystem services in the planning area as a result of

increased consideration of nature through guidance on *particular consideration to high nature values (n)*.

Ecological sustainability
For the ecological sustainability dimension, positive and negative effects are largely deemed to offset each other and to result in an overall neutral assessment compared with the zero alternative. Negative environmental effects are deemed to arise as a result of wind power establishment according to the plan proposal's guidance in the marine sub-region Kattegat, which is deemed to entail significant burdens on high nature values. At the same time, the establishment of wind farms means that fishing with equipment associated with extensive environmental impact will be limited or will cease in affected areas. Such a limitation of Commercial fisheries in the concerned energy areas is deemed to entail major positive environmental effects locally. On the condition that the fishing has the possibility to move to other areas, the pressures are assumed to increase in surrounding areas, which is why the total environmental impact from Commercial fisheries as a result of energy establishment is deemed to be the same in the plan proposal and zero alternatives. A positive environmental effect that is attributed to energy establishment is the climate benefit deemed to arise as a result of an expansion of sea-based wind power in the plan area. In addition, the plan proposal's guidance on *particular consideration to high nature values (n)* is deemed to entail reduced environmental impact.

Social sustainability
As for ecological sustainability, the overall result for the social dimension is deemed to be insignificant in relation to use in the zero alternative. Effects within the social dimension are primarily deemed to arise as a result of the establishment of wind power in Kattegat according to the plan proposal's guidance. Through substantial visual impact on the landscape, the perceived accessibility to the marine area is expected to decrease. The possible expansion of wind power is also deemed to potentially entail a negative impact on identity creation factors such as outdoor recreation, tourism, and Commercial fisheries. Energy establishment also entails a risk of damage to possible cultural environments on the seabed, although there is extensive uncertainty in terms of the scope of such effects. The identified negative effects are partially offset by the energy establishment also being deemed to be able to lead to higher employment.

9.2.3 Cross-border environmental impact

For Skagerrak and Kattegat, the cross-border environmental impact is mainly about the effects from the sectors of Transportation and communications, Commercial fisheries, and Energy. The cross-border impact deemed to be caused by the MSP mainly takes place in Kattegat close to the border with Denmark and in northern Skagerrak towards Norway's border and is deemed to be limited and in some cases positive.

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 impacts are cross border. Mobility also provides opportunities for improvements, where limits can be set on fishing and shipping in some especially impacted areas through cross-border cooperation, such as in Skagerrak where the areas with a high impact according to the MSP are mainly in areas where Commercial fisheries is the most suitable use.

Another activity that causes cross-border environmental impact is the establishment of wind farms in southern Kattegat, which yields the effect that the area is limited for Commercial fisheries, and this can preserve nature values through reduced trawling and withdrawal of fishing stocks. Collaboration with, in this case, Denmark can ensure that the positive effect remains.

The analysis highlights that pointing out areas with *particular consideration to high nature values (n)* has positive effects in the MSP. At the same time from a cross-border perspective, cooperation with the neighbouring countries is required, mainly in terms of further concretisation of management measures within the plan's areas with *particular consideration to high nature values (n)* that are within the border areas. This is current the case in northern Skagerrak where Sweden and Norway are jointly responsible for valuable marine areas, such as off of the Kosteröar islands. Another example is an area in northern Kattegat pointed out as an area with *particular consideration to high nature values (n)* where cooperation with Denmark will be needed to maintain the area's status.

The environmental impact that extends over national borders requires cooperation and dialogue between the countries. SwAM (2014) initiated a dialogue with all nine neighbouring countries that Sweden shares a marine border with. The discussions indicate shared problems and a good cooperation climate.

The dialogue arrived at the following conclusions regarding these problems (SwAM, 2014):

- A shared and collective illustration of the present situation as a starting point for the planning is desirable, and this should include 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 powerlines, 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 issues of secrecy often arise.
- 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. At the same time that there is much planning and discussion about wind power and to some extent aquaculture at sea; however, 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, which primarily affects the Baltic Sea (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 marine spatial planning.

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 continuous cooperation with the authorities that have responsibility for the different sectors and that they should be permitted to influence the marine spatial planning. The process should map common conflicts and synergy effects and 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.

The MSP for Skagerrak and Kattegat needs to be coordinated with Denmark to the west and Norway to the north. 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 expressed their openness for cooperation and have the possibility to exchange experiences with the Swedish process. Denmark is slightly behind Sweden in the process, while Norway is ahead, but at the same time Norway is not covered by the EU Maritime Spatial Planning Directive and thereby has a different type of process (European Union 2017, SwAM 2014).

9.2.4 Proposed revisions to the plan

Plan alternative compared with the zero alternative
The total cumulative environmental effect in the marine spatial planning area is the greatest in central and southern Skagerrak and near Gothenburg, which is the case in the present situation, the zero alternative, and the plan alternative. In a comparison between the plan alternative and the zero alternative, the plan entails no distinct change in the cumulative environmental effect. In areas pointed out with the instruction of *particular consideration to high nature values (n)*, the plan with its associated assumptions provides a lower cumulative environmental effect, and in total the plan thereby entails a somewhat lower cumulative environmental effect compared with the zero alternative. The positive effect is the greatest in areas that have the largest concentration of high nature values.
The interest Nature is favoured by the plan as a result of the instruction of *particular consideration to high nature values (n)*. These areas are assessed to provide large local positive effects that can also provide positive environmental effects in surrounding areas.

The plan is assessed to contribute positively to goal attainment of set targets, which is largely due to the good effect the areas with consideration to high nature values are deemed to be able to provide.

The sustainability assessment of the proposed MSP in Skagerrak and Kattegat shows no significant effects regarding any of the three sustainability dimensions in relation to the zero alternative.

Alternative formulations
The proposed MSP for Skagerrak and Kattegat contains no alternative formulations (SwAM, 2018b).

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 furthest possible extent enables fulfilment of the plan's guiding environmental and sustainability objectives.

In general, the positive effect can be pointed out here to be the result of areas with the use of *particular consideration to high nature values (n)* with their associated assumptions providing reduced environmental effects. In areas for Energy extraction in combination with *particular consideration to high nature values (n)*, the environmental effect will be even markedly better compared with the zero alternative. This is due to Commercial fisheries possibly being limited and thereby moving from the area to neighbouring areas. A recommendation is that more areas be identified where *particular consideration to high nature values (n)* shall be taken and to find possible coexistence with various sectors within these areas.

Moving or limiting the impact from Commercial fisheries entails a positive environmental effect, which the MSP should further highlight and work for. One such way is for the plan to more clearly take a standpoint for more marine protection that is stronger than the current areas with high nature values compared with *particular consideration to high nature values (n)*.

SwAM can propose regulations for areas if this is considered necessary to achieve the objective of the MSP. These can contain binding limits and might be a stronger alternative to areas with *particular consideration to high nature values (n)* without such areas being regulated as marine protection areas.

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

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 SEAs and sustainability assessments, is being held for 6 months from 15 February to 15 August 2018. The Espoo consultation with neighbouring countries is being held for 3 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, and this will be 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 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 impact that this environmental assessment describes. A control programme will therefore be prepared that describes how the follow-up will be done and what parameters are to be followed up. The control programme will be coordinated with other existing environmental follow-up to ensure the effective implementation of the plan.

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12 Glossary

Term	Explanation
Abrasion	Erosion 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 elsewhere.
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 this 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, 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 seeds enclosed in fruit (in contrast to gymnosperms).
HCH	Hexachlorocyclohexane
HELCOM MPA	Marine Protected Areas. Marine protected areas 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 seabeds provide a good substrate for seaweed beds and for seed plants and charophyte green algae. These are also characterised in contrast to the 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 these are an important part of the food chain because they are the main food for, among others, the endangered porpoises. 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 significantly affect the rest of the water environment through changed visual depth and food supply for animals that live in the body of water 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, 2015b). 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, which 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 eutrophication. 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, 2015). 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 therefore of utmost importance to place 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 of more unaffected marine environments. The offshore banks therefore 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.