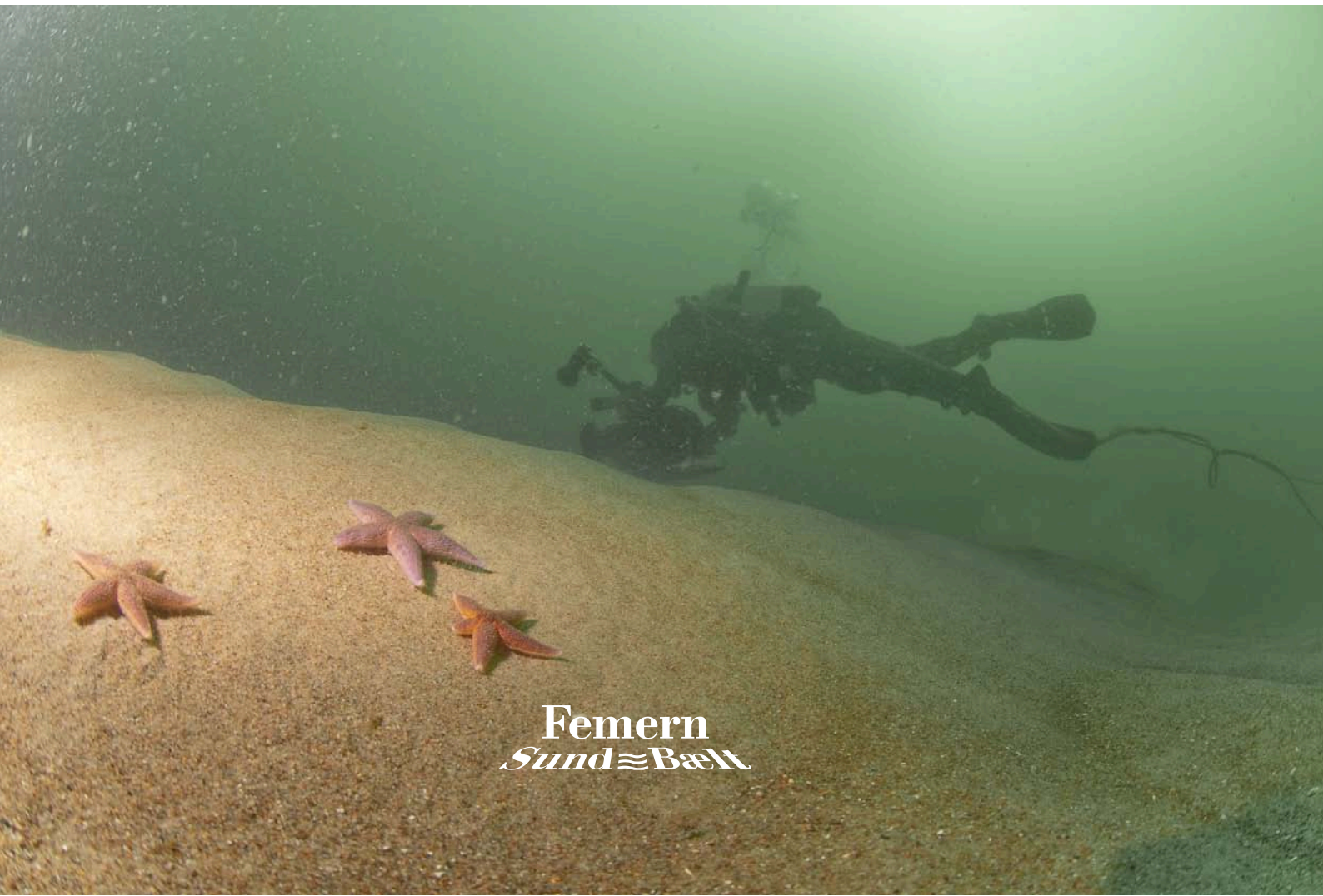
Femern Sund Bælt

Landesbetrieb Straßenbau und Verkehr Schleswig-Holstein Niederlassung Lübeck

June 2010

Proposal for environmental investigation programme for the fixed link across Fehmarnbelt (coast-coast)

EIA Scoping Report



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EIA Scoping Report

Femern Sund & Bælt

Landesbetrieb Straßenbau und Verkehr Schleswig-Holstein Niederlassung Lübeck

Prepared: Anders Højgård Petersen (Editor)

Checked: Susanne Koss

Approved: Anders Jensen

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Illustrations and photos: Femern A/S

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1. Introduction

1.1. Background and framework for the project

On 3 September 2008 Denmark and Germany signed the State Treaty to establish a fixed link across the Fehmarnbelt. The State Treaty was adopted by the national Parliaments and ratified by the two countries in 2009.

The Fehmarnbelt Fixed Link is planned as a combined rail and motorway link comprising of a double-track electrified railway and a four-lane motorway. The 19 km link will run from Rødbyhavn on the Danish side of the Fehmarnbelt to Puttgarden on the island of Fehmarn on the German side, crossing the Danish – German border midway between the coastlines of the two countries.

The link connecting Scandinavia with Northern Germany will be important for the whole of Europe. The objective of the combined road and rail link is primarily to improve conditions for the transport of passengers and goods. Overall, traffic links will improve greatly from Scandinavia to Germany and eastwards toward the Baltic regions.

Denmark is responsible for the planning and design as well as financing, construction and operation of the Fehmarnbelt Fixed Link. Denmark builds and operates the Fehmarnbelt Fixed Link and bears the costs of the user-paid link.

Under the provisions of the State Treaty, Germany is responsible for the approval of the fixed link in German sovereignty as well as upgrading of the German hinterland infrastructure.

In Denmark the State Treaty was ratified by the adoption of Act No. 285 of 15 April 2009 on Project Planning for a fixed link over the Fehmarnbelt, with Associated Land Facilities in Denmark. On the basis of this law, in April 2009 the Transport Minister gave the state-owned company, Femern A/S, the responsibility to plan and design the Fehmarnbelt Fixed Link. The Act gives the power to prepare, investigate, plan and design the fixed link. The construction of the fixed link will be adopted in a separate Construction Act.

For the part of the Fehmarnbelt Fixed Link the combined rail and road project here has two project applicants. Femern A/S is the project applicant for the railway section of the link in Germany, while the Schleswig-Holstein State Agency for Road Construction and Transport, Department of Lübeck (Landesbetrieb für Verkehr und Straßenbau des Landes Schleswig-Holstein, Lübeck Niederlassung), is the project applicant for the motorway section of the link in Germany.

The planning and approval process in Denmark and Germany has begun. This involves environmental investigations, geotechnical investigations and investigations relating to maritime safety. It also involves the design and planning of a bridge as well as an alternative tunnel solution. In both countries an environmental impact assessment (EIA) will be carried out

as a part of the national approval procedures in accordance with national legislation in the two countries. In accordance with the Espoo convention on EIA in a transboundary context, the countries of the Baltic Sea region will also be informed about the project and possibly participate in the process.

Before any proposal for a Construction Act is submitted, the EIA will be concluded, approvals will be obtained from the authorities in both Germany and Denmark and an international hearing will be held for the countries of the Baltic Sea region in accordance with the Espoo Convention.

1.2. Introductory remarks to the EIA Scoping Report

1.2.1. Legal framework of the scoping process

According to legislation in Denmark and Germany, prevailing EU directives and international law an EIA must be conducted for the construction of a fixed link across the Fehmarn Belt. The purpose of the EIA is to thoroughly identify, describe and assess the environmental impact of the project in good time. The results of the EIA shall be taken into consideration by the authorities in all decisions relating to approval as early as possible.

The EIA involves identification, description and assessment of the project's impact on the factors human beings (including human health), fauna and flora (including biodiversity), soil, water, air, climate, the landscape, cultural heritage and other material assets as well as the interaction between these environmental factors.

The project applicants must present information on the project's environmental impact which is essential to the decision making, the "Environmental Impact Statement" (EIS), to the competent authorities in Denmark and Germany. In the EIS all effects due to construction, presence of physical structures and operation of the fixed link on the above environmental factors will be identified, described and assessed.

The Danish Transport Minister has assigned Femern A/S the responsibility to conduct the EIA and draw up the EIS for the Fehmarnbelt Fixed Link.

With the present scoping report, Femern A/S and the Schleswig-Holstein State Agency for Road Construction and Transport, Lübeck Department, propose the framework for the EIA, which must be coordinated with the competent authorities. Apart from the competent authorities, environmental organisations in Germany and the public in Denmark are also participating in deciding on the framework of the assessment.

The purpose of the scoping process is to determine the framework for the content, scope and area of the studies in Denmark and Germany. The methods and other relevant subjects relating to the EIS are described and will be agreed on with the competent authorities.

1.2.2. Preparation and implementation of the scoping process – contents of the Scoping Report

This Scoping Report meets the practices of both countries for the preparation of EIS.

In Denmark the common technical approach is to describe the affected ecosystem and the project's significant impact on the ecosystem. In Germany it is generally more common to use a presentation and approach focusing on the individual environmental factors. Both these approaches are combined in the preparation of the Scoping Report. In accordance with Danish practice socio-economic issues are included in the EIA and a corresponding chapter will be included in the Danish EIS.

The central chapters in the Scoping Report contain a general introduction to the framework of the project and a project description in Chapter 2, followed by a preliminary description of the existing environmental conditions and ecosystem-related contexts in Chapter 3. In Chapter 4 the project's potential impact and effects on the environment are presented, and in Chapter 5 possible measures to prevent, mitigate and compensate for the environmental impact are described. The overall approach of the EIA is presented in Chapter 6. Comprehensive environmental studies are conducted as a basis for describing and assessing the environmental impact. The first detailed studies was started as early as in autumn 2008, even before the State Treaty came into force. Chapter 7 deals in more detail with the scope and methods applied for the individual environmental factors. In closing the impact assessment concerning Natura 2000 and protected species is dealt with in Chapters 8 and 9.

The EIS will reflect the content and scope of the studies as described in the Scoping Report. However, a more detailed structuring of the EIS is yet to be determined. The Scoping Report does not contain a non-technical summary or information relating to potential problems that might arise during the collection of information, as a result e.g. of technical limitations or lacking information.

The key sections of the EIS will deal with investigations of the different technical options and their environmental impact and provide a comparison between these. A detailed and transparent explanation will be given for the recommendations for the preferred technical solution based on all relevant aspects including environmental issues. The explanation will include the reason for the preference and why other options were rejected.

1.2.3. Previous environmental studies

In order to describe the environment in the Scoping Report and the actual EIS, results from environmental studies conducted over more than a decade will be included and the responses received in connection with an environment consultation held in 2006 will be taken into account.

From 1995 – 1999 comprehensive feasibility studies of the environmental and other aspects of the project were conducted (COWI-Lahmeyer, 1999). Below these studies are collectively

referred to as "The 1999 Feasibility Study".[1] The results and the most important conclusions are presented in a summarised report.

Additional studies were later conducted on selected key issues. What is most important for the coast-to-coast part of the fixed link is a preliminary risk assessment of bird life (Kahlert *et. al.* 2005) and a study of the effects of emissions to the air (COWI & NERI, 2005).

In 2006 the transport ministers in both Denmark and Germany initiated an environmental consultation process in both countries. The following year a comprehensive Environmental Consultation Report was issued containing descriptions of technical solutions and environmental issues relating to the future Fehmarnbelt Fixed Link. All interested parties were encouraged to submit remarks, wishes or ideas, which resulted in responses from the authorities, environmental protection organisations, other NGO's, organisations and private individuals. The responses provided an updated view of the opinions of both the public and the experts. This newly acquired knowledge is included in the study plans presented in this Scoping Report.

In addition, valuable experience and knowledge gained from the numerous detailed studies conducted in connection with the fixed links across the Great Belt and Øresund are also drawn on.

Femern A/S is in continuous contact with the environmental authorities in both countries and dialogue has been initiated with non-governmental environmental organisations and the general public on environmental aspects of the project.

It is expected that by 2012 it will be possible to submit proposals for a Construction Act based on design work, which in turn will give Denmark the right to start construction. In Germany planning work is concluded with a plan approval.

[1] See http://www.femern.com/home/publications

2. Description of the project

The fixed link across Fehmarnbelt forms part of the Transeuropean network. It connects the Copenhagen-Malmö region (with connection to the rest of Scandinavia) with the Hamburg-Lübeck region (with connection to the rest of the European continent), see Figure 2.1. Thus, the link will supplement the existing fixed link across Øresund.

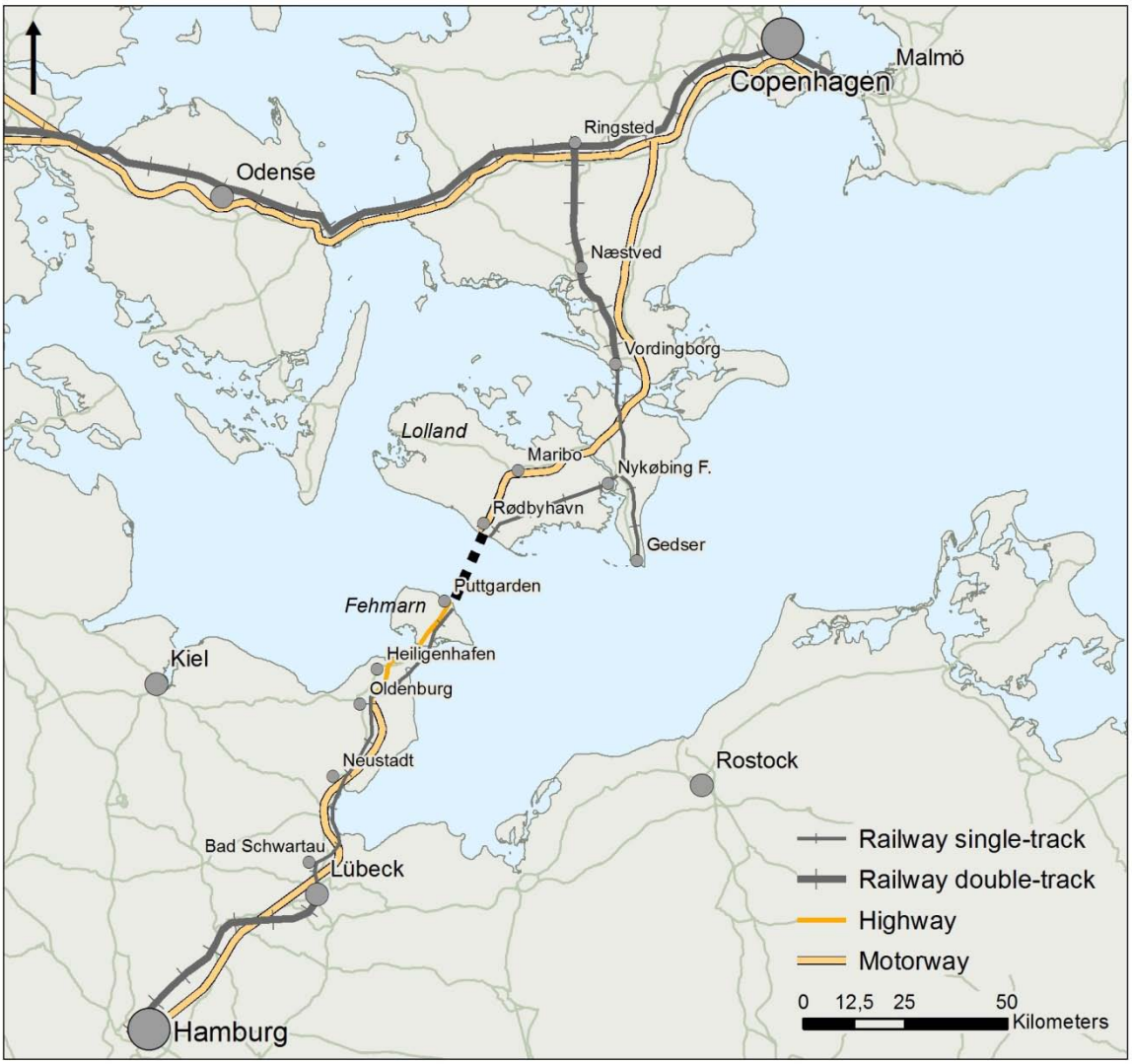


Figure 2.1 Location of the fixed link across Fehmarnbelt in the region of the Danish German border.

According to the State Treaty of 3 September 2008, the fixed link will be established between the island of Fehmarn in Germany and the island of Lolland in Denmark. It is planned as a combined double-track electrified railway and a four-lane road connection having the technical

standard of a motorway (a so-called 4+2 solution). The fixed link includes the stretch across Fehmarnbelt and the ramps and approach facilities on land as well as the tolling and administration facilities, which will be placed on the Danish side only.

The boundaries of the project are set at the points on Lolland and Fehmarn where it is connected to the existing road and railway network. The exact location of these points are determined in the ongoing planning process.

The following project description is based on the 1999 feasibility study, because a detailed plan of the project is not yet available. The feasibility study resulted in a number of feasible solution models, including a cable-stayed bridge, a suspension bridge, an immersed tunnel and a bored tunnel. These solution models were compared and evaluated based on criteria such as environmental impacts, traffic capacity, safety, technical design as well as investment, operation and maintenance costs. It was concluded that a cable-stayed bridge was the preferred technical solution and an immersed tunnel as the preferred alternative solution. This conclusion is adopted in the state treaty on the establishment of the fixed link. In the ongoing planning process the solution models are re-evaluated. The final Environmental Impact Statement (EIS) will contain a detailed updated project description of the selected solution models and a justification of the selection.

All solution models are designed as so-called 4+2 solutions providing four motorway lanes and two railway tracks. There will be emergency lanes on the bridges whereas the tunnel is planned without such lanes. All solutions will be designed for a lifetime of at least 120 years.

Based on the 1999 feasibility study the cable-stayed bridge and the immersed tunnel is described below as the two technical solutions suitable for realisation of the project. Therefore, suspension bridge and bored tunnel solutions are not described further. It should be stressed that this does not mean that a decision in favour of the two solutions has been taken. An evaluation of different tunnel and bridge solution will be part of the ongoing planning process.

The EIA will include the temporary impacts due to construction as well as permanent impacts due to the physical structures and the operation of the different components of the fixed link itself. These impacts will be treated in detail in the present scoping report. The impacts potentially caused by associated activities and facilities (e.g. construction sites, working harbours and other construction related areas) will be included in the EIA. These issues will, however, not be treated further in the present report as this cannot be done until a later planning stage.

Presently it is assumed that raw materials will be delivered by sea or by the public railway or road network. Relevant locations for extraction (dredging) of raw materials have not yet been investigated. Surplus dredged material from the construction work will, to the degree possible, be used for possible land reclamaiton within the project. It is presently assumed that additional surplus material can be placed in special areas designated for this purpose. Possible locations for this have not yet been investigated. If new additional space for deposition is needed, possible areas will be investigated within the framework of the EIA.

As opposed to the construction activities in the actual project area, concrete and steel elements for a tunnel or a bridge can be produced at locations farther away from the fixed link (up to 120 km). Bridge or tunnel elements produced at these locations are transported to the construction site where they are put together. At best the production is established in approved industrial areas, so that new production areas and approvals will not be necessary. Due to the procedure for tendering the construction work ("design-build project"), decisions about locations for production and raw material as well as choice of construction methods partly rest with the selected contractors. If necessary, separate approvals will be obtained in this connection.

Generally, the approach facilities, the toll and administration buildings, construction sites and working harbours as well as temporary storage areas will be established within the area of investigation (see below). If relevant, these items will also be considered in the choice of project solution model.

The construction period is expected to last six years. Based on present knowledge, this means that the link can be opened by the end of 2018.

All solutions will be designed for a lifetime of at least 120 years.

The suggested technical solutions of the fixed link from coast to coast are currently under further optimisation. In that connection different bridge and tunnel solutions and the options of connecting them to the existing infrastructure are analysed in equal levels of detail.

2.1. Route Options

The project will be connected to the existing railroad and road network a few kilometres inland. The specific connection points have not yet been defined. In accordance with the state treaty, the connection points of the railway are defined as the transition point between Danish and German railway technology. As regards the road part, the connection point with the German road network is close to connection to Puttgarden (the end of the exit ramp and the starting point of the approach ramp). This connection point is the last part included in the German road network. The exact locations of the connection points will be established during the ongoing planning process.

Because the location of the connection points above is not yet established, the same goes for the specific route of the fixed link across Fehmarnbelt. This will also be established during the ongoing planning process. An issue of general importance to this route is to cross the Baltic Sea (Fehmarnbelt) over the shortest distance possible (see Figure 2.2). The final environmental impact statement will include a detailed description of the alignment, corresponding to the actual stage of planning, as well as a justification of the solutions models that are treated in the EIA.

The present regional spatial plan for Lolland in Denmark (Regionplan 2005-2017, Storstrøms Amt, 2005) includes an area reservation east of Rødbyhavn for the ramps and approach and tolling facilities.

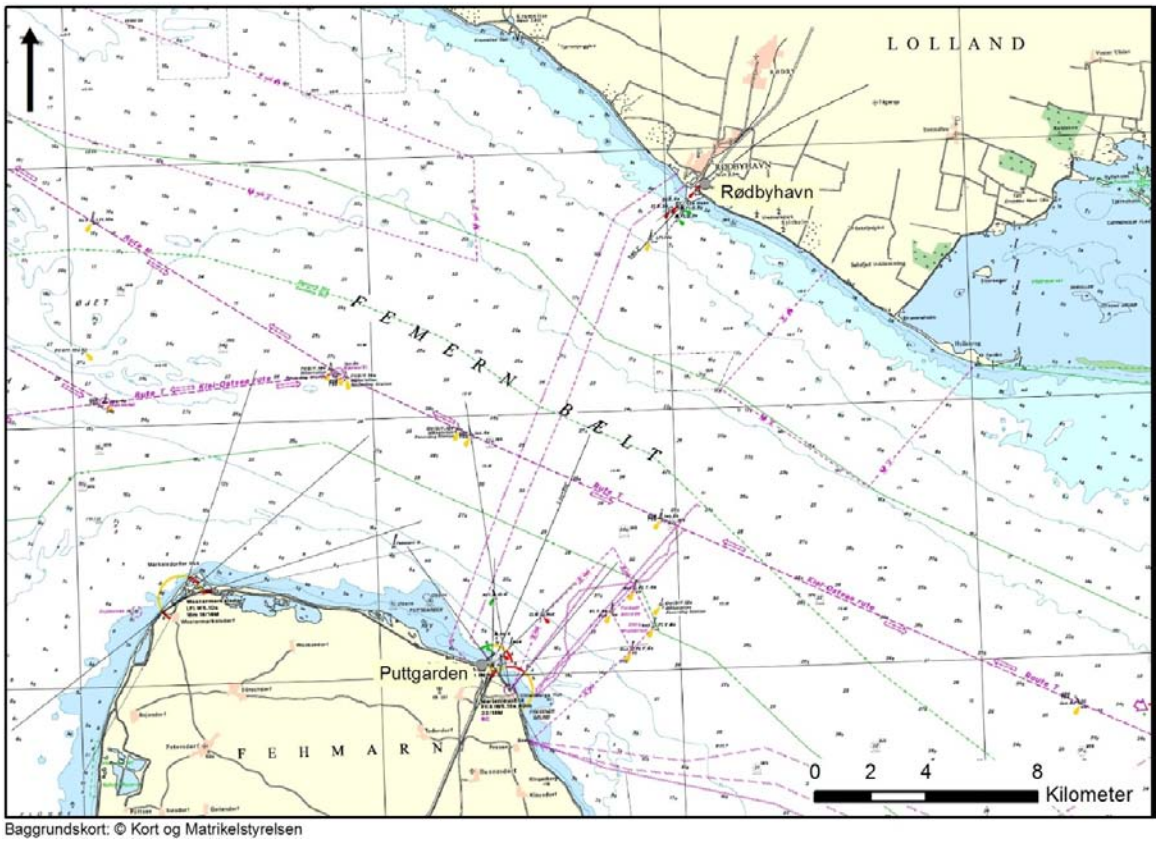


Figure 2.2 Fehmarnbelt between Puttgarden and Rødbyhavn

2.2. Technical Solutions

In the sections below a more detailed description of the two feasible technical solutions – cable-stayed bridge, and immersed tunnel is given. The describtion including all specifications (lengths, heights, distances etc.) is taken from the 1999 Feasibility Study. It should be stressed that the solutions during the ongoing planning process will be developed further and optimised in consideration of environmental, technical, navigational and safety as well as other requirements.

2.2.1. Cable-Stayed Bridge

The cable-stayed bridge comprises the main bridge, two approach bridges and two ramps.

Main bridge design

The span arrangement for the main bridge has been determined on the basis of navigational requirements. Eastbound and westbound shipping navigating in separate navigation channels require 2 times 700 m navigation spans. These are separated by 700 m that separates the traffic. The vertical clearance will be 65 m over the entire width of the navigation channels. Therefore the main bridge has been designed as a multispan cable-stayed bridge with three main spans of 724 m each and two side spans of 518 m each. Thus, the total length of the main bridge bridge is 3,208 m (Figur 2.3).

The 281 m high pylons of the main bridge will be founded in water depths of 28 m below sea level (Figure 2.4). It can be assumed that the pylon foundations will be constructed as pre-fabricated cellular caissons. The 46 m x 88 m caissons will be produced off-site in a drydock facility and towed to the site. They will be fully embedded into the seabed, thus reducing the resistance against the water-flow in the Fehmarnbelt. The pylons themselves will be constructed as concrete pylons in climbing formwork.

The superstructure of the main bridge comprises a 15 m deep truss girder, carrying traffic on two levels: the upper road deck, consisting of a concrete slab spanning transversely and the lower railway deck formed by a steel box. The stay cables are anchored in a steel edge beam. Cable-stays are attached to the steel truss at 24 m intervals, arranged in a semi-fan configuration.

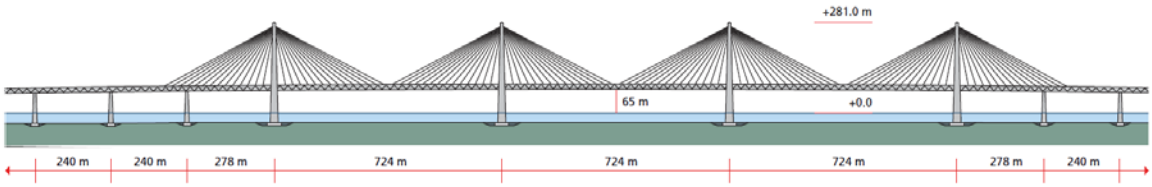


Figure 2.3 Lengthwise profile of the cable-stayed bridge solution

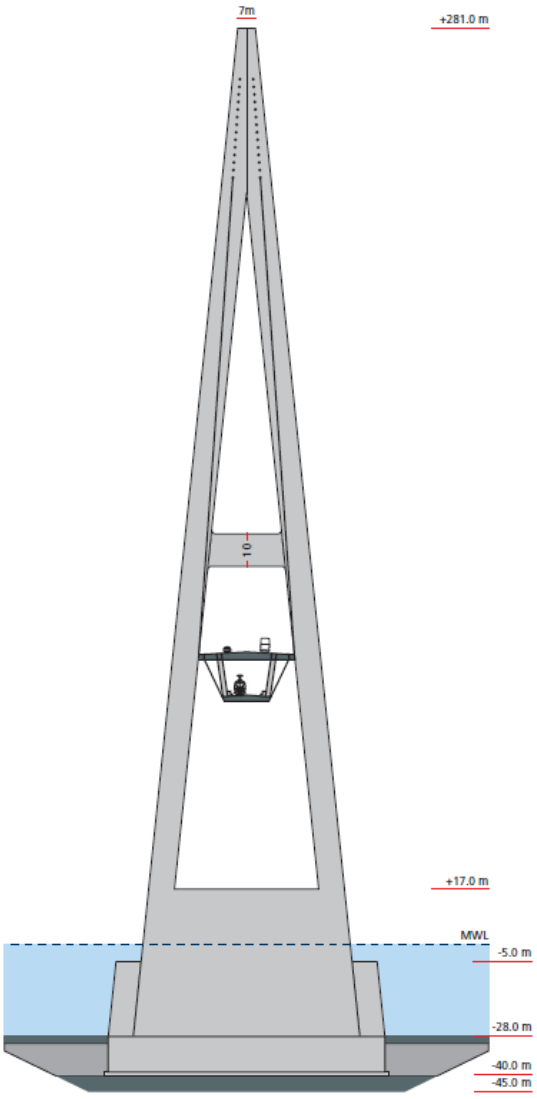


Figure 2.4 Cable stayed bridge pylon

Approach bridge design

The main bridge is linked to shore by two approach bridges with a length of 6,000 m for the southern and 9,360 m for the northern bridge.

Due to the two different geological conditions found in the area by the alignment, the northern part of the alignment allows for direct foundation of the piers in deposits of glacial materials where only moderate settlement can be expected. In contrast, the southern part of the profile is characterised by high-lying deposits of tertiary clay, for which greater settlement can be possible if piers are directly founded on the seabed. Therefore a piled foundation solution has been planned for the southern approach bridge piers.

The caisson bases and the caisson shafts are produced as one unit and the pier shaft as another. Caissons and pier shafts will be produced off-site in a dry-dock facility or pre-fabrication yard and transported to the site by tow-boats or heavy lift-vessels. The base structure will be fully embedded into the seabed. After installation the caisson shafts will be ballasted with sandfill.

Like the main bridge, the superstructure of the approach bridges carries traffic on two levels: the upper road deck and the lower railway deck. The 15 m deep girder carries the road deck designed as a concrete deck and the railway deck designed as a closed steel box. Floating cranes will complete spans offshore after girders have been prefabricated and assembled onshore.

Ramp design

Ramps accommodate the transition of the traffic from one level (onshore) to two levels (offshore). Ramps include viaducts of a total length of 600 m on the Fehmarn side and 624 m on the Lolland side. On land, additionally 1000 to 1500 m of motorway embankments will be established.

The construction of a bridge and the associated ramps will require construction site areas and construction harbours mainly for handling and storage of raw materials and prefabricated bridge elements. The facilities are estimated to occupy an area of about 40,000 m^2 (Femern A/S, 2010a).

2.2.2. Immersed Tunnel Solution

The solution comprises an immersed tunnel, two ramps and a ventilation islands.

Tunnel design

The cross section of the tunnel consists of four tubes: two tubes, each carrying a single rail-way track and two tubes, each carrying two motorway lanes (Figure 2.5). The tunnel cross-section has a rectangular shape of 41 m in width and 10 m in height. A 1.5 m wide gallery is placed centrally between both the railway tubes and the motorway tubes.

Each motorway tube is 10.0 m wide, each railway tube 6.37 m. Emergency walkways each 1.0 m wide are provided at each side of the service gallery. The service gallery in addition to service installations contain an escape corridor with escape doors provided at every 170 m. In this way the escape corridors are located between the main tubes and they ensure a safe evacuation in case of emergency.

The most likely construction method is production of the tunnel elements on a factory combined with dock for launching the elements similar to the method used for the Øresund project. However, if it is relevant, traditional construction of tunnel elements in a casting basin will be considered.

The tunnel is installed in a dredged trench. The trench is cleaned to ensure that no soft material is left in the trench where the element is to be positioned. Subsequently, a shredded gravel bed is established. The tunnel elements are towed out individually to the construction site, immersed and positioned. When the element is at its final position the joint to the previously installed adjacent element is completed and the temporary installation facilities are removed. Finally, the space between the tunnel and the trench edges is backfilled with sand and the tunnel roof is protected with a layer of cover stones.

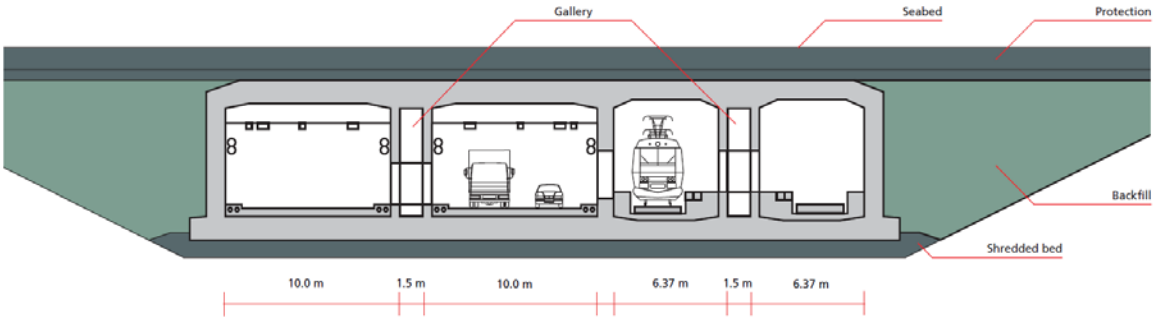


Figure 2.5 Cross section of the suggested immersed tunnel solution

Ramp design

On either side of the belt the ramps comprise three parts: a cut-and-cover tunnel where shallow water does not allow for towing in the tunnel elements, a portal building and an open ramp.

A pumping station is established under the lower part of the ramp for drainage purposes (mainly rainwater). In order to avoid permanent groundwater lowering the first portions of the ramps will be constructed as concrete structures and from there the trenches will be provided with an underlying membrane up to a level where bleeding no longer occurs.

The construction of an immersed tunnel will require construction site areas and construction harbours on both Lolland and on Fehmarn at each end of the tunnel. These facilities are needed mainly for handling of storage of raw materials and prefabricated construction elements. They are estimated to occupy an area of about 40,000 m^2 (Femern A/S 2010a).

Ventilation

An approx. 20 km long tunnel requires an effective ventilation system especially for road traffic. Fresh air must be supplied to ensure an acceptable air quality in the tunnel for health reasons. Furthermore, the ventilation system shall transport the smoke out of the tunnel in case of a fire in order to ease the access during emergency operations.

The railway tunnels are assumed to be “self-ventilated” (piston effect) during normal operation conditions, but a ventilation system is installed for emergency ventilation in case of a fire in the tunnel.

The design developed during the feasibility study assumes that the tunnel is divided into two sections, due to its length. A ventilation shaft constructed on an artificial island in Fehmarnbelt offers the possibility of directing the airflow in the tunnel away from a fire in order to increase safety in the tunnel.

The artificial island will be constructed at a water depth of 26-28 m and provides protection of the ventilation shaft, placed on top of the tunnel roof, against ice and ship collisions. The island is designed as a streamlined elliptical construction with a length of approx. 600 m and a width of 240 m occupying 0,03 km2 at the sea bed (Figure 2.6).

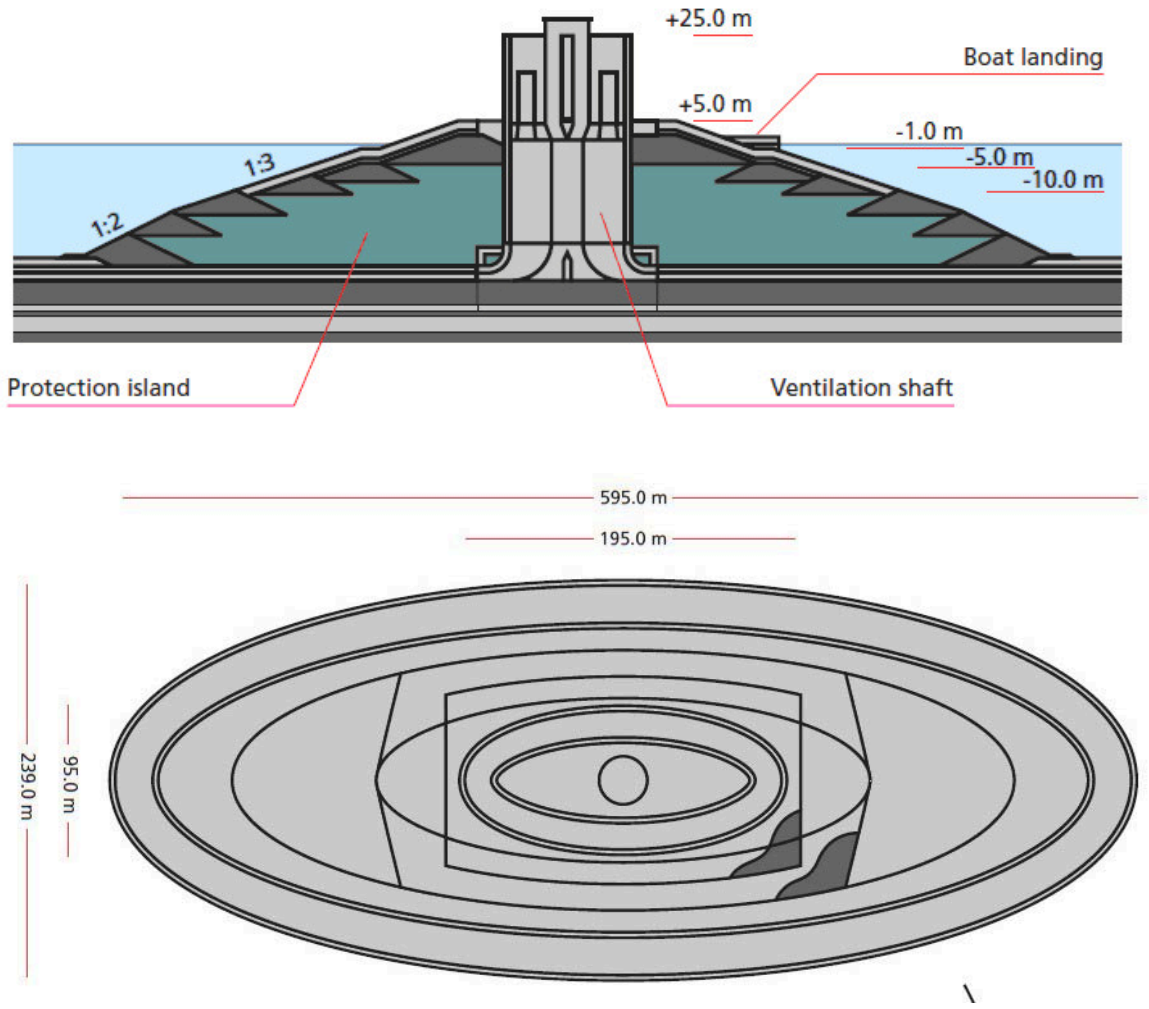


Figure 2.6 Ventilation island of the immersed tunnel solution

2.3. Dredging and Reclamation

A substantial part of the potential environmental impact related to the construction works results from the necessary dredging and reclamation activities. These activities will directly affect the seabed in the areas exploited and will result in a spill of a certain part of the handled amounts of seabed material.

The extent of land reclamation depends on the choice of solution. However, in any case reclamation be needed for the establishment of potential ventilation islands. Depositing of surplus dredge spoil may be needed as well.

Spill of material can influence the surrounding environment through the shading effect and due to sedimentation on the seabed in the vicinity of the dredging and reclamation activities.

2.3.1. Quantities

The expected quantities of dredging and deposition in Fehmarnbelt are presented in Table 2.1 together with requirements for imported seabed material, mainly sand. It is assumed that the volumes of re-usable sand in the dredged material from Fehmarnbelt are small and the required sand will have to be extracted elsewhere on the sea territory and transported to Fehmarnbelt. The dredged material volume given in the table is the volume after dredging and handling. The stated volumes is 35-45% larger after being dredged than the initial volume in the seabed. Volumes for special production facilities are included in the table.

2.3.2. Equipment

Earth handling for the Fehmarnbelt Fixed Link involves dredging under the following conditions:

- Varying material characteristics, from weak silty mud to very hard clay till with boulders
- Dredging down to 35-45 m below the water surface for bridge piers or tunnel trench depending on the solution model
- Long-distance transporting of material, up to 9 km in the alignment from the dredging location to a possible reclamation or depot site

Basically there are two different dredging principles which produce materials with different characteristics:

- Hydraulic dredgers which transport the material as slurry in steel pipelines or barges. Cutter-suction dredgers and trailing-suction dredgers are examples

- Mechanical dredgers which use mechanical action to dredge and transport the materials. Back-hoe dredger, dipper dredger, clamshell dredger and bucket-ladder dredger are examples

Other principles are likely to be applied for the possible extraction of raw material from the seabed.

Table 2.1 Balance for dredged material (based on the 1999 Feasibility Study)

	Dredged material million m^3	Re-use on site million m^3	Depot capacity Requirement million m^3	Import of sand million m^3
Cable-stayed bridge	4.6	1.8	3.2	4.4
Immersed tunnel	27.5	6.2	21.5	3.0

In the further planning of the project it will be examined whether it is possible to reduce the need for raw materials or to increase the re-use within the project.

2.3.3. "Import" of raw materials

On basis of an analysis of the "earth balance" for the two technical solution models it can be concluded that different amounts of sand, stones, gravel and pebble will be used for fill or for concrete production.

It is assumed that all material to be "imported" is transported from existing external storage spaces. The requirements depend on the final solution of the future link. The need for sand is presently estimated at at least million m^3. The extraction of this sand is not expected to take place as a direct part of the project and is accordingly not included in the EIA.

2.4. Demarcation of the area of investigation

Taking into consideration all conceivable alignment options and technical alternatives the area of investigation for the EIA shall be delimited in order to cover all expected environmental impacts. For this purpose the range as well as the path of the project derived environmental pressures need to be considered in order to identify, describe and assess the project and area specific and spatial impact on the individual environmental factors including their mutual interactions.

The demarcation of the area of investigation of the fixed link varies with the environmental factor in question and the expected type of impact. While e.g. the terrestrial vegetation will only be destroyed or deteriorate in the close vicinity of the alignment of the fixed link, the marine fauna and flora may become affected on a range of several kilometers due to suspended sediments from dredging work. Therefore the terrestrial area of investigation comprises the area that is affected by the different alignment solutions plus a sufficient margin

for alignment optimisation. The marine area of investigation comprises the entire area that could be affected by suspended sediments from dredging work. The marine areas of investigation are being demarcated on the basis of mathematical model simulations based on different sediment spill scenarios. In addition, the area of investigation also includes areas outside the impact area of the project including reference areas providing information for a future monitoring programme.

For the environmental impact assessment of the fixed link a project-specific area of investigation is distinguished from an area of investigation specific to each environmental factor or subfactor. The terrestrial project-specific areas of investigation are described below, statements on the factor-specific areas of investigation can be found in the subchapters of Chapter 7 either as separate paragraphs or in context with the description of the baseline investigations.

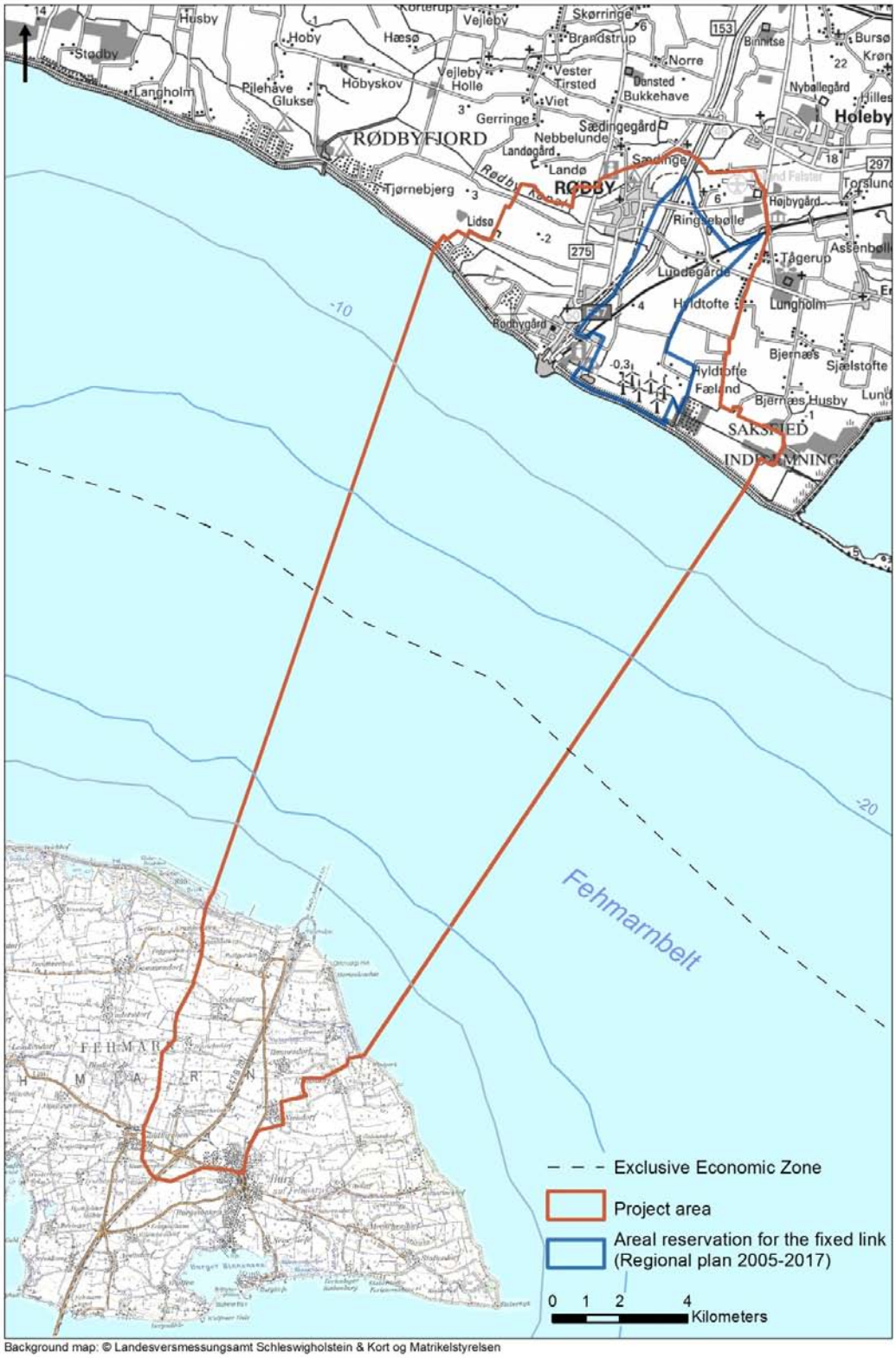


Figure 2.7 Demarcation of the project-specific area of investigation

2.4.1. Demarcation af the area of investigation on Fehmarn

The demarcation of an onshore area of investigation on Fehmarn is based on reasonably conceivable landing points of a bridge or tunnel solution taking into consideration the general convenience of making for the fixed link as short and direct as possible. Furthermore, the spatial extent of the potential impact on the relevant environment factors has been considered. The demarcation of the entire project area can be seen in Figure 2.7. Figures 3.1 and 3.2 show the onshore sections on Fehmarn and Lolland, respectively.

Since ferry operation between Fehmarn und Lolland must be maintained – at least during the construction phase of the Fehmarnbelt Fixed Link – the ramp and approach areas and connection points with the hinterland network (Road B 207, railroad line) cannot be placed in the central areas of the ferry terminal and the ferry port. However, more peripheral areas, such as parking lots and storage areas may be used.

Generally speaking, conceivable landing points of the Fehmarnbelt Fixed Link on Fehmarn are located west and east of the Puttgarden ferry port. The area of investigation is planned to include a 2.5 to 3 km wide corridor west and east of the B 207/E 47 road. This extent is chosen partly because of the far-reaching potential impact on the landscape and effects due to noise from a possible bridge ramp. To the west, the Natura 2000 sites SCI DE 1532-391 “West- und Nordküste Fehmarn“ (Western and Northern Coasts of Fehmarn) and the SPA DE 1530-491 “Östliche Kieler Bucht” (Eastern Kiel Bight, see fig. 8.1) as well as the coastline of the Baltic Sea to the east must be considered as areas for a reasonable demarcation of alignments of the Fehmarnbelt Fixed Link. An important issue is to avoid considerable deterioration of Natura 2000 sites and the national nature conservation area “Grüner Brink”. These are particularly important areas in the German landing region in terms of law and nature conservation. Very important conservation areas are found to the west along the entire northern coast of Fehmarn. The easternmost parts of the nature conservation areas above are included in the area of investigation in order to describe the relationships of the protected areas to their surroundings and to identify possible adverse effects caused by the project.

East of the ferry port and the B 207/E 47 road, a line connecting the villages Presen, Bannesdorf, Niendorf and the town of Burg is selected as the border of the area of investigation. This ensures that the existing high conflict potential and great sensitivity of residential areas (environmental factor human beings) can be considered in terms of project related impacts. Alignment options east of these residential are thus excluded.

The southern border of the area of investigation runs between Landkirchen and Burg, as it is conceivable that the new connection routes to the Fehmarnbelt Fixed Link will deviate from the existing routes relatively far to the south; for technical reasons or in order to avoid negative impacts. However, this depends on whether the connection roads and railroad lines run to the west or to the east. East of the Puttgarden ferry port, convenient landing points are only found between the ferry port and the village Marienleuchte. Landing points south of Marienleuchte would shift the link too far towards the eastern coast of Fehmarn, which would result in a considerably longer route at the sea running more or less parallel to the eastern shore of

Fehmarn. Furthermore a marine military range is sited here, where any kind of construction is prohibited.

Due to the demarcation explained above, the onshore area of investigation has a total size of approximately 31 km^2 (see Figure 2.7).

2.4.2. Demarcation of the area of investigation on Lolland

The area of investigation stretches along 12 km of coast east and west of Rødbyhavn and extends north for approximately 7 km. Along the coastal dike and behind this, the area of investigation includes large areas with salt meadows as well as areas with summer houses at Bredfjed and Hyldtofte Østersøbad. The eastern parts of the area of investigation includes parts of the Natura 2000 site SCI DK006X238 Smålandsfarvandet nord for Lolland, Guldborgsund, Bøtø Nor og Hyllekrog –Rødsand (Figure 8.1).

The perimeter of the area of investigation has been drawn to follow structures in the landscape such as roads since these often represent barriers and borders for the subjects investigated. This is the case in the east where the perimeter follows Højbygårdsvej and Hyldtoftevej passing through the villages Tågerup and Hyldtofte. In the north, the perimeter follows a line passing north of Rødby and continuing to the west to include the summer house area Bredfjed.

The area of investigation includes all areas where the fixed link will possibly be constructed.

As on Fehmarn, the basis for the demarcation of the area of investigation on Lolland is based on the conceivable landing points of a bridge or tunnel, which ensure an alignment of the fixed link being as short and direct as possible. The demarcation of the area is also based on the potential extent of the environmental impacts. The Regional Plan of 2005-2017 designates an area east of Rødbyhavn for the aproach and ramp facilities. However, in order to be able to assess western alignment, options areas west of Rødbyhavn are also included in the area of investigation.

The area of investigation also includes areas, which can be indirectly affected by the fixed link outside the areas directly occupied by construction. These areas are included since they can be affected by emissions of noise, pollution and visual effects. Also, the area of investigation contains areas of significance to migrating animal species. These species can be directly affected by barrier effects. This is e.g. the case for areas north of Bredfjed where natterjack toad (*Bufo calamita*) might occur.

The total extent of the area of investigation on Lolland is 53 km^2 (see Figure 2.7).

2.4.3. Demarcation of the main area of investigation in the Fehmarnbelt (Marine area)

Pursuant to the EU directives the area of investigation includes all protected areas that potentially are affected by the construction or operation of the Fehmarnbelt Fixed Link. The marine area of investigation therefore includes the entire Fehmarnbelt, parts of the Mecklenburg Bight as well as the stretch from the Kiel Bight and northwards to the southern tip of Langeland. The area of investigation totals around 6,000 km^2. Of this Fehmarnbelt itself occupies around 1,000 km^2.

The detailed description of the environmental factor-specific areas of investigation is presented in Chapter 7.

By linear connection of the two terrestrial areas of investigation on Fehmarn and Lolland, respectively, the technical project-specific marine investigation area (alignment corridor) is defined as depicted in Figure 2.7.

3. Environmental Conditions

The environmental conditions encompass the features and components of the terrestrial and marine environments. It also encompasses the human land use and exploitation of resources.

Human beings (including human health) are treated first. Then the marine environment is described including sediment, water, fauna and flora (other than birds), the cultural heritage and material assets. The subsequent sections address the environment on Fehmarn and Lolland separately, following the order soil, water, flora and fauna (other than birds), landscape, climate, air, the cultural heritage and material assets. Finally, the bird fauna is described followed by a brief overview of Natura 2000 areas in the vicinity of the project area.

3.1. Human Beings/Human Health

3.1.1. Fehmarn

The island of Fehmarn has a population of about 13,000 inhabitants of which about 2,300 live in Burg. Since January 1, 2003 the former municipalities of the island have been merged into a single municipality, Town of Fehmarn (Stadt Fehmarn). (A map of Fehmarn in the vicinity of the project corridor is shown in Figure 3.1) Settlement areas on Fehmarn are mostly residential areas, and mixed use zones and rural settlement areas. The main towns are Burg auf Fehmarn, Westfehmarn, Landkirchen, and Bannesdorf. Several small villages are scattered on the island.

The business structure is dominated by tourism, the ferry harbour of Puttgarden and agriculture which together provide the main workplaces on Fehmarn.

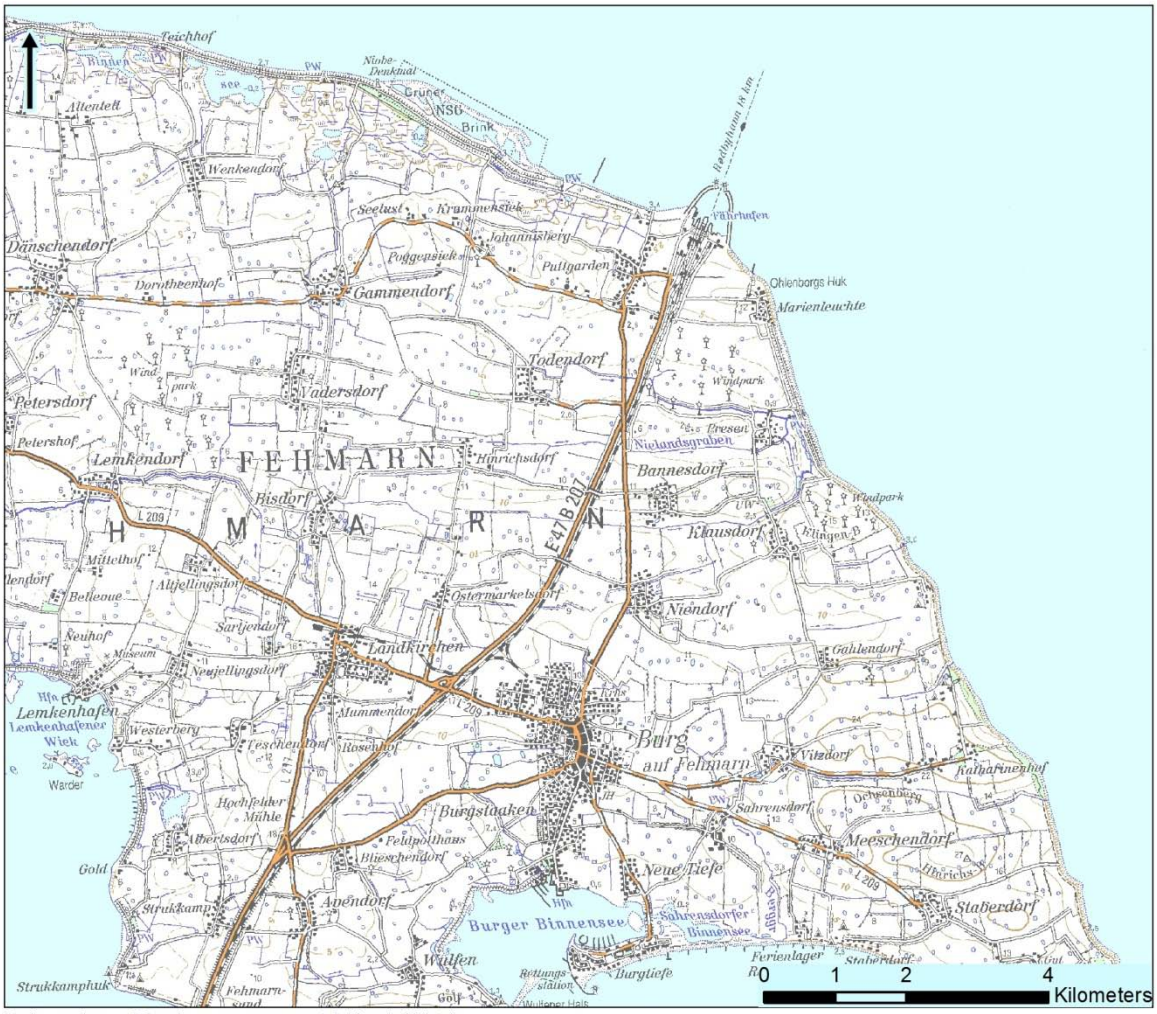
Fehmarn is a tourist hotspot. The existence of recreational infrastructure, points of interest and the scenic beauty of the coast are of noticeable importance to tourists as well as for the recreation of inhabitants of Fehmarn. As in most communities on the Baltic coastline in Kreis Ostholstein, the economy of the island is therefore heavily dependent on tourism. The island offers more than 25,000 tourism coordination units (tcu), mostly on campsites, in apartments and cottages. Altogether, about three million bed nights are sold every year in the areas Fehmarn and Großenbrode. The main points of interest for tourism is Burg, the peninsula of Burgtiefe with a holiday centre and a yachting harbour as well as the harbour of Burgstaaken partly used by fishing boats and excursion boats.

Due to the short distance to the beaches of the Baltic coast and the good network of small rural roads, footpaths and cycle-ways, there are good opportunities for outdoor recreation near the residential areas on Fehmarn. Particularly west of Puttgarden and on southern Fehmarn, the sandy beaches, the diversity of the Baltic coastline and the scenic beauty of the sea is of great value for recreational activities.

Among the tourist attractions are the lighthouse of Marienleuchte and the nature reserves Grüner Brink and Wallnau with guided walks. Furthermore, the long-distance “Baltic Sea cycle-way” and the numerous camping sites along the coast line should be mentioned.

The coastal waters around Fehmarn offer excellent conditions for water sports, particularly sailing and kite surfing. The main areas for water sports are located on the southern part of the island, e.g. in the area of the Fehmarnsund and Gold with yachting harbours in Orth, Lemkenhafen, Burgtiefe and Burgstaaken. The bay between Orth and Strukkamphuk is ideal for wind surfing.

The maritime climate is said to stimulate the human health, a so-called bracing climate caused by mild sea breezes, intensive sunlight and UV radiation, sea salt aerosols in the air and high humidity.



Background map: © Landesversmessungsamt Schleswig-Holstein

Figure 3.1 Fehmarn in the vicinity of the project area.

Existing loads of air pollution, noise and vibrations exist along the Federal highway B 207, the diesel operated railway line and in particular the ferries and the ferry harbour in Puttgarden. Furthermore there are preloads due to the wind energy plants in the wind park Presen in the southeast of the ferry port in Puttgarden.

3.1.2. Lolland

Lolland Municipality has 50,000 inhabitants of which 70% live in the urban areas whereas the remaining 30% live in the countryside. The municipality comprise the central and western part of the island. The municipality is a typical fringe area, with a significant depopulation of young habitants. Lolland is characterised by idyllic towns like Maribo, Nakskov, Sakskøbing, Nysted and Rødby and by small harbours. (A map of Lolland in the vicinity of Rødbyhavn and Rødby is shown in Figure 3.2).

According to the local business development strategy, the goal is to attract businesses by easing the settlement process for enterprises and by strengthening the basis for attracting educated working power through improvements of infrastructure, education, recreational areas and housing facilities.

Presently, the business structure is characterised by agriculture and service trade in the urban areas. Only a limited number of large enterprises are located in the municipality, e.g. the wind power company Vestas. The key sectors on Lolland are sustainable energy, (ecological) agriculture and tourism. The island has 30 enterprises based on tourism, which sells a total of almost 900,000 bed nights per year. About 33,000 of these are for German tourists, whereas Danish guests account for almost 650,000 bed nights. Generally, measured in bed nights, the tourism of Lolland Municipality is exceeding average growth on national level.

The two major tourist attractions on Lolland are the Knuthenborg Safari Park near Maribo, and Lalandia, a large holiday resort 1 km west of Rødbyhavn. Besides these attractions, the Nature Park Maribo Lakes, the castle of Ålholm and the city of Nysted should also be mentioned. There are several manor houses with surrounding large-scale landscapes. Along the southern coastline of Lolland, important recreational sites include the sandy beaches west of Rødbyhavn and the Lolland dike. The latter is a very special and characteristic attraction, which is used by cyclists and hikers who can enjoy the view from the top of the dike.

Currently, a certain level of air pollution, noise and vibrations are assumed mainly along the highway E47, the railway line and around the ferry harbour in Rødbyhavn.

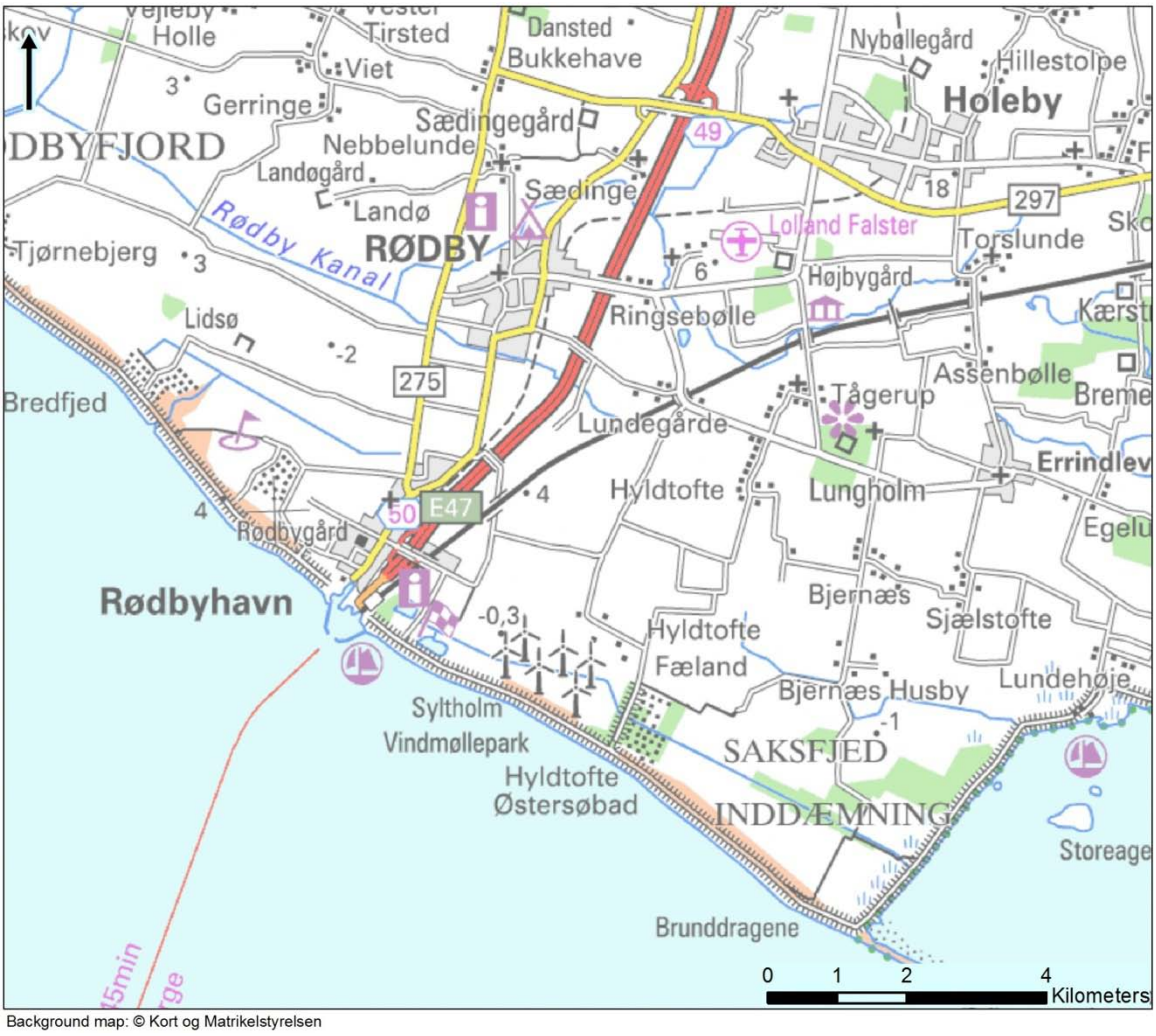


Figure 3.2 Lolland in the vicinity of Rødbyhavn and Rødby

3.1.3. Commercial fishery

Commercial fishermen catch a wide variety of fish species in the Baltic Sea and the Fehmarnbelt. Some of these species migrate though the Fehmarnbelt and are part of the catch only in certain seasons, whilst others are more stationary and occur in the local catch more often. The commercially most important landings from the Belt Sea (including Fehmarnbelt) include cod, herring and sprat, eel and various flatfish.

Trawling for cod is concentrated in autumn and winter months, and is carried out by trawlers from Germany, Denmark, as well as other parts of the Baltic region. Commercial fishery with pound nets in shallow waters is also significant around Fehmarn and along the southern coast of Lolland. Furthermore, gill net fishing, long line fishing and fishing with traps also takes place.

Local fishing harbours and villages are located on the southern coast of Fehmarn and on the German mainland between Heiligenhafen and Grossenbrode. Along the Danish coast of the Fehmarnbelt a number of local fishing ports are located.

3.1.4. Navigation

The Fehmarnbelt area is a very important and busy navigation corridor for ship traffic between the eastern and western Baltic Sea and even more important between the Baltic Sea and international destinations outside the Baltic region. The greater part is shipping with e.g. bulk carriers, oil tankers, ro/ro ships and container ships. The Rødbyhavn-Puttgarden ferry service operates directly in the project area across the Fehmarnbelt.

Besides the commercial traffic, the Fehmarnbelt area is frequently used for recreational purposes by pleasure boats. A number of recreational harbours exist on both sides of Fehmarnbelt (e.g. Nysted, Rødby, Kramnitze, Burgtiefe Burgstaaken, Lemkenhafen, Orth, Großenbroder Fähre, Fehmarnsund og Heiligenhafen).

3.2. Geology, bathymetry, sediments and coastal morphology

3.2.1. Geology

The Fehmarnbelt area has a very dynamic geological history (Novak and Björk 2002). After the final retreat of the glaciers, the topography was further reshaped by the rivers draining the Baltic Ice Lake. Geological profiling down to 600 m identifies four geological layers: upper and lower quaternary deposits overlay tertiary clay; except in the central parts where cretaceous chalk is observed beneath the lower quaternary deposits. The tertiary clay is closer to the surface in the area around the southern part of the alignment. A map of Fehmarnbelt and the surrounding region is shown in Figure 3.3.

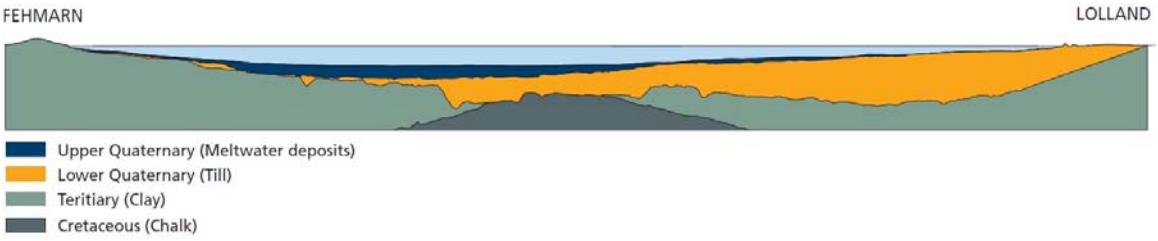


Figure 3.3 Geological profile of Fehmarnbelt

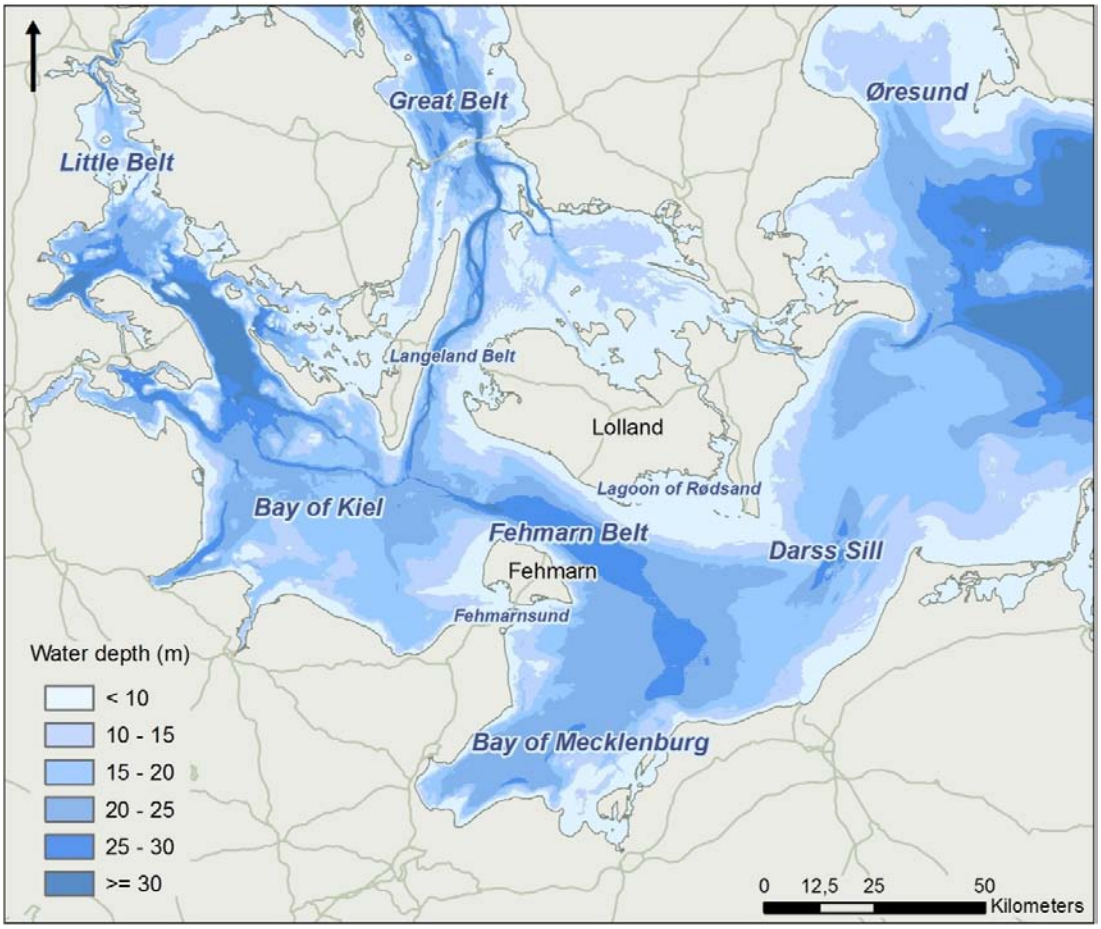


Figure 3.4 Bathymetry of Fehmarnbelt and the surrounding region

3.2.2. Bathymetry (the marine landscape)

Fehmarnbelt has a maximum depth of about 30 m. In the project area the width varies between 18 km (Rødbyhavn-Puttgarden) and 25 km. The seabed in the central parts is smooth with gentle slopes towards the coast of Lolland. On the Fehmarn side the slopes are slightly steeper.

A striking feature of the slopes is the sand waves (sand bank-like sea bed structures, mega ripples) (Fiedler 2000). In the Fehmarnbelt, a sand wave area has been identified 4-6 km west of the project area in the Natura 2000 area “Fehmarnbelt” (SCI DE 1332-301 see Figure 8.1). Here the sand waves are about 3 m high with wave lengths ranging from 12 to 100 m; and typically at water depth in the range of 16-20 m. Sand waves are also registered in the Langeland Belt and most likely more sand waves occur outside the previously surveyed areas.

The impact of surface water waves on the sand waves is small compared to the water current, but only very rare flow situations are expected to actually contribute to the dynamics of the sand waves.

3.2.3. Sediment Properties

In the deeper parts outside the sand wave areas the surface sediment consists of sand with a varying content of fine grained mud (COWI-Lahmeyer 1998a). Along the coastline in shallower water medium to coarse grained sand are dominating. During storms these surface sediments are resuspended and make the water turbid. In some areas, in particular in the coastal areas, a more gravelly seabed is found with both small stones and large boulders, which form an excellent substrate for macro algae. This kind of sea bed is found in shallow areas near the coast of Lolland and at a few locations north of Fehmarn, however the location and extent are not known in detail.

The chemistry of surface sediments has been studied at stations across the project area (COWI-Lahmeyer 1998a) and in the Baltic Sea in general (Leipe *et al.* 2008). The content of organic material is rather low (0.1%-9.9% of dry weight) with the highest content in the deepest central part. The nutrient concentrations reflect the organic content. The concentration of toxic substances in surface sediments of Fehmarnbelt is not well described. However, the concentration probably mainly reflects the diffuse sources and is probably at the same intermediate level as in other open parts of the Belt Sea and in the Kattegat.

3.2.4. Coastal morphology

Both along Lolland and Fehmarn, the coastlines consist of sandy often rather steep beaches. The steepness is mainly governed by the coastal dikes built to protect the low lying hinterlands. However, natural cliffs are found on the north east of Fehmarn. Except for a stretch east of Puttgarden, the natural sediment transport along both coastlines is usually east-going due to the predominant westerly winds and waves. The coastal drift of sediment is moderate; in the order of 10-40,000 m^3 sediment/year. The coastlines are described in detail in the 1999 Feasibility study (COWI-Lahmeyer 1996, 1998b). The recent and historical development of the coastlines of the Baltic Sea is described by Leipe *et al.* (2008).

The harbour at Rødbyhavn acts as a barrier and traps the eastward drift of sand. This results in accretion of the beach on the west side and erosion on the east side of the harbour. The retreat of the shoreline is prevented by a revetment and beach nourishments. Furthermore, breakwaters parallel to the shore with sand replenishment have been established a few kilometres east of the harbour.

The coastline west of the harbour of Puttgarden is characterised by shoreline instabilities governed by very oblique incoming westerly waves and resulting in bars and spits. The largest of these is the protected “Grüner Brink” to the west of Puttgarden. The east-going sediment transport is reflected in the migration of these features. On the east side of the harbour the sediment transport is west-going and slow accretion occurs in the corner formed by the shoreline and the harbour.

3.3. Marine Water

3.3.1. Hydrography

Fehmarnbelt is part of the Belt Sea connecting the Baltic Sea Proper with Kattegat. In addition to Øresund (the Sound) the Belt Sea include the straits Little Belt and Great Belt and the Kiel and Mecklenburg Bights. To the east, the Belt Sea is bordered by the shallow Darss Sill (about 18 m deep). The hydrodynamic conditions were investigated as part of the 1999 Feasibility Study (COWI-Lahmeyer 1998c). The long term evolution is discussed by Feistel *et al.* (2008).

The Belt Sea is characterised by significant horizontal variations in salinity, with the highest levels towards Kattegat and lower salinities to the east where the influence from the Baltic Proper is pronounced. Vertically, the water column of the Fehmarnbelt is stratified with low saline surface water overlaying a high saline bottom layer. Between these two layers is a halocline, a water layer featuring the salinity gradient between surface and bottom layers. The halocline is typically observed at around 13 m depth and typically coincides with a temperature gradient.

The flow through the Fehmarnbelt is governed by the meteorological conditions and the presence of water masses of different salinities. The dominant flow direction in the surface layer is west-bound, i.e. outflow from the Baltic Sea Proper towards the Kattegat. During such outflows, the current in the bottom layer may be insignificant or even reverse. The saline inflow to the central Baltic Sea is limited by the presence of the Darss Sill.

Inflow of saline water through Fehmarnbelt and across the Darss Sill is typically induced by westerly winds and low pressure over Scandinavia. With these inflows, new oxygen-rich saline water is forced over the Darss Sills and continues as a dense bottom current along the sloping seabed into the deepest part of the Central Baltic Sea. In the deeper Central Baltic Sea the salinity stratification limits the supply of oxygen from the surface to the bottom layer. Therefore, the replenishment of the oxygen pool is depending on such horizontal supply.

During the past thirty years only three so-called major saline inflows have been observed, in contrast to 4-7 per decade before 1980 (Feistel *et al.* 2008). However, the low frequency of major saline inflows has not resulted in a decreasing salinity in the Baltic Sea basins and they must have been compensated by an increased number of medium and small inflow events. On a longer time scale, there has been a tendency towards increasing salinity within the last century (Omstedt *et al.* 2004).

Changes in inflow of saline water and overall changes in the exchange flows have a direct implication for the stratification and the vertical exchanges in the Baltic Sea (Reissmann *et al.* 2009), as well as for the ventilation of the deeper layers by lateral transports of oxygen-rich water. This may in turn influence the distribution of fauna and flora habitats in the Baltic Sea, including recruitment to the cod stock.

The present impact of human activities on the local hydrodynamics in Fehmarnbelt and thereby also potentially on the exchange flow with the Baltic Sea has not yet been quantified. Possible influencing factors are the breakwaters at the harbours of Rødby and Puttgarden, existing and planned offshore wind farms, ferry services and in the longer perspective also climate changes.

3.3.2. Marine water quality

The water quality of the Fehmarnbelt is primarily governed by nutrients imported from the neighbouring seas. The whole western Baltic Sea is classified by HELCOM (Helsinki Commission – Baltic Marine Environment Protection Commission) as "affected by eutrophication" (HELCOM 2009). This is documented by extensive historic data showing deterioration during the past 50-60 years (Feistel *et al.* 2008).

As a consequence the frequency of oxygen deficiency is apparently increasing. The regional oxygen balance is mainly determined by the stratified water flow. Particularly during late summer and early autumn oxygen deficient water is transported into the area and cause oxygen deficiency in the Kiel and Mecklenburg Bights. In Fehmarnbelt, oxygen depletion is less frequent. The degree and the duration of low oxygen concentration affect the benthic fauna generally resulting in impaired conditions (Feistel *et al.* 2008).

Water quality is also an important issue to bathing waters. In general the bathing water quality of beaches along Lolland and Fehmarn are good, and faecal bacteria pollution is considered to be limited. However, on calm summer days the water quality of the bathing water can be affected by blooms of blue-green algae.

During storms, resuspension of sea bed surface sediments in shallow water results in a high turbidity, i.e. a high concentration of suspended matter reducing the transparency of the water.

3.4. Marine Fauna and Flora

3.4.1. Planktonic fauna and flora

Phytoplankton and zooplankton serve as food for fish, bottom living (benthic) animals and other marine organisms. All fish and most invertebrates depend on plankton for food during their larval phases, and some species such as mussels continue to consume plankton their entire lives.

The species composition and biomass of the plankton algae and zooplankton undergo seasonal variations reflecting the patterns of the entire Baltic Sea area. The highest activity and biomasses generally occur during summer time. Blooms of (toxic) blue-green algae are common during warm summers following winters with high concentrations of phosphorus.

Every summer, mass occurrences of moon jellyfish (*Aurelia aurita*) are reported for the western and central Baltic Sea. The occurrences are believed to originate from nursery

grounds (polyp colonies) in the higher saline areas like Fehmarnbelt. Also the invasive jellyfish *Mnemiopsis*, known from its impact on the Black Sea ecosystem and fisheries, has been found repeatedly in the western Baltic Sea since 2007. Jellyfish are important predators on small zooplankton organisms and when occurring in high densities they can prey on fish larvae and compete with fish for food.

3.4.2. Marine bottom flora

Sea bed vegetation such as perennial macroalgal communities and eelgrass beds, provide habitat for many invertebrates and smaller fish, and they serve as spawning grounds and nursery areas for several pelagic fish species. The plants are important food sources for invertebrates and birds and they play an important role in nutrient cycling and oxygen production. In Fehmarnbelt a total of 33 species of submerged bottom flora was identified during the 1999 Feasibility Study (COWI-Lahmeyer 1999). Five of these are on the German red list for the Baltic Sea but none of the species are considered threatened in Denmark as they are common at higher salinities, e.g. in the Kattegat.

Theoretically the amount of light reaching the bottom of Fehmarnbelt can support macroalgal growth down to 18-20 m depth, and red algae as *Delesseria sanguinea* and *Coccotylus truncates* are known to form dense vegetation on solid substrate in deeper waters. Knowledge of the species composition, abundance and distribution at these depths is, however, scarce.

At shallow water (5-10 m) along the coast of Lolland areas with hard substrate is dominated by the red algae *Furcellaria lumbricalis,* and *Polysiphonia* occur widespread. On the east coast of Fehmarn, the macroalgae cover is less dense and the red algae *C. truncatus* dominate in deeper waters too. Brown algae are generally more rare except for occurrences at the west coast of Fehmarn. Here, *Fucus* algae are found down to 6 m which is the deepest occurrence of this alga along the German Baltic coast (Führhaupter *et al.* 2008).

Due to strong currents and wave exposure, rooted vegetation such as eelgrass beds is not characteristic distinctive feature for the Fehmarnbelt. However, in the nearby shallow lagoon of Rødsand large mixed communities of eelgrass*,* pondweed (*Potamogeton*), *Furcellaria* and *Fucus* exist. The only equally dense eelgrass beds are found in Orth Bight on the south-west coast of Fehmarn. Otherwise only small-scale, scattered stands of eelgrass occur down to 5 m depth.

3.4.3. Marine bottom fauna

The bottom fauna is distributed according to depth, substrate and salinity. Both in terms of biomass and ecological role, bivalves constitute a very important group which exert intensive grazing on the plankton and at the same time constitute the primary food for wintering sea ducks. Blue mussels occur in rather high biomasses (3-5 kg/m^2) where phytoplankton is available and where currents sustain a continuous supply of the plankton algae (phytoplankton). The mussels occur particularly along the coasts of Lolland while they appear to be scarcer around Fehmarn.

At larger depths with more stable and higher salinities, the diversity of the benthic fauna increases. Burrowing marine bristle worms (polychaetes) and bivalves become increasingly important. Areas of particular high species diversity of the western Baltic are the sandy rises and the plateaus with diversified substrate (sand, gravel, and boulders) northeast of the Fehmarn coast. Also the sand wave fields provide good living conditions for bottom fauna. More than 200 species were observed during comprehensive investigations in 2003 to 2005 (Zettler *et al*. 2008). Approximately 40 species is included on the German red list of threatened species. However, these species are generally not considered as threatened in Denmark as they are common at higher salinities, e.g. in the Kattegat.

3.4.4. Fish

The important fish populations include cod, flatfish, sprat and the spring spawning herring (mainly the Rügen herring). The greater Fehmarnbelt area provides important spawning grounds for cod, and transport of cod larvae from the western Baltic to the Baltic proper is believed to be of importance for the entire Baltic cod stock. Sprat on the other hand is known to spawn in the deep basins of the Baltic, but the larvae are transported by currents to shallow water nursery grounds all over the Baltic, including the Fehmarnbelt.

The shallow waters of the Fehmarnbelt comprise important nursery and feeding grounds for a number of economically and ecologically important species. The vegetated habitats along the coasts of Lolland and Fehmarn are important for reproduction of the said species, and the availability of high quality nursery grounds is an important factor for the recruitment of many fish species. The vegetated habitats do also act as pantry for many species. In addition, non-vegetated sandy or silted sea beds are important feeding grounds for demersal fish such as flatfish.

Many of the important fish species migrate to, from or through the Fehmarnbelt. Both spring and autumn spawning herring have been said to migrate to and from spawning grounds in the Fehmarnbelt area. However, recent investigations indicate that only rarely or not at all do herring spawn in the Fehmarnbelt.

European eels are transported by the Gulf Stream as eel larvae from the spawning area in the Saragossa Sea to the coasts of Europe. Some of the eel larvae are transported through the Danish straits and belts and on to the Baltic Sea, where the eel, which now is an elver, migrate into fresh water to forage and grow. Cod, in contrast to herring and eel, moves in large areas when foraging, but are not believed to migrate between spawning grounds and feeding area, as it is the case for e.g. herring and eel. The cod, which spawn in the Fehmarnbelt are believed to be exclusively Western Baltic cod, and this population spawn in deep parts of the Fehmarnbelt, in the Arkona Basin and other places.

The Baltic Sea ecosystem has undergone great changes in the fish communities during the last two decades. Cod, European eel and herring stocks have decreased dramatically while sprat stocks and landings show large increases. Cod, European eel and autumn spawning herring are now considered as threatened species. The cod is on HELCOM´s list of

“Threatened or declining species” while the European eel and the autumn spawning herring are on the German red list.

3.4.5. Marine mammals

Three species of marine mammals occur regularly in the Fehmarnbelt area: The harbour porpoise (*Phocoena phocoena*), the harbour seal (*Phoca vitulina*), and the grey seal (*Halichoerus grypus*). The Fehmarnbelt is believed to provide important habitats to the species and to constitute an essential transit area for migration between the eastern and western parts of the Baltic Sea.

For harbour porpoises, the Fehmarnbelt represents the southern extent of their main distribution range in the western Baltic Sea. Possibly separate populations inhabit the eastern and western parts of the western Baltic Sea respectively, with an unknown exchange rate through the Fehmarnbelt.

Fehmarnbelt provides an important haul-out habitat for harbour seals, at the Rødsand sand bank south of Lolland, 25-30 km east of the project area. This is the most important haul-out and breeding site of the Baltic Sea. Less used haul out sites are Vitten and Skrollen in the Rødsand Lagoon.

Rødsand also is the location with the highest recorded number of grey seals in Denmark. This is also where the first breeding of a grey seal in the western Baltic since the early 20th century was recorded recently. This suggests that this is the most likely site for a re-establishment of the population in the western Baltic Sea. On the German side there are no haul-out places for seals.

3.4.6. Bats

At the time of writing no scientific information is available on the possible bat migration between Germany and Scandinavia crossing Fehmarnbelt. However, it is generally known that migration across the Baltic Sea can occur. Therefore it can also be assumed to take place over Fehmarnbelt.

3.5. Cultural Heritage at Sea

Settlement sites, ship wrecks and other historical and ancient monuments from all historical periods could be located in the entire project area. Such finds are protected by Danish and German legislation.

During the Palaeolithic and Mesolithic periods the water level was significantly lower than today. Therefore, the settlements once located at the coast are now under water, which means that stone age remains may be present in the alignment corridor. The only obvious place for Bronze Age finds in the alignment corridor is around Puttgarden. The Iron Age finds

and traces close to the Puttgarden coastline indicate not only activity both on land and at sea but also a potential former harbour area at Puttgarden.

Shipwrecks are registered in the alignment corridor, some of which have historical interest. More shipwrecks and other items of maritime origin may be present. Wrecks of World War II aircraft are also likely to be found in Fehmarnbelt.

Seabed surveys in the project area carried out in 2008 and 2009 using sidescan sonar and magnetometer, has revealed several manmade objects, some of which are of archaeological value.

3.6. Material Assets (Sea area)

Offshore wind farms

Two Danish wind farms will be in operation or under construction in the Fehmarnbelt area by the end of 2010: Nysted (about 160 MW), and Rødsand 2 (about 200MW). They are located along the coast of Lolland, south of the Rødsand Lagoon and cover a total area of about 75 km^2. Nysted Wind Farm commenced operation in 2003 while Rødsand 2 is still under construction. No wind farms exist in the German part of the Fehmarnbelt and no current plans of new wind farms are known for this area.

Extraction of seabed resources

Denmark has two areas allocated for extraction of sand and gravel in Fehmarnbelt. They are used periodically and last time in 2006. Further areas are located south-east of Keldsnor/ Langeland and Gedser, respectively. All permissions expire by December 2009, but they are expected to be prolonged with the exception of one area, which is very rarely used.

No sites for extraction of marine raw materials are found in the German territorial waters of the Fehmarnbelt. Some smaller areas in the eastern Mecklenburg Bight are presently being phased out.

3.7. Soil Conditions (Fehmarn)

Fehmarn represents the easternmost natural landscape of Schleswig-Holstein; being the biggest island (185 km^2) of the state, separated from the mainland by the Fehmarnsund. It stands out with very fertile soils and a sunny, relatively dry climate, and a flat landscape suitable for intensive farming.

The soils of Fehmarn were formed during the glacial and post-glacial periods. The dominant soil type is textural-class clay till with varying layers of sand, clay and silt (grey-brown podsolic

soil or pseudogleys). The ground relief formed during the glacial period is flat or lightly undulating.

In the areas of the wetlands and low areas (Blankenwisch, Grüner Brink, Presen, Wallnau and Flügger Teiche) peat soils (low bog) and organic mud occur. Particularly at the northern and southern coasts, sand is deposited by the shoreline by the erosion-deposition processes described in Section 3.2,leading to the formation of steep beaches (storm beaches) and coastal lagoons.

3.8. Water (Fehmarn)

The low permeability of the sub soil clay till results in a relatively high groundwater level (impeded water). On the other hand this is lowered by agricultural drainages. The accurate local distribution, extent, sequence and properties of the groundwater in the project area are however unknown. This also applies for the hydrodynamics and the water chemistry, e.g. the groundwater level fluctuations, the transition between fresh groundwater and sea water, etc. No water conservation areas are designated close to the project area.

Surface water bodies include coastal lagoons separated from the sea, ditches, ponds (marl pits) and wetlands with seasonally occurring groundwater. Fehmarn is drained by ditches, and only few of them display a natural structure. Dikes for coastal protection are located on the north and west coasts and on parts of the south coast. Examinations of the Ministry for Agriculture, Environment and Rural Regions Schleswig-Holstein (*Ministerium für Landwirtschaft, Umwelt und ländliche Räume*, MLUR) show that the water quality is affected by pollution in all the watercourses of Fehmarn.

3.9. Fauna and Flora (Fehmarn)

Comprehensive data exist on habitats, fauna and flora of the potential impact area. The data are provided by various sources like open space structure plans in context of zoning, landscape conservation plans, impact assessments of Natura 2000 sites and the comprehensive landscape plan for Fehmarn Island.

The main biotopes are cultivated fields structured only by a few lines of trees and hedgerows and small water bodies, including ponds protected by the Nature Conservation Act of Schleswig-Holstein (LNatSchG). At small water bodies, amphibians, dragonflies and other important insects can occur. For amphibians and other small animals living on the ground, the B 207 highway appears as an almost total barrier. Grasshoppers, butterflies, moths, beetles and other invertebrate species as well as reptiles occur locally.

Because of the relatively sparse vegetation and other habitat structures, it is unlikely that significant bat populations occur in the potential project area. However, man-made structures such as buildings and bridges may serve as bat habitats. Furthermore, it has been claimed

that migration of bats takes place from Sweden to Germany (Nathusius's pipistrelle (*Pipistrellus nathusii*)). The extent and complexity of this migration has to be assessed.

The coastal habitats are made up of lagoons (often not directly connected with the sea), salt marshes and brackish water reed swamps (habitats protected under LNatSchG). They offer habitats for a variety of specialised and endangered species. They also represent roosting and feeding areas for the migratory birds on their way between Scandinavia and the south. A variety of waterfowl winters at the coasts of Fehmarn (for information on birds see Section 3.23).

3.10. Landscape (Fehmarn)

The current visual quality of the landscape of Fehmarn is a result of the historical and economic development of the island. The natural scenery is characterised by a flat morphology with extended agricultural use, structured only by a few lines of trees and hedgerows. The area is marked by a number of settlements including the major settlements of Petersdorf, Landkirchen, Burg and Burgtiefe. At various locations of the island the landscape character is dominated by infrastructure facilities such as the B 207 Federal highway, the railway line and extended marshalling yard, the Puttgarden ferry harbour, dikes along the shoreline in the north and east, the impressive structure of the Fehmarnsund Bridge, the wind farms in the west and north of the island, as well as the high-rise building of the Burgtiefe.

Also the coastal landscape with the sea forms an important part of the natural scenery. Naturally developed areas occur in the northwest, like the coast landscape Grüner Brink and the Blankenwisch wetland, the Wallnau nature reserve with surrounding wetlands to the west and low cliffs of Staber Huk to the southeast. The coastal landscape is characterised by coastal erosion, deposition and formation of steep beaches (storm beaches), as well as by the emergence of lagoons with salt marshes and brackish water reed swamps.

3.11. Climate (Fehmarn)

Schleswig-Holstein is located in the transition zone between the European continental landmass and the North Atlantic, and the climate of the region can be categorised as a moderate oceanic climate (mostly westerly winds, cool summers, mild winters). The climate of Fehmarn is marked by the regional climate. It is mild due to its position in the Baltic Sea. The annual precipitation is amongst the lowest in Germany while the annual rate of sunshine is amongst the highest.

3.12. Air (Fehmarn)

Because of the predominant regional climate with frequent wind the air quality on Fehmarn is good. Nevertheless some air pollution in the project area is assumed due to the B 207 Federal highway, the diesel operated railway line and the ferry harbour in Puttgarden. The air quality may also be affected by long-distance transport of pollutants from industrial areas in the European mainland and as a consequence of the very busy ship traffic routes in the Fehmarnbelt.

3.13. Cultural Heritage (Fehmarn)

In the northwest of Fehmarn, there are no protected archaeological monuments (Monument Preservation Act, *Denkmalschutzgesetz* S-H §5) but an extended potential site of archaeological interest (*Verdachtsfläche*) is situated between Bannesdorf, Puttgarden and Marienleuchte. Beside this, only a few other known places of finds are listed in the archaeological register (*Archäologische Landesaufnahme*) of Archaeological Agency of Schleswig-Holstein.

3.14. Material Assets (Fehmarn)

Fehmarn as a whole is dominated by intensive farming. On the north and west coasts, dikes protect the hinterland.

The largest settlements of the northern part of Fehmarn are Puttgarden, Marienleuchte, Todendorf and Presen. Public institutions are concentrated in Puttgarden, and the capital of Fehmarn is Burg in the south of the island.

The federal highway B 207 and the parallel railway track run between the Fehmarnsund Bridge and the ferry facilities of Puttgarden. Other material assets to be recognised are the existing ferry facilities of Puttgarden, the harbours located on the southern Fehmarn, as well as the marshalling yard, dikes, wind farms, lighthouses, and finally the military facilities at Marienleuchte as well as interregional supply lines.

3.15. Soil Conditions (Lolland)

The main soil type on Lolland is profound layers of moraine clay (up to 90 m) from the last glacial period with smaller areas of moraine sand and gravel. The surface deposits are rich in chalk, and previously the soil was used for marl exploitation. Due to the layer of clayish soil rich in lime, the land is very fertile and valuable for agricultural purposes, although the texture necessitates comprehensive drainage.

A bentonite resource is located in the eastern part of the study area on Lolland. The resource has been investigated several times, but excavation from this area ceased because of the poor quality of the bentonite.

Also a number of sites near the Rødbyhavn harbour area may be contaminated due to spills from oil tanks and from vehicles in the ferry terminal and railway station areas. A disposal site for contaminated soil is situated east of Rødbyhavn.

3.16. Water (Lolland)

In the area of investigation on Lolland there is a number of small watercourses, ponds (old marlpits) and drainage ditches,. Most of the water bodies are protected according to the Danish Nature Protection Act (so-called §3-areas). The ditches are strongly regulated and characterised by slow-floating water and the quality objective of most of the watercourses are “moderate” (the lowest acceptable) and they have a low water quality. Most ponds are isolated on cultivated fields. The watercourses are often deep, as they serve to drain the surrounding fields. There are a number of bogs and moors.

The exploitation of groundwater resources on Lolland is concentrated in an east-west oriented corridor in the center of the island. However, there is no groundwater extraction in the vicinity of the project area or in the area of investigation, due to the risk of intrusion of salt water. The nearest public groundwater extraction facility is north of Holeby. Close to Rødbyhavn the seabed has been reclaimed. This area now lies below the surface of the sea and is kept dry by pumps. The groundwater table is therefore located relatively close to the surface (3-0.5 m.b.s.). The authorities have pointed out that the area is sensitive to nitrate contamination.

3.17. Fauna and Flora (Lolland)

The primary land use on Lolland is agriculture and the area of investigation consists mainly of cultivated fields. Hence, the most important plants and animals are concentrated along the coast, where sandy soils (former seabed) improve the conditions for plants of high botanical interest. This is the case in areas on and around the dikes where the soil is rarely used for agriculture.

Further from the coast in areas like the old Byhave Forest, the swamp Ringbølle Mose and the old partly abandoned railway yard important and rare insects and spiders have been registered, which are not found anywhere else in Denmark. Several species listed in Annex IV of the EU Habitats Directive and on the Danish red list are also known to occur in the area. Other features of importance are hedgerows, ponds originally created marl by marl extraction of and small sporadic forests.

3.18. Landscape (Lolland)

The island of Lolland is characterised by moraine landscapes with mainly clayish soils originating from the last glacial period, the Weichsel glaciation. Near Rødbyhavn, some of the land is reclaimed and appears flat with a dense pattern of straight drainage canals. While most of the terrain on Lolland does not exceed an altitude of 10 metres, the reclaimed land is below or close to sea level.

Even though the topography varies little, the scenery on Lolland is recognised for its patchwork landscape with wide expanses consisting of fields, farms, ditches, small villages and hedgerows. The many pits and ponds bear witness of a former marl exploration ─ the chalky moraine clay that was used to manure agricultural soil.

Along the southern coastline of Lolland, a 63 km long dike was built in the late 1870's to protect the low-lying land against flooding. Although it is a man-made structure, it has recreational, natural and cultural value.

3.19. Climate (Lolland)

Lolland has a typical coastal climate with mild weather in winter and cool weather during summer, often accompanied by clouds, rain or showers, mainly governed by the dominating westerly winds. However, the weather on Lolland is also influenced by the weather on the European continent. This means that in periods with easterly or southerly winds, the weather tends to be more hot and sunny during summer and colder during winter.

3.20. Air (Lolland)

As for Fehmarn the air quality in the project area on Lolland is rather good due to the predominant climate with frequent wind. However, some pollution is assumed to arise from local infrastructure components such as the E47 motorway, the railway line and the ferry harbour in Rødbyhavn as well as air pollution from more remote areas.

3.21. Cultural Heritage (Lolland)

There are numerous cultural heritage values in the area of investigation on Lolland. The values reflect man’s use of the area and his impact on the landscape from the oldest stone age settlements to modern times buildings and cultural environs.

The values comprise archaeological sites, protected monuments like burial mounts, protected earth and stone dikes, protected buildings and other buildings worth to preserve, cultural environs as well as churches and church environs.

Among the most significant cultural heritage values in the area are the protected Neolithic (New Stone Age) burial mount and passage grave “Bag-Hyrdehøj” located about 3 km east of Rødbyhavn and the Lolland Dike. This 63 km long and 4 metres high dike along the southern coast of Lolland was built after a serious flooding in 1873.

3.22. Material Assets (Lolland)

A wind farm is located close to the coast less than 2 km east of Rødbyhavn. About 2.5 km west of Rødbyhavn there is a natural gas pipeline. A high-voltage power line is located 0.5 km north of Rødby. East of Rødbyhavn there is a bentonite resource. However, as mentioned before it has not been exploited for several years.

The largest towns in the vicinity of the area of investigation are Rødby and Rødbyhavn; both with public institutions like schools, day care centres, municipality administration etc. as well as areas for trade/retail as well as industry, harbour and ferry harbours. Just east of Rødby-havn there is a Go-Kart track. In addition, the area is characterised by small villages and areas for dwelling and recreation.

The existing motorway and the railway connection to the north terminates at the ferry in Rødbyhavn and smaller roads cross the landscape. The Lolland-Falster Airport is located 3 km east of Rødby.

3.23. Bird Fauna (both sea and land)

The area around the Fehmarnbelt is an internationally significant resting ground for birds and an important migratory flyway. Many species of birds and their resting grounds are protected by the EU Birds Directive and international agreements, and numerous EU special protected areas (SPAs) are designated around the Fehmarnbelt. However, most of the central Fehmarn-belt – including the direct corridor between Rødbyhavn and Puttgarden – is not classified as SPA. However, these areas, including the SCI in the Fehmarnbelt are also used by several sea bird species. Both the bird populations in the Fehmarnbelt and bird migration over the Fehmarnbelt have been well described through recent and ongoing research and monitoring such as Natura 2000 monitoring (e.g. Durinck *et al.* 1994, Kahlert *et al.* 2005, Garthe *et al.* 2003, Koop 2004, Berndt *et al.* 2005, Skov *et al.* 1998) and the data available allows a good first assessment of the area’s significance for birds and provides a basis for the assessment programme.

Parts of the Fehmarnbelt and the bordering areas of water serve as wintering and resting grounds for birds, in particular for water birds and seabirds. The most common are various species of bivalve-eating seaducks such as the common eider (*Somateria mollissima*), the common scoter (*Melanitta nigra*), the long-tailed duck (*Clangula hyemalis*) and the tufted duck (*Aythya fuligula*).

Breeding water birds are considerably less significant in this area. There are nationally significant colonies of terns and gulls on Fehmarn, however, in protected areas such as Wallnau and Grüner Brink, as well as in the Rødsand Lagoon on Lolland (Figures 3.1 and 3.4).

With regard to food consumption, the bivalve-eating water birds are the most important in the ecosystem. According to the standard data sheets for the EU SPA's around the Fehmarnbelt, there are as many as 400,000 birds, which belong to bivalve-eating species. Fish-eating species such as the red-breasted merganser (*Mergus serrator*), the great crested grebe (*Podiceps cristatus*) and the red-necked grebe (*Podiceps grisegena*) mostly occur close to the coast, however the SCI "Fehmarnbelt" in the central part of Fehmarnbelt is also an important area for the red-necked grebe and divers.

The areas around the planned ramp and approach facilities on Lolland and Fehmarn are characterised by cultivated land, populated areas, roads and wind farms, which is reflected in the biocoenosis of non-breeding and breeding birds. The agricultural areas are used as resting and feeding grounds by water birds and waders. Up until now, neither the population of breeding birds nor that of non-breeding in these areas birds has been classified as particularly significant in terms of conservation.

There are no general trends known for non-breeding and migratory birds, which are specific to the Fehmarnbelt area. The number of different species is subject to annual variation, which may be related to general trends in populations or to changes in environmental conditions in the area, especially local weather conditions during winter. Comprehensive historical data shows that environmental conditions in the Fehmarnbelt have been affected by eutrophication in the last 50-60 years.

Migratory birds as well as resident birds use the coastal areas as feeding grounds. The relatively large area with shallow waters provides a rich food supply for carnivorous birds, as well as herbivorous and fish-eating water birds (piscivores). Benthic seaweed meadows and mussel beds, the most important marine habitats for birds, are common and wide spread over larger areas in the belt sea. According to current research, however, the most important food sources are not located close to the alignment corridor. The alignment corridor has generally relatively deep waters and only few shallow areas, which can be very important for resting non-breeding birds.

Certain water birds migrate over large distances and the numerous migratory birds pass through the Fehmarnbelt on their way between the North Sea (mainly the Wadden Sea) and the Baltic Sea and between the eastern and western Baltic Sea. This applies to species such as the brent goose (*Branta bernicla*), the barnacle goose (*Branta leucopsis*), the common eider (*Somateria mollissima*), the common scoter (*Melanitta nigra*), the red-throated diver (*Gavia stellata*) and the arctic diver (*Gavia arctica*). The main migratory direction of these migratory birds is along the east-west axis of the Fehmarnbelt, i.e. across the planned fixed link alignment.

Furthermore, the region around the Fehmarnbelt is very important for a large number of long-distance migratory land birds, which migrate to and from breeding grounds in Fenno-Scandinavia and Russia. Visual and radar observations have demonstrated that diurnal migrants may be concentrated in the Fehmarnbelt as they take advantage of the short distance over the sea there. In particular certain birds of prey such as the honey buzzard (*Pernis apivorus*), the common buzzard (*Buteo buteo*) and the sparrow hawk (*Accipter nisus*), but also the common wood pigeon (*Columba palambus*), finches and larks are concentrated here on their migratory path. In contrast, the night migratory routes are more spread out and much less influenced by land structures such as coastlines. The planned Fehmarnbelt Fixed Link would run parallel to the main land bird migratory route.

Even migratory movements over small distances are significant for water birds. Especially tufted ducks move from inland lakes, where they stay and sleep during the day, to feeding grounds in Fehmarnbelt and around Fehmarn, which they seek out at night. The back and forth movements of non-breeding birds between feeding grounds to the east and west of the Fehmarnbelt are important for various species and are also mentioned with regard to this area in the conservation objectives of the EU SPAs. There is also probably some degree of movement between breeding birds on Lolland and Fehmarn.

3.24. NATURA 2000

Several Natura 2000 sites are designated in the region around and in the project area. These comprise Sites of Community Interest (SCIs) protected under the EU Habitats Directive as well as Special Protected Areas (SPAs) protected under the EU Birds Directive. The extent of these areas is shown in Figures 8.1 and 8.2. Information about the individual Natura 2000 sites including the conservation objectives are presented in Appendix A.

A list of the Natura 2000 sites considered relevant to the Natura 2000 impacts assessment of the project is presented in Chapter 8. This chapter also includes a summary of the potential impacts on the sites and the methodological approach of the Natura 2000 impact assessments.

4. Environmental Pressures

The technical description of the project constitutes an essential background information for the investigation of the environmental pressures.In the present context the term environmental pressures covers the specific factors of the project, which may give rise to environmental impacts.

The following sections identify these pressures and their potential consequences, which will be investigated qualitatively and quantitatively. The pressures include factors related both construction activities and the completed fixed link. The main types of pressures are summarised below along with the main types of potential effects.

4.1. Environmental pressures during construction, from physical structures and during operation

The following environmental pressures are relevant for the investigation. They are divided into pressures during construction, pressures caused by the permanent physical structures and pressures due to the operation of the fixed link:

Main pressures during construction (temporary) and the potential effects:

- Restricted working areas, equipment, facilities and physical structures of the fixed link structures, which will take up land and sea areas and may:
    - cause visual impacts on human beings and the landscape
    - cause barrier effects for human beings and fauna
    - influence the hydrodynamic regime, which in turn may cause effects on water and fauna and flora
    - cause increased risk of environmental accidents due to ship collisions
- Construction activities, which emit noise, vibrations, visual disruption and light, which may cause nuisance to human beings or fauna
- Dredging, excavation and disposal activities, which directly affect the soil and the seabed sediments and destroy flora, fauna and habitats
- Spill and spreading of marine sediments from dredging, which affect the water quality, and potentially sediment, fauna and flora
- Emissions of CO_2, nutrients and contaminants to air, water and soil, which may also affect human beings, flora, fauna and climate.

Potential effects on the environment induced by the presence of the (permanent) physical structures and associated facilities of the fixed link:

- Loss of land/sea areas (which then cannot be used for other purposes)
- Loss and deterioration of fauna and flora habitats

- Visual effects on human beings and landscape
- Barrier effects on humans and fauna
- Change in water currents at the sea potentially affecting water quality and water exchange in the Baltic Sea, which in turn may affect the ecosystems
- Potentially increased migration of (new) animal species between the two countries
- Increased risk of environmental accidents due to ship collisions
- Threat of birds and bats due to higher collision risk.

Environmental pressures related to the operation of the fixed link:

- Emission of noise, vibration, visual disruption and light, which may cause nuisance to human beings and fauna
- Emission of CO^2 and pollutants to the air potentially affecting human beings, fauna and flora, soil, air and climate
- Traffic related collision risk of birds, bats and terrestric fauna
- Potential risks and effects due to electric and magnetic fields by the operation of electrified railway sections.

4.2. Assessment of Pressures

4.2.1. Sediment spill

The construction works in Fehmarnbelt will involve dredging, transport, deposit and backfilling activities. During these activities some seabed material will unavoidably be lost to the surrounding water and be transported away from the construction site. This sediment spill will act as an increase of the natural sediment transport and sedimentation processes. A reduced light penetration due to sediment particles in the water and increased sedimentation may cause effects on fauna and flora in the surrounding areas due to shading and smothering.

The amount of sediment spilled to the environment during a dredging operation depends on several factors of which the most important are:

- The characteristics of the dredged material
- Dredging equipment, methods and the transport and deposit methods applied
- The conditions of the water column (current, waves, water depth).

In order to assess the spill during the Fehmarnbelt project, experience from the fixed links in Øresund and the Great Belt will be exploited. Sediment spill is normally calculated as per-centage of the handled materials. The projects above have produced a comprehensive knowledge on the spill percentages resulting from different methods and different conditions.

This experience combined with scenarios of all dredging and reclamation works will be developed into spill scenarios, which describe the expected quantity and distribution of sediment spill in time and space.

The actual sediment loading in the surrounding areas will depend on the way the spill is spread by the water movements such as waves, mixing and currents. This will be analysed by combining the spill scenarios with advanced modelling of typical hydrodynamic regimes of the relevant area. These analyses are discussed further in Chapter 7.

4.2.2. Noise and vibration (land areas)

The assessment of the noise and vibration pressure covers construction activities and noise from rail, road and ferry traffic in the operation phase.

The assessment of the noise effects is accomplished by modelling the sound propagation in the close proximity of the sources. The assessment of the operation phase will be based on a comparison of the predicted noise emission in different technical solutions with the noise in the zero scenario (the no build option). The comparison regarding noise is expected to be based on the situation in 2025.

For both Fehmarn and Lolland, the noise situation on land will be illustrated by noise maps for the relevant indicators and sources. The changes compared to the zero scenario will be shown. Additionally, the situation at some representative emission points and exposed buildings in the vicinity of the Link will be discussed in relation to human beings. The noise maps will also provide input to the assessment of the effects on animals.

The assessment of the vibration during construction and operation will follow the procedures mentioned below.

At some points the approach for assessing the noise and vibration impact is different in Germany and Denmark. The assessments will be carried out in accordance with the legislation of the country in question.

Within the scope of German legislation, the assessment of traffic noise follows the DIN, the Traffic Noise Control Ordinance (16. BImSchV) will be adhered to. Road and railway noise will be calculated by applying the German guidelines RLS-90 (road noise) and SCHALL 03 (railway noise). For the assessment of the total noise situation the navigation and the ferry roll on/roll off processing will be included according to the German guideline “TA Lärm” (technical guideline on noise protection). Furthermore preloads by other commercial and industrial uses are comprised within the assessment following the “TA Lärm” (commercial areas, wind energy plants among others).

The assessment of the construction work’s noise immissions is considered at the immission locations which are affected the most following the “Allgemeine Verwaltungsvorschrift zum Schutz gegen Baulärm – Geräuschimmissionen – (AVV Baulärm)”.

The assessment of vibration in Germany will consider the guidelines “Vibration during construction” (DIN 4150 Erschütterungen im Bauwesen).

In Denmark, the assessments will follow guidance documents from the Danish Environmental Protection Agency. These are “Noise from roads” (Vejledning fra Miljøstyrelsen Nr. 4 2007), ”Noise and vibrations from rail roads” (Tillæg til vejledning nr. 1 1997, Miljøstyrelsen, juli 2007), ”External noise from companies” (Vejledning fra Miljøstyrelsen Nr. 5 1984), ”Vibrations from railroads” (Miljøstyrelsens referencelaboratorium orientering nr. 10 1989) and “Low frequency noise, infrasound and vibrations in the external environment” (Vejledning fra Miljøstyrelsen Nr. 9 1997).

4.2.3. Noise (marine areas)

The present ambient underwater noise in the sea will be measured by autonomous recording systems deployed at different sites in the Fehmarnbelt area for periods of three to four weeks at different times of the year in order to investigate the present temporal and spatial variation of ambient noise in the project area. Using weather data and ship data from AIS systems[2], a GIS-based model shall be applied that relates ambient noise to other variables such as wind speed and wave height.

Due to the complex structure and shallow waters of the Fehmarnbelt (<30 m), the acoustic environment cannot be sufficiently described from a few single measurements and conventional sound propagation models. Therefore, sound propagation will be measured at several different locations according to water depth, distance from the ferry route and main navigational corridors. Sound propagation models will be developed based on these measurements. This is particularly important for the shallow areas with less than 10-15 m depth where sound propagation is generally difficult to predict.

As all acoustic emissions from construction and operation of the fixed link will have to be assessed against background noise level from all sources, the measured and modelled data of the present noise levels form the essential baseline for further impact assessments. The model will be used to predict the impacts of noise emission related to the project.

Information from literature (earlier investigations) on relevant underwater noise sources supplemented with new measurements will be used to predict noise exposure in the Fehmarnbelt from the construction activities. These sources include different dredging techniques, sheet piling, ship operations etc. Based on these data, the underwater noise regime in the Fehmarnbelt area during construction will be modelled using various transmission loss formulas.

[2] System, which continuously register the positions of ships

Measurements of the underwater noise at the Great Belt Fixed Link (at both the bridge and the tunnel) will provide information for the assessment of the underwater noise emission in the operation phase.

The assessment of underwater noise emissions will provide input to the impact assessment of marine mammals and fish.

4.2.4. Light

The construction activities will involve some light emission. However, as the emission of light in the operation phase is considered more important, the assessments in relation to light will focus on this phase. In the operation phase, light emission will possibly arise from the lighting of the fixed link and associated structures – and from the lighting of the traffic on the link. In order to assess the emission from the link and facilities, scenarios of the lighting will be developed. The emission from the traffic will be based on the traffic prognoses combined with experience on light emission. In order to establish light emission scenarios of the the individual light sources the geographical position, angles, shading structures will be considered. Finally, the future light intensity in the surrounding environment will be modelled and compared against the existing light emission background from settlements, roads, railways, ferry harbour, windfarms and other man-made structures.

For the German area, the "Light Emissions Guideline" (“Licht-Richtlinie LAI“ Länderausschuss für Immissionsschutz, 2000) will be used for estimating the possible impacts. If possible, and considered relevant, it will also be used on the Danish side.

The assessment of light emissions will provide input assessment of impacts on mainly human beings (including recreation/tourism) and the fauna (birds, bats, insects, marine mammals, fish).

4.2.5. Air pollution

The potential pressures with regard to air quality relate to the emissions of pollutants from a number of sources in both the construction and the operation phases. Emission sources during construction include:

- Construction equipment
- Transport of materials (road and railway traffic and shipping)
- Site supervision and monitoring by ships and planes.

Emission sources in the operation phase include:

- Traffic on the fixed link.

The most relevant air pollutants include nitrogen oxides (NOx), benzene (C_6H_6), particulate matter (PM_{10} and $PM_{2,5}$) derived from traffic emissions and sulphur dioxide (SO_2) mainly due to ship traffic.

The assessment of air pollution will be based on the emission values of current guidelines and regulations i.e. EU Directives, as adopted in the German "BImSchV" ordinance and "TA Luft" guideline. The European directives have not yet been implemented in the Danish national legislation. If necessary, other precautionary levels for example from the German "Länderausschuss für Immissionsschutz" (LAI) and the Danish "Air Guidance" (Vejledning fra Miljøstyrelsen nr. 2, 2001). All main sources locally in the project area and the large-scale background pollution will be considered.

Within the scope of the EIA study, it is planned to use the dispersion model AUSTAL2000 (Umweltbundesamt) in order to get additional information concerning the short distance pollution. The calculations will be based on annual time series for each source with a resolution of 1 hour. If necessary, the impact of buildings may be considered by calculating the small-scale wind fields using TALdia (Umweltbundesamt) or MISKAM[3] (Dr. J. Eichhorn). If relevant impacts are expected close to the construction site, some separate investigations may be performed. For the operation phase, the dispersion model will also be used to calculate nitrogen deposition impacts on Natura 2000 sites.

The impact on the environment by higher nitrogen emission caused by the project will be assessed for sensitive areas. This is done through calculation of the existing and possible additional emissions in comparison to critical loads. The determination of the emission factors of the exhaust gases from road vehicles in Germany will be based on the "Handbook on Emission Factors for Road transport" (HBEFA, German Federal Environment Agency (Umweltbundesamt UBA) 2004). The emission of particulate matter by abrasion and swirling due to the operation of motor vehicles is investigated on the basis of current emission factors (Düring, 2004). For the calculations of the emission in Denmark other emission models like COPERT[4] or TEMA[5] may be applied.

The emission of particulate matter from dust re-suspension from road traffic will be estimated based on traffic prognosis.

The emissions from the construction work, especially dust (particulate matter), can be

[3] TALdia = diagnostischen Windfeldmodell (Diagnostic wind field model included in AUSTAL2000). MISKAM = Mikroskaliges Klima- und Ausbreitungsmodell, (3-dimensional non-hydrostatic climate -, flow - and dispersion model developed by Dr. J. Eichhorn, University of Mainz)

[4] COPERT = Computer Programm to calculate Emissions from Road Transport (European Environment Agency, EEA)

[5] TEMA = Transporters Emissioner under Alternative forudsætninger (COWI/Transportministeriet)

stimated using available data from US EPA (U.S. Environmental Protection Agency), German guidelines (VDI-guideline 3790), CORINAIR[6] or other specialist tools or literature.

In relation to global climate change the emission of greenhouse gas (GHG) can potentially constitute an environmental pressure. GHG emissions are closely connected to the energy/fuel consumption in all the different phases of the project.

The main sources of GHG emissions are expected to be:

- Production of the main construction materials
- Transport of the main construction materials and soil
- Operation of machinery and other technical equipment onshore and off-shore
- Emission from the traffic on the fixed link
- Emission from the ferry traffic.

The estimation of the emission of GHG will be based on the principles of ISO 14040:2006 - Environmental management - Life cycle assessment. The purpose is to:

- Predict the GHG emissions related to the production and construction of the fixed link
- Predict the future GHG emissions in different project scenarios (solution models) and the zero scenario i.e. the situation if the fixed link is not constructed
- Pinpoint the main sources of GHG emission
- Assess the potential possibilities for prevention and mitigation as part of the project.

The emission of CO_2 from ferry and road traffic in the operation phase will be based on a new report on the topic.

GHG emission factors for the most important construction materials will be based on values found in literature or by contacting material suppliers directly.

GHG emission factors for road and ship transport will be based on previously mentioned tools and guidelines such as TEMA, COPERT, CORINAIR and HBEFA.

Emission factors for heat and electricity consumption will be based on the specific key factors of the two countries.

[6] CORINAIR = CORe INventory AIR emissions. Developed by the European Environment Agency (EEA) and its European Topic Centre on Air and Climate Change (ETC-ACC)

5. Mitigation and compensation measures

During all stages of the EIA study, teams of environmental experts and construction engineers will work closely together to identify solutions to prevent significant environmental impacts or, if this is not possible, to mitigate these. Where mitigation measures are not possible and significant impacts actually occur ecological compensation measures will be established.

The most important measures to avoid or minimise significant impacts are seen in an environmentally motivated optimisation of the fixed link route, design and the construction methods as well as all legally required measures (e.g. noise abatement).

Optimisation of the fixed link design and construction methods

Design optimisation can be accomplished by streamlining underwater constructions in order to reduce hydrodynamic effects. In case of a bridge solution, the risk of bird collisions can probably be reduced by choosing the right lighting regime for the offshore structures. The design of the bridge may also be optimised in order to reduce possible barrier effects on migrating birds.

The fixed link will constitute functional barrier in residential and surrounding areas in the approach and ramp areas. This effect can be reduced by adjustment of the alignment and its height above the ground. Fauna passages can help maintaining the ecological connectivity of the area. Finally, an appropriate aesthetic design of the fixed link structures is sought in order to substantially reduce the visual impacts. This also goes for the tunnel portals.

In the construction phase of the fixed link it is important to minimise the sediment spill during dredging operations. The purpose is to avoid a reduction of the water transparency to the extent possible and in this way reduce the effects on the marine fauna and flora and the bathing water quality. This can be done by optimising dredging procedures in terms of dredging equipment, timing and duration. Timing in relation to biologically sensitive periods and the bathing season can be efficient means of mitigation.

Noise abatement will be relevant during both the construction and the operation phases. During construction the underwater noise emissions can be reduced through the choice of construction methods. This may be essential in relation to marine mammals. Noise abatement may also include the establishment of noise screens on land.

The risk of environmental accidents due to potential ship collisions with a possible bridge can be reduced by efficient vessel traffic control systems. Furthermore, the establishment of protection structures at bridge piers and pylons is a possible measure to avoid or mitigate possible adverse effects in case of collisions.

6. General Approach of the EIA

This chapter outlines the methodical approach of the environmental impact assessment (EIA) (cf. Figur 6.1 and 6.2). Especially the different steps of examination and assessment of alternatives are being explained. A detailed description of the proposed baseline investigations as well as the environmental issues to be addressed and the planned impact assessments is given in Chapter 7.

As described in Chapter 2, the exact route of the fixed link has not yet been determined. In Denmark and Germany the selection of the main route alternative will be based on the results from the ongoing environmental investigations and this will be reported in detail in the Environmental Impact Statement (EIS) and other plan approval documents. All relevant environmental issues will be dealt with in accordance with Danish and German legislation and guidelines.

As the first step a spatial sensitivity analysis will be carried out to identify “relatively low impact corridors” for possible routes within a study area extending to the east and west of Puttgarden. The entire potential on- and offshore project area of the fixed link will be examined (see Figure 2.7). On land, the area extends both west and east of the ferry ports of Puttgarden and Rødbyhavn[7]. The spatial sensitivity analysis (*Raumempfindlichkeitsanalyse*) will analyse the importance and sensitivity of the environmental factors in relation to the project largely based on information already available.

Within the determined corridors with the least possible conflict, the technical planners develop the various general alignment alternatives for bridge and tunnel solutions. Alternatives include alignments with landing sites west of Puttgarden and Rødbyhavn (west-west), landing sites east of Puttgarden and Rødbyhavn (east-east) as well as alignments diagonally from east to west etc. These route alternatives are then assessed and optimised with respect to environmental concerns, but also with regard to aspects of traffic, navigation safety, economy as well as other factors. A comparison of the alignment alternatives with respect to environmental impacts on the environmental factors and components will form the basis for a prioritisation of the alternatives, and lead to a selection of the alignment alternative with the least environmental impact for both the tunnel and the bridge solution.

[7] On Danish territory, an alignment corridor has already been selected through the Regional Planning process (Storstrøms Amt, 2006). As a result, an area east of Rødbyhavn has been reserved for the approach and toll facilities (Figure 2.7) Nevertheless, possible alignment alternatives both inside and outside this area will be described in the EIA

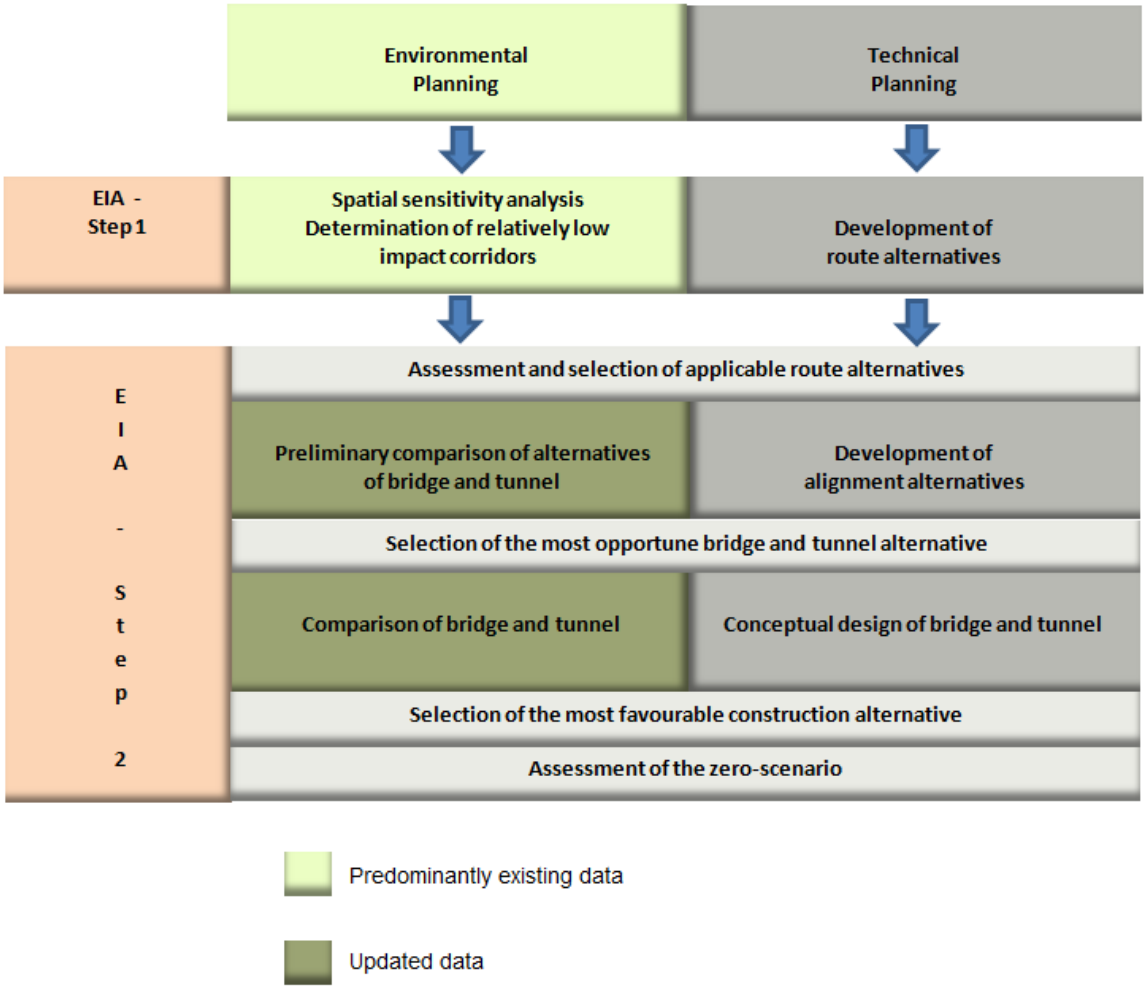


Figure 6.1 Procedure of the EIA in interaction with technical planning.

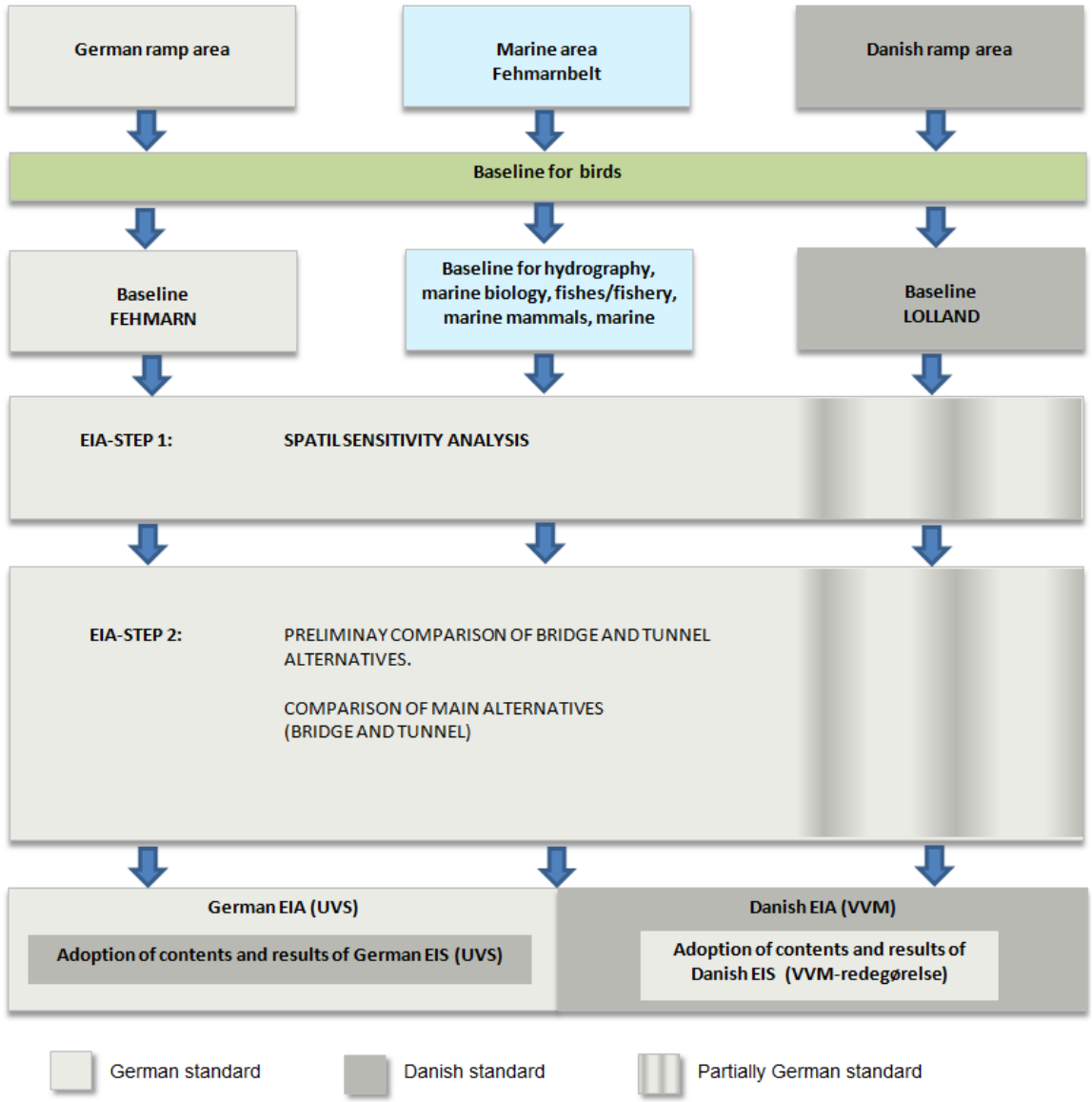


Figure 6.2 Overview of the structure of Danish and German environmental studies.

6.1. Legislative standards

The following legislative standards and official guidelines form the basis for the methodology outlined below:

- Vejledning om VVM i planloven (Guidelines for EIA according to the Danish Planning Act [Ministry of the Environment, guideline no. 9339 dated 12/03/2009])
- Vejledning om inddæmning og opfyldning på søterritoriet (Guideline on offshore reclamation and deposition [Ministry of Transport, guideline no. 6 dated 23/01/2002])

- Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency), 2007: Standard-Untersuchungen der Auswirkungen von Offshore-Windenergieanlagen auf die Meeresumwelt (Standard Investigations of the Impact of Offshore Wind Energy Plants on the Marine Environment; StUK 3)
- Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency), 2003: Instruction Sheet on the Composition and Structure of an EIS (Basic Investigation) for Building an Offshore Wind Farm in the EEZ
- Leitfaden zur Umweltverträglichkeitsprüfung an Bundeswasserstraßen (Guidelines for the Environmental Impact Assessments in Federal Waterways) (ed. Bundesministerium für Verkehr, Bau und Stadtentwicklung [Federal Ministry of Transport, Building and Urban Affairs], June 2007)
- Merkblatt zur Umweltverträglichkeitsstudie in der Straßenplanung MUVS, 2001 (Guidance on the Environmental Impact Assessment in Road Planning) (Forschungsgesellschaft für Straßen- und Verkehrswesen [Research Society for Road and Transport Matters], 2001)
- Richtlinien für die Erstellung von Umweltverträglichkeitsstudien im Straßenbau (RUVS 2008) (Guidelines for the Preparation of Environmental Impact Assessments in Road Construction) (Bundesministerium für Verkehr, Bau und Stadtentwicklung [BMVBS] [Federal Ministry of Transport, Building and Urban Affairs], 2008 draft)
- Entwicklung von Methoden zur Umsetzung der Anforderungen aus dem UVPG und dem BNatSchG auf der Ebene der Linienfindung (Richtlinien UVS) sowie Entwicklung von Darstellungsformen für Umweltverträglichkeitsstudien (Musterkarten UVS) (Development of Methods of Implementing the Requirements from the EIA Act and the Federal Nature Conservation Act on the Level of Route Finding [EIA Guidelines] as well as Development of Ways of Visual Representation for Environmental Impact Assessments [EIA Sample Maps]) (Gutachten F+E Projekt Nr. 02.0236/2003/LR im Auftrag des Bundesministeriums für Verkehr, Bau und Stadtentwicklung, Stand 2008, dient als Grundlage der RUVS 2008 [expert opinion on R&D project no. 02.0236/2003/LR, commissioned by the Federal Ministry of Transport, Building and Urban Affairs, last revised 2008; serves as the basis for RUVS 2008])
- Umwelt-Leitfaden zur eisenbahnrechtlichen Planfeststellung und Plangenehmigung sowie für Magnetschwebebahnen, Teil III Umweltverträglichkeitsprüfung, naturschutzrechtliche Eingriffsregelung (Environmental Guidelines for the Assessment and Approval of Railway Plans as well as for Maglev Trains According to Railway Laws, Part III: Environmental Impact Assessment, Nature Conservancy Regulations on Intervention) (Eisenbahnbundesamt, Stand Juni 2005 [Federal Railway Authority, last revised June 2005])
- Orientierungsrahmen zur Bestandserfassung, -bewertung und –ermittlung der Kompensationsmaßnahmen im Rahmen landschaftspflegerischer Begleitplanung für Straßenbauvorhaben (General Guidelines for Population Assessment and Evaluation

– and Determination of Compensation Measures in Landscape Conservation Planning in Connection with Road construction Projects) ([Kompensationsermittlung Straßenbau Schleswig-Holstein, 2004]).

The formal legal documents relevant to the EIA process and the investigatiions are listed in Chapter 10 under “Laws, orders etc.”

6.2. Environmental investigations

The substance and extent of the proposed investigations fulfil Danish and German legal requirements and standards. International norms and standards for environmental investigations like HELCOM recommendations are also taken into consideration. If relevant, The “Baltic Sea Pressure Index” (list of environmental pressures) will be included in the investigations, if HELCOM has finished the development of this before the EIA is concluded.

Furthermore the extent of the offshore baseline investigations is oriented towards the German Standard Investigations of the Impact of Offshore Wind Energy Plants on the Marine Environment (StUK 3, BFH, 2007). In order to account for the specific conditions for the Fehmarnbelt Fixed Link project some adaptations of this standardised investigation concept are required, though the concept will in general be complied with. As a basic principle of the overall investigation concept, two full seasonal cycles for the investigation of the marine environment and birds are planned. Some of these investigations were already initiated during winter and spring 2008/2009, and are continued through 2010. In the two onshore investigation areas mainly one-year baseline investigations are conducted during 2009 or 2010.

The following environmental factors are analysed in detail with respect to those potential environmental impacts which are relevant for the EIA of the Fehmarnbelt Fixed Link:

- Human beings, incl. human health, flora, fauna and biological diversity
- Soil, water, air, climate and landscape
- Cultural heritage and other material assets
- Pertinent interactions among the afore-mentioned environmental factors.

Analysis of the baseline status (present condition, population, geographical extension) for the single environmental factors including the legal protection status and possible preloads, will be based on an evaluation of the existing data, literature as well as the investigations and inventories described in Chapter 7. Analysis and evaluation of the baseline status for the single factors will include the entire project investigation area (cf. Chapter 2.4 and 7).

The baseline evaluation is conducted by applying criteria which are derived from EU Directives, the national legislation and administrative orders as well as the political goals and

the objectives of planning regulations. These criteria serve to describe the environmental factor related importance of every site-specific component and its sensitivity to the project.

The importance of the environmental factors and their components (e.g. species, populations, habitats for the environmental factor flora and fauna) will be assessed on the basis of existing and new baseline data. The importance is a measure of the functional value for the natural environment and for the landscape. Concerning the environmental factor “human beings” though, especially the value in relation to health, dwelling and outdoor recreation are considered. The importance of the different components an environmental factor are used to evaluate the impacts of the project, for instance in terms of loss of land (cf. Section 6.4.2 under “Forecast method 1”).

The assessment of the sensitivity of environmental factors and their components is carried out on the basis of the baseline data combined with findings on the sensitivity and vulnerability of an environmental factor or component to specific project pressures. Thus, the sensitivity has to be assessed in relation to the environmental pressures from the project (e.g. the sensitivity of the soil towards (1) compaction during construction or (2) towards pollutants during construction and operation). Each specifically determined sensitivity is being consulted for assessing possible functional impairment of environmental factors and their components due to the pressures imposed from the project (cf. Section 6.4.2.under “Forecast method 2”).

For each assessment criterion (sensitivity and importance) and each relevant combination of environmental components and project pressures a number of levels on a value scale are defined. These levels are guided on the one hand by the available data and on the other by the applicable legal standards, models and other aspects based on professional considerations.

A scale with ranked levels (ordinal scale) is applied. Based on the complexity of most environmental factors or components a scale consisting of four levels is generally applied. The levels are: Minor, medium, high and very high importance or sensitivity (Table 6.1). When the environmental component is less complex, the scale may be reduced to two levels termed “general” and “special” importance or sensitivity.

Table 6.1 Two- and four-level scale of importance/sensitivity of the environmental factors

Two-level scale	Four-level scale
special importance/sensitivity general importance/sensitivity	very high importance/sensitivity high importance/sensitivity medium importance/sensitivity low importance/sensitivity

The assessment and recording of importance and sensitivity are guided by the German “General Guidelines for Population Assessment and Evaluation – and Determination of Compensation Measures in Landscape Conservation Planning in Connection with Road Construction Projects” (Orientierungsrahmen zur Bestandserfassung, -bewertung und

Ermittlung der Kompensationsmaßnahmen im Rahmen landschaftspflegerischer Begleitplanungen für Straßenbauvorhaben (Kompensationsermittlung Straßenbau Schleswig-Holstein, 2004“).

This method ensures a transparent and logical balancing of the different project solutions and alignments, and it has the following additional advantages:

- In the EIA and the German subsequent Landscape Conservation Plan the compatibility of the recordings and assessments of the environmental factors are safeguarded as well as a good traceability of the different work steps on both planning levels
- The “Orientierungsrahmen (General Guidelines)” are largely compatible with the requirements of EIA and the Landscape Conservation Plan in railway construction in Germany
- The assessment of the individual environmental factors is performed in accordance with German guidelines and the approach is also known from offshore projects in Denmark.

6.3. Spatial resistance analysis and determination of relatively low-conflict corridors (EIA step 1)

In accordance with the principles of environmental precaution and environmental optimisation, the first step in the EIA process is an analysis of the environmental sensitivity towards the pressures imposed by the project. The objective of the spatial resistance analysis is to identify, at an early planning stage, the route corridors with the least environmental impacts from the fixed link across Fehmarnbelt. Furthermore, the analysis shall delimit investigation corridors for the more detailed alignment planning. The individual steps are described in the following sections.

Baseline data

Primarily existing data is being consulted as baseline data for the description and assessment of the environmental factors within the spatial resistance analysis as well for the determination of relatively low conflict corridors.

6.3.1. Identification of the spatial resistance (areas with differing conflict potential)

The spatial resistance is determined in the area of investigation, in which feasible and convenient solutions (route alternatives) for achieving the project target can be found (cf. Figure 2.7).

The area of investigation is divided into areas of different environmental resistance, meaning different levels (or densities) of conflicts between the project and environmental interests. This is based on the identification, description and expert assessment of the environmental factors as well as taking into account the legal protection status or binding planning commitments of

areas and properties. This is achieved by assigning the baseline status to the three so-called "**spatial resistance classes**" (BMVBS 2008).

Table 6.2 Definition of the spatial resistance classes

Spatial Resistance Class (RWS)	Definition	Colour on the map
RWS I	Conditions where considerable environmental impact is to be expected due to the project-related impairment and which may be an obstacle to approval (generally based on legally binding protection standards, particularly important species, such as migrating birds and harbour porpoises).	Red
RWS II	Conditions where considerable environmental impact is to be expected due to the project-related impairment and which is significant for the assessment (based on a legally binding / sublegal protection standard and expert assessment of environmental impact).	Orange
RWS III	Conditions where environmental impact of various degrees of significance is to be expected due to the project-related impairment and with limited relevance for the decision (generally based on legally binding protection standard).	Yellow
No class or no assignment to class	Conditions where insignificant or minor environmental impact is to be expected on account of the project-related impairment. Or: Conditions about which no sufficiently specific statements can be made at the present project stage and for which assignment to a spatial resistance class is not possible.	White

In the first step, spatial resistance classes are determined and shown separately for each environmental factor. Based on this a spatial resistance pattern can be presented for every environmental factor. The overall spatial resistance is derived from the non-weighted overlay of the single of spatial resistances of the individual environmental factors. Within this overlay, the deciding value is the highest environmental factor specific spatial resistance class to be found within an area.

6.3.2. Demarcating relatively low-conflict corridors

On the basis of the areal classification of the spatial resistance, relatively low conflict corridors can be demarcated. Corridors are of relatively low conflict when they are mainly found in the (yellow) spatial resistance class III.

The identified relatively low-conflict corridors constitute the areas in which the more detailed route planning should be performed. The corridors are ranked according to their environmental impact. Generally the assessment of the potential impairments in the individual corridors is based on the high and medium conflict potential ("red" and "orange"), because these areas are the focal points of conflict, whereas the low or negligible conflict potentials ("yellow") are less important for the decision in this context. The result is an assessment of the conflict potential

of all investigated corridors.

6.4. Comparison of alternatives (EIA step 2)

6.4.1. Impacts to be assessed and assessment methodology

Following the descriptions in Chapter 4, impacts due to the construction, presence of link structures and operation of the fixed link on the environmental factors are identified, described and assessed. Pursuant to national and international requirements and the current EIA-practice direct, indirect and cumulative impacts are considered in the impact assessment. Adverse (negative) as well as beneficial (positive) effects on the environmental factors are considered.

The potential environmental impacts due to potential accidents will be addressed as a special case of the impacts related to the operation of the link. This assessment will focus on ship collisions with bridge piers, for which specific accident scenarios are examined. Finally, the environmental impacts due to decommissioning of the fixed link following the end of its operation are examined.

6.4.2. Impact forecast

The general approach to the impact forecast includes two essential steps:

- The assessment of the impacts according to character, magnitude and duration, and
- The assessment of the severity (importance) of the impacts.

The resulting impact forecast is based on the importance and sensitivity of the environmental factors combined with the identified and as far as possible quantified pressures arising from project (i.e. in terms of for instance areal demands, sediment spreading, noise etc.).

Baseline data

For the procedure of impact forecasting (especially for the comparison of main alternatives) updated baseline data is used, which relies on an evaluation of existing documents as well as the results of the targeted investigations of the individual environmental factors as described in Chapter 7.

Potential impacts

The potential impacts expected to be included in the environmental impact assessment is listed below for each environmental factor.

Environmental factor human beings – subfactor habitation

- Loss of dwelling houses
- Loss and fragmentation of further areas of importance for habitation (areas around dwellings)
- Deterioration of areas of importance for habitation (dwellings and surrounding areas) due to noise exposure
- Visual and other perceptual deterioration of areas of importance for habitation (dwellings and surrounding areas) including emission of pollutants, light and vibrations
- Barrier effects in areas of importance for habitation.

Environmental factor human beings – subfactor recreation

- Loss and fragmentation of recreational areas at the coast
- Loss and fragmentation of further areas of recreational importance (On Fehmarn: Other areas of special recreational importance according to the Landscape Framework Plan)
- Deterioration of areas of recreational importance due to noise exposure (coastal and other areas of special recreational importance)
- Visual and other perceptual deterioration of areas of recreational importance (coastal and other areas of special recreational importance)
- Fragmentation of paths of recreational importance
- Barrier effects areas of recreational importance
- Deterioration of marine recreational areas.

Environmental factor flora, fauna, biodiversity (terrestrial)

- Loss of habitat types including legally protected habitats
- Loss and fragmentation of natural areas of importance to flora, fauna including the biological diversity
- Deterioration of areas within Natura 2000 sites (input from Natura 2000 impact assessments)
- Deterioration of areas of importance to flora, fauna due to the input of pollutants (such as nitrogen deposition)
- Loss and deterioration of habitats of particular groups of terrestrial species groups (e.g. red list species and strictly protected species) including impairments due to the noise and light emission and disturbance and barrier effects
- Threats to animal species due to road deaths

- Deterioration of fauna and flora habitats due to change in local hydrological conditions
- Introduction and promotion of invasive species abundance in favour of native species due to changes in the ecological conditions.

Environmental factor flora fauna and biodiversity (marine)

Marine plankton

- Effects on phyto- and zooplankton due to changes in the light conditions and nutrient concentration due to sediment spill during dredging
- Risk of burial of copepod resting eggs due to sedimentation of dredged material with potential consequences for the recruitment
- Changes in the pelagic productivity and food web due to changes in local hydrodynamic conditions (like vertical mixing) with potential consequences to, e.g. the occurrence of algal blooms
- Permanent reduction of plankton due to filtering epifauna (mainly mussels) on underwater structures
- Promotion of invasive species due to changed ecological conditions
- Locally increased abundance of jellyfish polyps due to the introduction of hard substrates, such as bridge pillars, and hence an increased abundance of adult jellyfish
- Effects due to harmful substances from drainage of storm water, release of chemical substances from physical structures or maintenance in the operation phase.

Fauna and flora on the seabed

- Temporary loss of bottom fauna and flora due to dredging in the construction phase
- Effects on the bottom flora (macroalgae and flowering plants) due to shading caused by increased concentration of suspended sediment from sediment spill
- Effects on bottom fauna and flora due to increased sedimentation during dredging
- Permanent loss, deterioration or change of seabed habitats caused by physical structures or changes of seabed characteristics
- Permanent changes of the benthic communities due to increased areas of hard substrate habitats (bridge piers etc.) including possibly increased food resources for e.g. fish
- Introduction and promotion of invasive species due to changed ecological conditions
- Effects due to harmful substances from drainage of storm water, release of chemical substances from physical structures or maintenance in the operation phase.

Fish

- Temporary deterioration of spawning, nursery and feeding grounds due to the sedimentation of dredged material in the construction phase (sediment spill)
- Effects on fish eggs and larvae due to suspended sediments in the construction phase (sediment spill)
- Permanent effects on the migration of certain fish species due to underwater structures and exposure light and noise emission from a bridge solution
- Permanent loss or deterioration of habitats due to the underwater structures and changes of the seabed
- Changed recruitment of cod in the Baltic Sea due to changes in the exchange of salt water and oxygen through Fehmarnbelt.

Marine mammals

- Disturbances due to underwater noise and vibrations during construction and in the operation phase
- Barrier effects caused by underwater structures (bridge piers etc.)
- Loss of habitats due to underwater structures
- Changes in the food source, including a possible increase due to the introduction of underwater structures (reef effect)
- Contamination of food sources with harmful substances due to sediment spill
- Potential reduction of the noise pressure if the ferry services are discontinued.

Environmental subfactor birds

- Changes in the water bird populations, including abundance, distribution and behaviour and due to permanent loss or gain of feeding areas
- Temporary deterioration of the feeding areas of water birds due to dredging and sedimentation of dredged material
- Barrier effects on the long and short distance migration of water birds and terrestrial birds due to physical structures, noise and light emission and other human activity
- Permanent changes in the utilisation of feeding areas by water birds due to potential barrier effects
- Collision risk with bridge structures
- Loss and fragmentation of breeding and resting habitats
- Disturbance of birds in their breeding and resting habitats

- Threats to breeding, resting and migrating birds due to road deaths.

Environmental factor soil

- Loss of terrestrial and marine soil and geological formations
- Deterioration of terrestrial and marine soil and geological formations
- Deterioration of areas within Natura 2000 sites with conservation objectives concerning soil, seabed and geological formations
- Deterioration of soil and seabed due to release or discharge of pollutants
- Changes of the seabed topography due to removal, deposition and spreading of sediments during dredging as well as physical structures of the fixed link, and changed sediment dynamics caused by these structures
- Effects on the dynamics of seabed sandwaves due to changes in the sediment or the hydrodynamics
- Increased sedimentation due to sediment spill during dredging
- Increased release of nutrients, pollutants and oxygen-consuming substances from suspended sediments from dredging
- Changes in the erosion or sedimentation along the coast (changes of the coastal morphology) due to sediment spill or the underwater structures of the link.

Environmental factor water

<u>Subfactor seawater</u>

- Changes of the hydrodynamic conditions caused by the underwater structures of the link. This includes the vertical mixing in the Fehmarnbelt area and water current within and through the Fehmarnbelt and possible derived impacts on the water exchange in the central Baltic sea and thus the water quality in the Baltic Sea
- Increased concentration of suspended matter (deterioration of bathing water quality and light conditions in the water column) due to sediment spill
- Changes in the concentration, distribution and dynamics of nutrients in the water column caused by changed hydrodynamic or biological conditions
- Changes in the oxygen concentration at the local level (Fehmarnbelt and adjacent bays) and at a regional level (Baltic Sea) due to changed hydrodynamic and biological conditions
- Changes in the dilution and transport of sewage discharge due to changed hydrodynamic conditions

- Discharge of stormwater from the link and release of chemical substances from underwater structures and from chemicals, paint etc. used for maintenance purposes in the operation phase.

Subfactor surface water

- Loss of surface water bodies
- Deterioration of surface water bodies due to release of pollutants or discharge of wastewater from the construction or operation of the fixed link
- Pressures on surface water recipients due to increased drainage peak levels during precipitation events
- Deterioration of surface water bodies due to lowering of the groundwater table.

Subfactor groundwater

- Loss or deterioration of areas of special significance for the groundwater
- Loss or deterioration of the legally protected water area on the Baltic Sea coast (Fehmarn and Lolland)
- Deterioration of groundwater quality due to emission of pollutants
- Risk of seawater intrusion in the groundwater due to temporary or permanent lowering of the groundwater table
- Impact on the formation of groundwater due to paving or permanent or temporary lowering of the groundwater table
- Increased groundwater consumption in the construction and operation phase.

Environmental factor climate and air

- Deterioration of the air quality due to emission of pollutants from the operation of the fixed link
- Reduced pollution levels due to the electrification of the railway traffic between Hamburg and Copenhagen and to the shortening of the freight train routes (the 175-km route over Jutland will be eliminated)
- Decreased pollution level due to the reduced ferry operation as a consequence of the Fehmarnbelt Fixed Link
- Temporary increased concentration of dust and pollutants during the construction
- No climate-ecological compensation areas (such as forests close to a big city) have been identified in the Fehmarnbelt region. Therefore, an assessment of impacts on such areas is not relevant
- Change in the local wind conditions due to the physical structures of the link

- Change in the greenhouse gas emissions due to the construction work and operation.

Environmental factor landscape

- Loss and fragmentation of the landscape
- Deterioration of the landscape in the form of changes and perceptual deterioration

Environmental factor cultural heritage and material assets

- Loss of items or areas above or below the ground or the seabed, which are important to cultural heritage or other material assets
- Potential locally increased erosion of the seafloor due to the fixed link structures, which may expose buried shipwrecks or other cultural heritage objects and thus accelerate degradation processes
- Visual and other kinds of perceptual deterioration of cultural landscapes and the surroundings of cultural heritage values
- Barrier effects causing fragmentation of the landscape and deterioration of intact cultural heritage values like earth and drystone dikes
- Deterioration of functional or historical connections of significance to cultural heritage such as old roads and paths, small villages, etc (barrier effect)
- Deterioration of material assets due to vibrations.

Interaction between environmental factors

The assessment of the environmental impact does not only deal with the individual pressures and individual environmental factors and components. The interaction between the factors and possible synergy between different pressures are also considered. The interactions of the ecosystem are generally recorded indirectly and included in the account of the impact on the individual environmental factors (for instance, increased sedimentation could lead to a temporary reduction in common mussel biomass, which again could lead to a reduced food level for fish and birds). Such interactions leading to indirect impacts especially occur in the marine environment where most of the environmental factors interact with each other.

In connection with the planned assessment of indirect impacts a description of the interaction between the individual impacts and resulting impacts on other environmental components will be elaborated. These environmental impacts are mainly assessed qualitatively.

Project related impacts (impact areas, impact zones, pressure intensity)

Each of the above potential impacts is assessed with respect to nature, magnitude, spatial extent and duration based on the pressures imposed by the project. The environmental pressures related to construction, the presence of physical and the operation of the link is derived from the technical planning documents as described in Chapter 4. Impact areas and

impact zones are subsequently derived from the pressures. This is as far as possible based on relevant numerical modelling, where the pressure are introduced as one or more point loads.

Impact areas are areas in which an environmental factor – depending on its distribution and sensitivity towards the actual project pressure – is subject to a significant impact. Impact areas not only comprise land and seabed areas that are directly occupied by the project, but also areas subject to e.g. increased sedimentation during construction.

Impact zones are subdivisions of the impact areas, where an impact on a certain environmental factor is predicted and classified according to pressure intensity. For classification of the impact zones the **pressure intensity** is indicated in a four-level scale (very high, high, medium or low) derived from the expected impact induces by the pressure. Generally the level "very high" will result in loss of function, but instances are analysed individually. Thresholds are established for the individual impacts on each environmental factor.

Forecasting methods

Two different forecasting methods are applied for the impact assessment, depending on the environmental impacts to be determined:

Forecast method 1: Assessment of the area loss

The method for assessing the area loss will be applied when an area will be lost as a direct consequence of the project or when the function of an environmental factor or component will be lost as a direct consequence of the planned use of an area. There will be direct area losses in the area of the planned alignment. This seabed includes seabed areas for e.g. the immersed tunnel or bridge piers. Furthermore, direct losses of functions of environmental factors due to utilisation of an area may occur in the slope areas and the construction field. The specific demarcation of lost areas will be determined based on construction activities and the position of permanent physical structures, respectively.

The assessment of area loss or direct loss of functions of environmental factors is performed quantitatively according to areas, ranges, etc. The severity (importance) of the impact on the environment as a result of the loss is assessed and illustrated based on importance level of the environmental factors concerned (Figure 6.3 and Table 6.3).

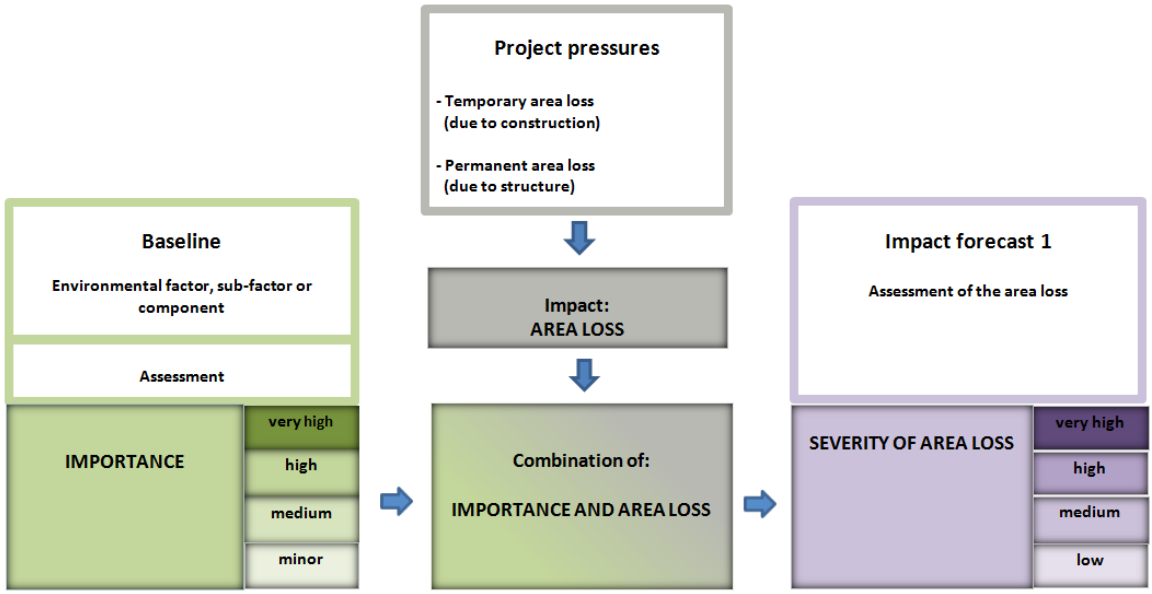


Figure 6.3 Assessment of the area loss within the impact forecast.

Table 6.3 Combination matrix to assess the severity of loss with two or four levels of importance.

	Importance of the environmental factor			
	Special		**General**	
Magnitude of loss	**Special**		**General**	
	Importance of the environmental factor			
	very high	**high**	**medium**	**minor**
Magnitude of loss	very high	high	medium	minor

Forecast method 2: Impairment of functions

This method is applied when the function of an environmental factor or component is impaired. The area subject to impairment is assessed quantitatively based on the proportion of affected and ranges or if relevant biomass or number of units etc. The degree of impairment is derived from the combination of the intensity of the project pressure and the sensitivity values of the environmental factors or components. Very high project pressure intensity is generally assumed to cause a total function loss, but this is always examined in each individual case.

The degree of impairment is given using a two- or four-level scale (very high, high, medium, low). As a general rule, the degree of impairment results from the combination of the sensitivity of an environmental factor (with respect to the function in question) towards a certain project pressure and the predicted magnitude of this (see Figure 6.4 and Table 6.4). In each

individual case the results may deviate from the examples given in the matrix below. If plausible reasons can be given, the resulting function impairment may be modified subsequently.

Finally, the severity (importance) of the impairment is derived from a similar combination of the degree of impairment with the importance of the environmental factor.

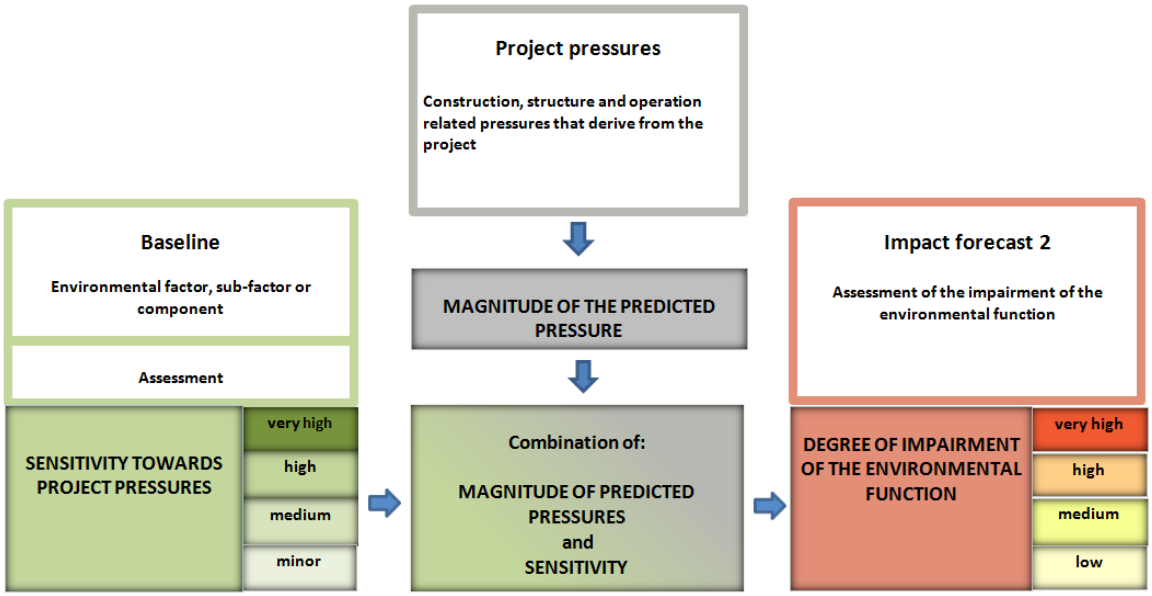


Figure 6.4 Examination of impairment of functions.

Table 6.4 Matrix to assess the degree of impairment of functions with two and four levels of sensitivity

Magnitude of the predicted pressures	Sensitivity of the environmental factor	
	Special	**General**
Very high	Generally loss of function, must be substantiated for specific instances	
High	very high	high
Medium	high	medium
Low	medium	low
Degree of impairment: coloured boxes		

Magnitude of the predicted pressures	Sensitivity of the environmental factors			
	very high	**high**	**medium**	**minor**
Very high	generally, loss of function, must be substantiated for specific instances			
High	very high	high	high	medium
Medium	high	high	medium	low
Low	medium	medium	low	low
Degree of impairment: coloured boxes				

Strategy for the comparison of alternatives

The objective of the comparison of alternatives is to determine a ranking of the alternatives regarding their impact on the environment. The comparison of alternatives is performed in two steps. First the investigated alternatives are treated separately for each environmental factor. This is followed by a comparison, which includes all environmental factors.

Comparison of alternatives with respect to the environmental factors

The individual alternatives are first compared with respect to impacts on the environmental factors. The impact assessment supplies large number of results for each environmental factor concerning impacts, which have been predicted quantitatively and/or qualitatively.

For the quantitatively assessed area losses and impairments (see forecast methods 1 and 2), the individual criteria of the alternatives to be compared are ranked by absolute numerical values (areas with a certain impact level, reduced biomass, number of individuals affected etc.).

For impacts assessed qualitatively, an assessment of the severity of impairments (forecast method 2) forms the basis of the ranking. A further ranking of the impairments is subsequently based on qualitative arguments.

The ranking based on the environmental factors is finally presented in the total overview of the ranking results. The result of the ranking is described qualitatively. In this context, consideration can be given to the fact that all predicted environmental impacts do not have the same degree of relevance regarding the decision, i.e. the choice of alternative.

Comparison of alternatives considering all environmental factors

The results of the overall rankings by environmental factors are compared in a common table. The prioritisation is elaborated qualitatively in consideration of nature conservation objectives and regulations, regional and other spatial plans as well as environmental quality objectives and general environmental and planning goals.

6.4.3. Preliminary comparison of project alternatives (alignments)

The first step of the comparison project alternatives is a preliminary comparison of alternative alignments, which include the technically and economically feasible tunnel and bridge alternatives located as far as possible in the identified low conflict corridors . The result of this comparison is a ranking of the different tunnel alternatives and a ranking of the different bridge alternatives. These rankings by environmental impacts will influence the decision regarding the favoured tunnel alternative and the favoured bridge alternative, both of which will be developed further. The favoured tunnel alternative and the favoured bridge alternative are compared with each other within the subsequent comparison of these main alternatives.

The comparison of alternative alignments is performed in two steps. First the tunnel and bridge alternatives are investigated separately in relation to the impact on each environmental factor. This is followed by a comparison, which includes all environmental factors.

The preliminary comparison of alternative alignments comparison is based on the assessment of the potential environmental impacts listed in Section 6.4.1 above. Quantitative and/or qualitative assessments are performed.

The individual alignment alternatives are presented according to the level of detail required in the route planning with a footprint resulting from construction and permanent physical structures (use of the area, including associated areas, such as slopes, associated facilities and areas used by construction activities).

6.4.4. Comparison of main alternatives (technical solutions)

In the comparison of main alternatives, the favoured tunnel alternative and the favoured bridge solutions are compared. The objective of the comparison of the main alternatives is to forecast all conceivable environmental impacts of the two main alternatives in order to be able to provide a basis for the decision regarding the favoured technical solution (either tunnel or bridge) from an environmental point of view.

The comparison of main alternatives is performed in two steps. First the preferred tunnel and bridge alternatives are investigated separately with regard to impacts on each environmental factor. This is followed by a comparison, which includes all environmental factors.

The comparison of main alternatives is based on the assessment of the potential environmental impacts listed in Section 6.4.1 above. All impacts are presented for each environmental factor and the interaction between these. Quantitative and/or qualitative assessments are performed.

The presentation concerning the tunnel and bridge alternatives is more detailed than that of the alignment alternatives in the preliminary comparison. They are now presented with any potential mitigation measures (e.g. noise protection measures, optimised dredging scenarios etc.) and with loss zones related to construction and physical structures (use of the area for the structures and construction facilities).

6.4.5. Zero-scenario

In addition to the project alternatives of the Fehmarnbelt Fixed Link a so-called zero-scenario is being examined, describing the future situation without the establishment of a fixed link and with a continuation of the ferry services. This zero-scenario is being compiled on the basis of up-to-date traffic forecasts and, if the information is available, the expected technical developments of ferries (e.g. high capacity ferries and low-emission engines).

6.5. Cumulative and transboundary impact

The obligation to carry out an environmental impact assessment also pertains to impact of cumulative projects as well as transboundary impact.

6.5.1. Cumulative impact

The assessment of cumulative impact first of all aims at preventing that EIA-obligations are being bypassed. In addition, environmental impacts shall be identified and evaluated comprehensively according to the actual situation by taking into account parallel projects. This way it is avoided that projects are approved just because they commence earlier than others. As soon as the preconditions for cumulative projects are met, the environmental impact statement has to include cumulative effects. The same is true for transboundary impacts (see below).

The EIA will identify the projects to be included. The main criterion for the selection of cumulative parallel projects is if there is a spatial overlap or functional interaction between the potential environmental impacts of the project in question and those of the fixed link.

According to the actual state of knowledge projects to be considered comprise the hinterland infrastructure projects related to the fixed link including road and railway connections in Germany and Denmark.

6.5.2. Transboundary Impact

On the basis of multilateral and bilateral treaties, in particular the Espoo-Convention and its implementation in German and Danish legislation, the EIA will take into account potential transboundary impacts. As regards the fixed link across Fehmarnbelt an environmental impact in other countries cannot be ruled out beforehand. The international public and administrative participatory process is conducted by the respective authorities of Germany and Denmark.

6.6. Climate Change

Because of the long lifetime of the fixed link climate change it is necessary to consider possible climate induced changes of the environmental conditions in the assessment of the environmental impacts of the project. In addition to global and regional climate changes, which will entail rises in temperature and sea water level, local and regional changes in the ecosystems can also be expected including shifts in the distribution ranges of animal and plant species (see e.g. BACC Author Team, 2008).

In order to be able to include climate changes in the EIA, Femern A/S convened a workshop in May 2009 with international experts within climate research. The purpose was to identify the most relevant climate scenario in relation to the fixed link in accordance with the latest research in this field (FEHY & DMI, 2009).

Climate scenarios describe the expected changes in specific climate parameters based on climate models. The calculations are based on emission scenarios describing the future emission of greenhouse gasses.

The international experts recommended applying the emission scenario A1B provided by the IPCC (the Intergovernmental Panel on Climate Change). This is a scenario in the warm end of the IPCC scenarios, but it is not the most extreme one. It has been reported to result in a rise in an air temperature of 2.3-5.3° by the end of year 2100 depending on the specific projection (IPCC, 2007). The corresponding figure for sea level rise is 1 m (FEHY & DMI, 2009).

As regards the choice of climate model the international experts recommended to take advantage of the results of the EU Framework Programme project ENSEMBLES (see http://ensembles-eu.metoffice.com/). Specifically, it is expected to apply to the HIRHAM Regional Climate Model from the Danish Meteorological Institute.

The importance of climate change will be considered in relation to possible impacts caused by the permanent physical structures and by the operation of the fixed link. The effects will be investigated systematically for the different environmental factors. Climate change is not relevant in relation to the construction phase.

The assessment of project related impacts on the marine hydrodynamics including the water flow through the Fehmarnbelt and thus the water exchange of the Baltic Sea is based on hydrodynamic model simulations. For the general impact assessments the situation with and without the fixed link is modelled based on the present conditions (1991-2009). The implication of climate changes will be assessed by running supplementary scenarios of the situation in the period 2080-2100 based on the selected climate change scenario. The model analysis will be done at a regional level, which includes the entire Baltic Sea. The model MIKE3 FM HD calculates water current, temperature and salinity (see Section 7.3.1, below). Further analyses will include water quality modelling (nutrients and oxygen) and ecological modelling of phytoplankton biomass (chlorophyll).

Possible consequences of climate change for water birds will be analysed through climatic niche models, CNM (Guisan and Thuiller, 2005). A large-scale statistical modelling approach will be applied using available data on the climatic and environmental factors determining the non-breeding distributions at sea of the relevant waterbirds in Northern European waters. The work will predict the future regional distribution of individual species in the Fehmarnbelt region in light of climate and environmental change. The study will focus on species relevant to the Fehmarnbelt region.

The possible implications of climate change for marine benthic flora and fauna, fish, marine mammals, terrestrial and freshwater flora and fauna, coastal morphology and surface and ground water will be addressed in a more qualitative manner based on literature and the outcome of the hydrodynamic and ecological modelling. The basic questions will be: How will climate changes affect important parameters and species, and is there reason to believe that this will enhance or reduce the potential impacts of the project? Several recent scientific

investigations of the possible response of species and ecosystem to climate change can provide information for these considerations. Of special relevance in the present context are the BACC projects (BALTEX Assessment of Climate Change for the Baltic Sea Basin) (BACC Author Team, 2008).

As regards human beings, soil (apart from coastal morphology), air, climate, landscape, material assets and the cultural heritage, the implications of climate changes for the project related impacts are considered less relevant and will not be specifically addressed.

6.7. Considerations on other EU Directives

6.7.1. Marine Strategy Framework Directive

In 2008 the Marine Strategy Framework Directive was adopted in the EU (Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy).

In the directive 11 qualitative descriptors are listed, on which the future marine strategies shall be based. In the first half of 2010 decisions will be taken concerning the specific indicators and methodological standards to be applied in the coming task of achieving good environmental status at the sea.

The environmental investigations and assessments in relation to the fixed link will to the extent possible include the indicators and measuring parameters, which will be applied in the future implementation of the Marine Strategy Framework Directive.

6.7.2. Water Framework Directive

The planned location of the fixed link across Fehmarnbelt is in an area, which is covered by the river basin management plans named “Flussgebietseinheit Schlei / Trave” and ”Vandplan Østersøen”, on the German and Danish side respectively, in reference to the EU Water Framework Directive (Directive 2000/60/EC). The river basin management plan is not finalised in Denmark, while the hearing is finished in Germany.

The environmental investigations and assessments in relation to the fixed link will provide the information needed to assess whether the establishment of the fixed link across Fehmarnbelt will influence achievement of the goals of the two river basin management plans. Furthermore, they will indicate how to ensure that the fixed link will not permanently hinder the achievement of good environmental status.

7. Baseline investigations and impact assessment. scope and methods

For each environmental factor this chapter goes through the scope and methods of the planned baseline investigations and impact assessments. As regards the assessment of the individual environmental factors, each environmental pressure and the delimitation of the issues are presented.

In order to avoid repetitions, the investigation and assessment methods of the ramp and approach areas on Lolland and Fehmarn are treated jointly. In cases where the legal requirements of the two countries differ, this is taken into account.

In Denmark it is – in contrast to Germany – a legal requirement to investigate and assess the derived socio-economic impacts. Therefore these will be included in the EIS.

7.1. Human Beings including Human Health

Baseline investigations

The description of the present residential areas and dwellings will be based on field surveys, as well as the land use plan (Stadt Fehmarn, Stand 02/2009) and the legally binding land-use plans of Fehmarn and the municipal plan of Lolland (Lolland Kommune, 2009; Rødby Kommune 2004).

The assessment of the existing importance and sensitivity of residential areas and dwelling environs will be determined using the following indicators:

- Existing residential areas and areas with predominant dwelling function, as well as housing development zones
- Urban green belts and dwelling environs with recreational functions for the inhabitants (play, sports, outdoor neighbourhood communication) and open spaces close to residential areas
- Current level of e.g. traffic noise and air pollution.

The inventory of recreational areas is based on field surveys. In Germany, the land-use plan (Stadt Fehmarn, Stand 02/2009) and open space structure plan (Stadt Fehmarn, 2007) of the municipality of Fehmarn (Stadt Fehmarn) (http://www.b-planpool.de) and the landscape framework plan of Planning Region II Schlesvig Holstein (Ministerium für Umwelt, Naturschutz und Landwirtschaft des Landes Schleswig-Holstein, 2003) is also taken into consideration. In Denmark, the sources of information include the regional plan 2005-2017 (Storstrøms Amt, 2005), the municipal plan of Lolland and of the former municipality of Rødby (Lolland Kommune, 2009; (Rødby Kommune 2004)), data from the local tourist board, "Friluftsrådet" (Visit

Denmark, 2009; Visit Lolland-Falster, 2009), local outdoor recreational societies and leaflets on hiking paths, shelters and nature schools.

The assessment of the existing value and sensitivity of recreational areas will be determined using the following criteria:

- The quality of the characteristic landscape and landscape scenery suitable for landscape-related recreation and the actual recreational use
- Accessibility of landscape to tourists and local inhabitants looking for outdoor recreation, as well as the existence of footpaths and cycle-ways
- Accessibility and availability of coastal and marine areas suitable for leasure activities such as yachting, surfing and bathing
- Existence of tourist recreational infrastructure and points of interest
- The current levels of e.g. traffic noise and air pollution.

Potential impacts

A number of potential impacts on human beings may arise from activities related to the construction and operation of the Fehmarnbelt Fixed Link:

- Temporary loss of land due to construction sites and related access roads as well as permanent loss of land due to the establishment of the fixed link
- Changes in the landscape structures/features through (e.g. changes in the topography and loss of habitats for fauna and flora)
- Loss of recreational or residential areas or areas with future potential in these respects
- Barrier effects causing restricted access to recreational and residential areas
- Restrictions in outdoor recreational activities
- Impairment of views and other visual perception of the area caused by alteration of landscape structures
- Temporary or permanent impairment of marine recreational activities like changes in water quality, currents or coastal morphology impacting the beach areas
- Nuisance to human beings,human health and the quality of dwellings
- Increased air pollution – caused by increasing traffic – which affects human beings and their recreational, dwelling or working environs, and which may affect human health
- In some areas, air pollution levels may decrease due to the fixed link
- Vibrations and percussions from construction work may cause nuisance to human beings and potentially affect their health. It may also damage residential areas or single buildings

- Light pollution hindering the perception of the sky at night and potentially disturbing the sleep of human beings, and thus their health.

Planned assessment

The assessment of the impacts on the environmental factor human beings due to construction, physical structures and operation of the Fehmarnbelt Fixed Link will comprise:

- Noise, air pollution, lighting emissions and vibration. (The methods used for these assessments are described in Section 4.2.2 above
- Visual impairment and barrier effects
- Loss of areas and functions in residential areas, dwelling environs and recreational areas (e.g. along the coast) as well as loss of recreational infrastructure
- Improved or reduced accessibility to dwelling and recreational sites caused by new infrastructure
- Consequences to beach areas: Recreational value and water quality. Assessment of impacts on bathing water areas based on the analyses of effects of the fixed link on marine hydrodynamics, water quality and coastal morphology. (See the subsequent chapter).

7.2. Seabed, marine sediments and coastal morphology

7.2.1. Area of investigation

The area of investigation applies to morphology and sediments of the seabed and the coastline. Based on existing knowledge on local conditions and impacts from physical structures and sediment spill, two areas of investigation in different scales have been defined - a local and a regional area. The local area of investigation is a corridor extending 20 km east and west of the planned alignment corridor (Figure 7.1). The regional area of investigation has been defined as the entire western Baltic Sea and the Belt Sea area.

In this way the area of investigation covers the largest possible impact area determined in the preliminary investigations. It is also ensured that the sandwaves of the SCI “Fehmarnbelt” are included in the area of investigation. The sandwaves are one of the main designation criteria of the SCI.

The investigations of seabed forms and coastal morphology are mainly of local extent. Sediment investigations are carried out on a regional level.

The extent of the areas of investigation also include the largest possible areas subject to impacts from the permanent physical structures and impacts caused by sediment spill in the construction phase.

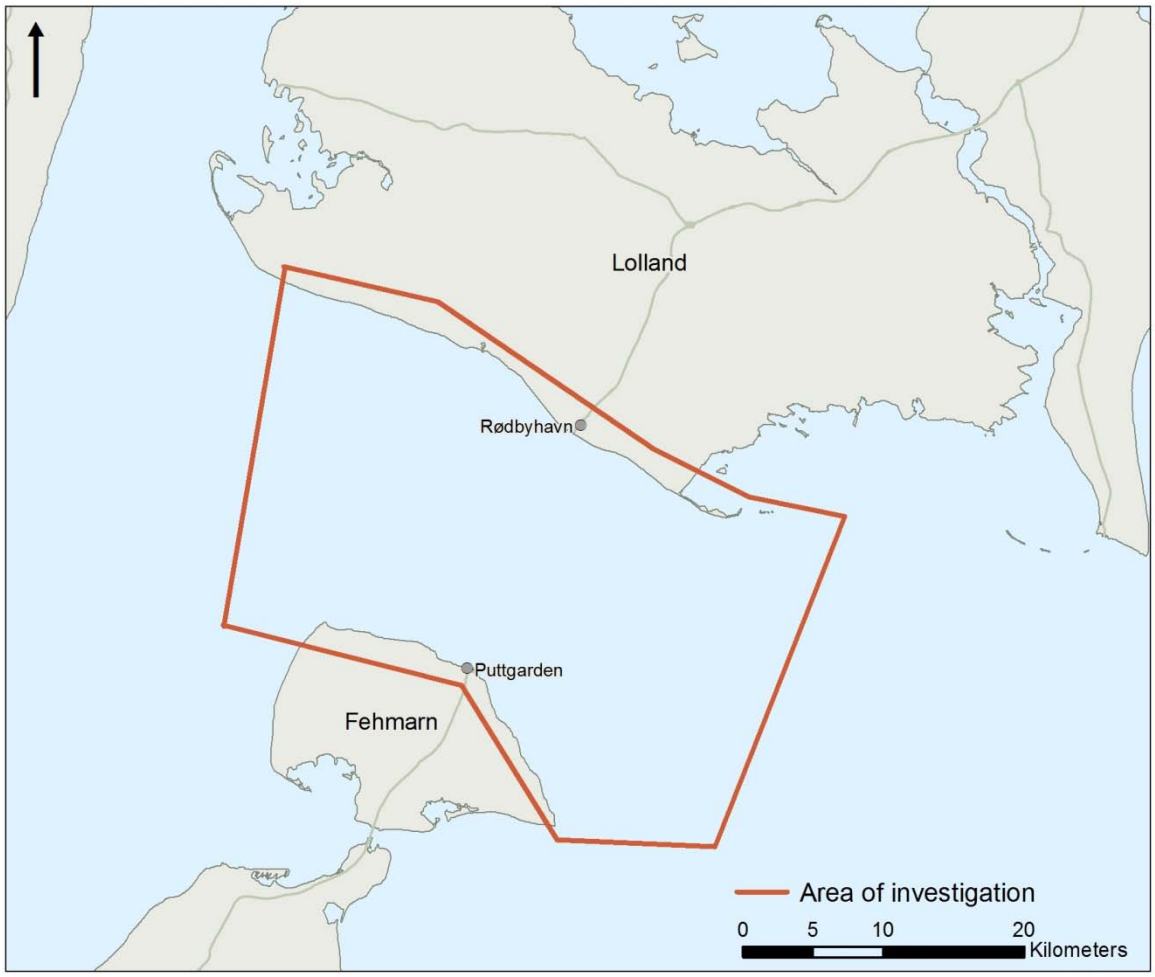


Figure 7.1 Area of investigation (red) for seabed, marine sediments and sea water.

7.2.2. Seabed Morphology

Baseline investigations

Surveys will be complemented to consolidate the knowledge on geological, topographical, morphological and sedimentological characteristics of the seabed in and around the project area. The baseline investigations will focus on the following:

- Detailed mapping of seabed topography (i.e. the depth characteristics or bathymetry) will be conducted in the area of investigation shown in Figure 7.1 using side-scan, single-beam and multi-beam echosounders (2m resolution)
- The dynamics of the sand waves will be investigated including studies on the interaction between hydrodynamics and sand waves.

The applied investigation methods are further described in Appendix B.

Potential impacts

The most important potential impacs on seabed topography are:

- Dredging and deposition activities and physical structures potentially creating temporary or permanent changes in water depth and seabed slope
- Sediment spill resulting from dredging, deposition and reclamation work during the construction phase
- Changes in water flow caused by underwater structures of the fixed link.

Particular attention is paid to the question whether changes in sediment and/or hydrodynamics will result in changes in the dynamic of the sand waves. The potential impact depends on the mobility of the sand waves. In summary the potential impacts to sand waves involve:

- Temporary changes in sand wave dynamics due to sedimentation in the troughs
- Long-term changes in the composition of the deeper sediments in sand wave areas due to sedimentation in the troughs
- Long-term changes in the geometry of the sand waves due to modification of the water current caused by bridge piers.

Sedimentation in the troughs of the sand waves can occur if fine sediment released during dredging, is trapped in the so-called “dead-zones” in the lee of each sand wave. Even if the amount of spilled sediment per unit area is quite small, the amount of sediment trapped in the troughs may be important as transport along the seabed could cause accumulation of sediment in certain areas. If the sand waves are dynamic, the fine sediment trapped in the troughs will be covered by coarser sediment as the sand waves migrate, and thereby cause long term changes in the composition of the deeper sediments. Further filling of the troughs may reduce the flow resistance from the sand wave area, leading to changes of the current.

Planned Assessments

The assessment of the seabed morphology will focus on the consequences of the fixed link for the occurrence and dynamics of sand waves, i.e. an assessment of the influence of sediment spill and changes in hydrodynamics.

If such impacts are predicted, the analyses will also concern possible consequences of the changes in sand wave occurrence and dynamics for the flow patterns in the Fehmarnbelt area. The assessment will be based on data and dynamic modelling of hydrodynamics and sediment transport.

The modelling will be conducted using 3D MIKE models developed for simulation of transport of sand by water currents (MIKE by DHI 2009a). In addition a special 2D model (Dune) will be used for understanding and quantifying the importance of seabed structures like sand waves – and potential changes of these – on the hydrographical conditions in the Fehmarnbelt (see

e.g. Tjerry and Fredsøe 2005, Grunnet *et al*. 2009, Jensen and Fredsøe 2001, Niemann *et al*. 2006).

7.2.3. Marine Sediments

Baseline investigations

Considering the results of the 1999 Feasibility Study the baseline investigation of the marine sediment involves the following:

- Determination of the structure of the uppermost sediment layers of the Fehmarnbelt area. This is also an important input to the biological habitat mapping
- Detailed mapping of the sediment structure and chemistry (pollutants, nutrients and oxygen consuming substances) in the area of investigation with focus on areas and depths expected to be influenced by dredging or other construction work causing spreading of sediment
- Field investigation of settling and resuspension of sediment in order to improve the knowledge on the natural sedimentation processes in the Fehmarnbelt area. Three to five sites will be investigated by deploying sediment trap at three different depths in the water column. The results are important inputs to the impact assessment of seabed fauna and flora.

The applied investigation methods are further discussed in Appendix B.

Potential impacts

Potential impacts on the properties of seabed sediment is primarily related to dredging and reclamation work during the construction phase which may cause:

- Removal/change of seabed surface due to dredging and deposition
- Increased sedimentation as a consequence of elevated levels of suspended matter in the water caused by sediment spills
- Instable seabed surfaces and increased resuspension due to non-consolidated new sediments
- Increased release of nutrients, contaminants and oxygen consuming substances from the suspended sediment.

As mentioned above, long-term impacts of the construction work lasting into the operation phase must be considered. This is partly due to the strong currents of the Fehmarnbelt, which prevent permanent deposition of dredged sediment. Therefore, redistribution of temporarily deposited sediments may occur for a prolonged period. Similarly, it may take years before dredged seabed areas (e.g. above the possible immersed tunnel) has attained its final characteristics.

Planned Assessments

The assessment will include:

- Impacts of sediment spills on sediment dynamics in the Fehmarnbelt area, including extent and strength of changes in sediment structure, sediment spreading and settling, and re-suspension of sediment
- Risks of significant release and spreading of nutrients, toxic contaminants and oxygen consuming substances from suspended sediments.

The impact assessment will be based on baseline data, field experiments quantifying key processes, and dynamic modelling of hydrodynamics and sediment transport using a 3D model. The field experiments shall clarify dispersion and fall velocity rates relevant to the Fehmarnbelt areas and provide quantitative data on re-suspension as a function of the local hydrodynamic conditions.

The 3D models to be applied are MIKE models developed for state-of-the-art simulation of hydrographical conditions (see under Sea Water) and sediment transport. The sediment transport model is developed especially for simulating of transport of fine (mud) sediment (DHI 2009b). It has been applied in the 1999 Feasibility Study (COWI-Lahmeyer 1998d), for one thing.

The assessed scenarios will represent the expected time schedule of the different earth works and dredging methods which will differ depending on the choice of physical structure. The investigations will comprise spilling from a) construction of the Link itself, b) construction of reclaimed landfills if relevant, c) sand extraction and d) deposition at disposal sites offshore.

The first step of the impact assessment regarding nutrient and toxic contaminants will be a screening to evaluate if the existing concentrations in the sediment give rise to concern. For heavy metals and organic pollutants, the baseline results will be compared to standard ecotoxicological standard criteria. Only if concentrations show to be significant, further investigation will be carried out involving advanced modelling, experiments and further measurements of concentrations.

The result of the sediment assessment will be essential to the evaluation of the possible impacts of the fixed link on the marine biology, the marine landscape (see above) and the coastal morphology (se below).

7.2.4. Coastal Morphology

Baseline investigations

The baseline description of the coastal morphology will include:

- Mapping of the present coastline; including the quantity and direction of the sediment transport along the shoreline
- Determining the historical development of the coastline based on historical aerial photos and satellite images covering the period 1979-2008 and identifying the mean water line from the images and water level observations
- Establishing an overall sediment budget for the coastal zones based on the detailed mapping of the seabed topography and the sediment properties The budget will be used to calibrate and validate a modelling complex analysing the sediment transport along shore (littoral drift)
- Calculation of the littoral drift using the model complex in combination with wave, current and water level statistics for the coastlines of Fehmarn and Lolland.

The applied investigation methods are further discussed in Appendix B.

Potential impacts

The main potential impacts on the coastal morphology will be associated with the permanent physical structures (constructions, reclamations, etc.). Most impacts during the construction phase will be due to sediment spill, which is dealt with in connection with the marine sediment issues.

The potential impacts include changes in the littoral drift of sediments and changes in the sediment budget along the coast. Such changes may in turn change the evolution of the coastlines of Lolland and Fehmarn, due to increased or decreased erosion or build up of land along the shorelines. In the end this may challenge the present coastal protection (breakwaters and revetments).

Planned Assessments

The assessment of the coastal morphology will focus on the question whether:

- the fixed link will change the littoral drift and sediment budgets and in this way influence on the shoreline evolutions. This involves assessment of changes in the nearshore wave conditions as these are the primary determining factor of the coastline development
- the environment will be influenced by underwater structures (e.g. bridge piers or ventilation islands) and reclamations or other development along the coastlines on the adjacent coastal stretches.

The coastline evolutions for the coming 20 years will be predicted also considering the global climate change. The key tool used for the analyses will be a complex of detailed models including wave, hydrodynamic and sediment transport models. These will be MIKE-models (explained in the former and following chapter).

7.3. Sea Water

7.3.1. Area of investigation

The area of investigation of sea water is defined by the basic characteristics of the hydrodynamic and water quality of the wider Fehmarnbelt area (i.e. the western Baltic Sea) and neighbouring seas. Existing knowledge indicates that if notable changes occur in the Fehmarnbelt area, these can potentially influence the water exchange with the central Baltic Sea and thereby the environmental conditions here. Similar effects are not plausible for the Kattegat and the Belt Sea. Furthermore, the area of investigation is defined by the possible local and regional impacts of the fixed link. In this way the area of investigation covers the entire Baltic Sea and the Kattegat extending from the Bothnian Bay to the transition to the North Sea at the Skagerrak. The main focus is on the western and central part of the Baltic Sea as well as the project area.

Three scales are relevant for the assessment of potential impacts. One local scale comprising the near field around the link structures and a corridor extending 20km on each side of the alignment (Figure 7.1) and another local scale comprising the western Baltic Sea (“local area” in Figure 7.2). Finally, one regional scale is applied including the neighbouring seas (Figure 7.2). Among the neighbouring seas, focus is on the central Baltic Sea.

Figure 7.2 The areas of investigation for sea water (red squares)

7.3.2. Hydrography

Baseline investigations

The baseline investigation of hydrography shall analyse seasonal and inter-annual variations and historical trends of the hydrographic conditions and will comprise:

- a monitoring programme with two year continuous registration of key hydrographic variables at three fixed offshore stations; two in Fehmarnbelt and two in Meclenburg Bight (Figure 7.4)
- two years of monthly ship borne measurements of key hydrographic variables at 120 stations/transects (Figure 7.3)
- statistical analyses of long-term time series extracted from earlier Danish and German routine monitoring and targeted surveys (BSH, ICES and the Danish Nature & Environment Portal, the 1999 Feasibility Study) and the dedicated monitoring within the Fixed Link Project
- dynamic modelling of the historical and present hydrodynamic conditions of the Fehmarnbelt area as well as modelling of the water exchange with the central Baltic Sea.

The key hydrographic variables include water level, salinity, temperature, current and waves. Further variables are measured as part of the water quality study described below and the plankton baseline studies under Marine Fauna and flora. Analyses will be done according to national and international endorsed methodologies. The station net covers the potential sediment spill impact area as well as reference areas.

Data will be analysed using statistical and dynamic modelling. The key tool will be dynamic modelling using advanced 3-dimensional models (3D models) providing high spatial and temporal resolution simulations of the development and causal relationship of the hydrodynamic conditions. To ensure highly confident results of the modelling, the two independent model complexes will be applied. Two spatial resolutions will be applied: Fine resolution set-up for Belt Sea area for Fehmarnbelt analyses (local scale) and coarser resolution for the whole Baltic Sea and North Sea area for regional Baltic Sea analyses (regional scale). The model will be calibrated with data from the dedicated monitoring, long time series and satellite data. The models to be applied at different scales are summarised in Table 7.1.

Table 7.1 Models applied in the hydrographical investigations

	Regional scale modelling	Local scale modelling
MIKE3^{TM} FM HD	x	x
GETM	-	x
IOW-MOM	x	-

The MIKE3^{TM} FM HD is developed for simulation of hydrographical conditions in scales adapted to the subject to be clarified (see DHI 2009b; DHI 2002, Edelvang *et al.* 2004, Vedsted *et al.* 1992). The MIKE3 model system was applied for the environmental assessment studies of the Great Belt and Øresund bridges and in the feasibility study for the Fehmarnbelt Link (COWI-Lahmeyer 1998c).

GETM represents a similar modelling approach, which has been utilized in several coastal and shelf sea studies, amongst other covering the western Baltic Sea (http://www.getm.eu/data/getm/doc/getm-doc-devel.pdf, Burchard and Bolding 2002, Burchard *et al.* 2009).

The IOW-MOM model is a specific adaptation of the Modular Ocean Model (MOM) prepared by IOW based on long term investigations of the hydrodynamic conditions of amongst other the Baltic Sea (Pacanowski and Griffies 2000). The model has e.g. been applied for long-term studies of the Baltic Sea and for high resolution investigations of the south-western regions of the Baltic Sea (Neumann and Schernewski 2008; Siegel *et al.* 2005).

The applied investigation methods are further discussed in Appendix B.

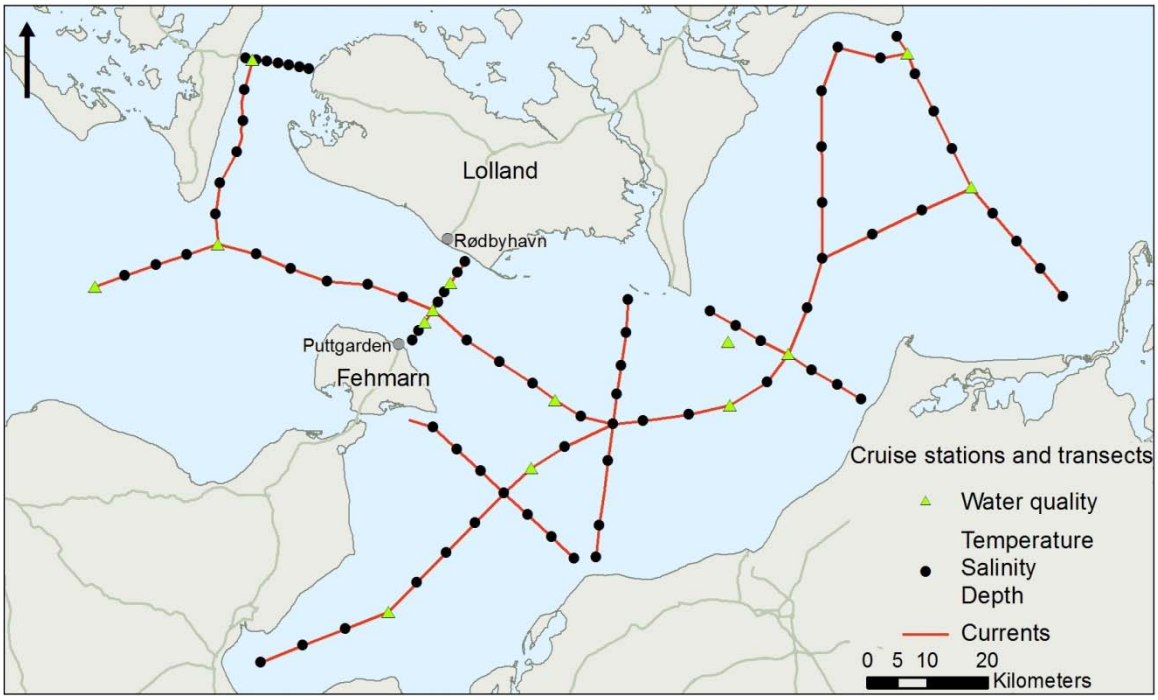


Figure 7.3 **The position of the 120 *in situ* monitoring stations and tansects used to map hydrodynamic and water quality conditions.**

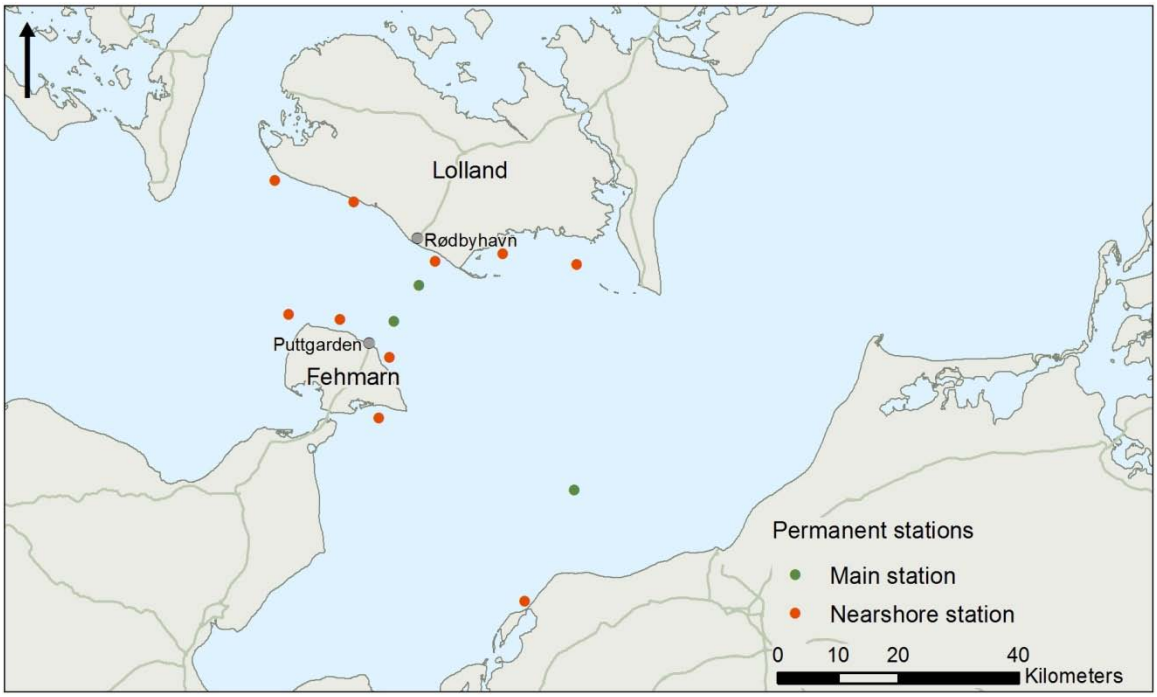


Figure 7.4 **The position of the permanent stations (3 main stations and 10 nearshore stations) used to map hydrodynamic and water quality conditions.**

Potential impacts

The key concern regarding the investigations of hydrodynamics focuses on local and regional scale potential impacts imposed by the presence of the underwater structures of the fixed link. These will cause local changes in the water flow (blocking effects) which can cause:

- Modifications of the vertical mixing in the Fehmarnbelt area
- Modifications of current pattern (water flow) within and through the greater Fehmarn-belt area
- Modifications of the water exchanges with the central Baltic Sea and consequently re-striction of the vertical mixing there with consequences to the oxygen content of the Baltic Sea bottom water.

The possible environmental impacts will develop gradually during construction the fixed link.

Planned assessments

The focus areas of the assessment of the hydrodynamic impacts are:

- Quantification of the blocking effects caused by underwater physical structures of the fixed link

- Derived changes in the currents and water mixing in the Fehmarnbelt and the adjacent marine areas, with and without ferry services
- Consequences to the bottom water conditions of the central Baltic Sea i.e. the inflows of saltwater and the oxygen conditions.

The present knowledge will be reviewed based on findings from earlier fixed link studies and relevant scientific literature. Further laboratory and field experiments will be carried out to clarify the resistance component of the substructures as well as their effect on mixing. The blocking effect of the individual link structures and the mixing by ferries will be carefully studied in laboratory tests and by field measurements at the Great Belt Link and in Fehmarnbelt combined with very high resolution modelling in order to provide proper descriptions of the hydrodynamic effects to be implemented in the Belt Sea and Baltic Sea models. This study will also provide information and data for optimisation of sub-structures like piers and islands.

Using the established dual 3D models complex, different solution models will be analysed to study effects on the local and regional scale. The regional scale models will include 20-30 years simulation periods, whereas the local modelling will cover at least a full annual cycle - repeated for each scenario. The combination of a fixed link and likely climate changes will also be modelled.

7.3.3. Marine Water Quality

Baseline investigations

As for the hydrography, the water quality baseline investigation shall analyse seasonal and inter-annual variations and historical trends of key water quality variables. The variables include: nutrients, oxygen, and suspended matter and the thereof derived turbidity and light conditions. Chlorophyll is treated below in section 7.4.1.

The baseline assessment is based on:

- A targeted monitoring programme (Figure 7.3) including 2-years monthly ship borne measurements at about 14 offshore and 10 nearshore stations as well as sensor measurements at three offshore and 10 nearshore fixed stations (Figures 7.3 and 7.4). Analyses will be done according to national and international endorsed methodologies. The station net covers the potential sediment spill impact area as well as reference areas. At the fixed stations continuous measurements of the turbidity are conducted. Furthermore the possibility to use satellite images, (earth observation), will be investigated
- Statistical analyses of long-term time series extracted from earlier Danish and German routine monitoring and targeted surveys (BSH, ICES and the Danish Nature & Environment Portal, the 1999 Feasibility Study) and the dedicated monitoring. The analyses of the data will bring out empirical casual relationships and trends which are important inputs to the dynamic modelling

- Dynamic modelling of the historical and present water quality conditions of the Fehmarnbelt areas and of the central Baltic Sea. For this task, the dual 3D Hydrography model complex will be supplemented with an ecological model simulating the bio-geochemical processes of the water.

The applied investigation methods are further discussed in Appendix B.

Potential impacts

Potential impacts on water quality can derive from permanent changes in the hydrodynamics and spreading of sediment during dredging caused by a fixed link, i.e. mainly in the operation phase, and from sediment spill during the construction phase. The key concerns are:

- Alterations of the water turbidity. This may affect bathing water quality and light condition in the water column and at the seabed with potential derived effects on the marine fauna and flora
- Alterations of the distribution and dynamics of oxygen and nutrients in the water column caused by changes in the hydrodynamic conditions and by sediment spill
- Alterations of the oxygen conditions on a local scale (Fehmarnbelt and adjacent bights) and a regional scale (the deep parts of the Baltic Sea) as a result of changes in the hydrodynamic condition
- Modification of the dilution and transport of bacterial discharges as a result of changes in the hydrodynamic condition
- Leaching of chemical substances from subsurface physical structures
- Spillage of surface treatment chemicals during maintenance in the operation phase
- In case of changes in currents, the pattern of outfall plumes from storm water and treatment plants can be changed and ultimately end up contaminating the beaches with faecal bacteria. This can have an impact on bathing water quality.

In case of an open drainage system surface runoff from the bridge solutions could also cause potential impacts on water quality, particularly in case of accidents involving spill of oil and/or other pollutants. However, proper drainage control systems could reduce the risk associated with such accidents.

Planned assessments

The assessment of the possible environmental impacts on the water quality will focus on:

- Impacts on nutrient dynamic and availability, and on the magnitude, frequency and distribution of oxygen depletion in Fehmarnbelt
- Impacts on magnitude, frequency and distribution of oxygen depletion in the central Baltic Sea

- Impacts on concentrations of suspended matter and the derived turbidity and light availability in the water column and at the seabed
- Impacts on bathing water quality due to changes in dilution and spreading of bacterial pollutions and due to sediment spill from dredging operations
- Impacts of surface runoff and accidental spills from a bridge solution.

The possible effects of the fixed link solutions will be analysed using the two dynamic 3D model complexes mentioned above under hydrography.

7.4. Marine Fauna, Flora and Biodiversity

7.4.1. Area of investigation

The extent of the area of investigation is defined by the requirements set by the basic characteristics of plankton, benthic vegetation and benthic fauna communities in the Femarnbelt area and in the nearest Natura 2000 sites. Furthermore, it has been based on existing knowledge on local conditions and potential impacts from physical structures and sediment spill.

For benthic vegetation and benthic fauna impacts are only plausible in an area close to the fixed link. Therefore the area of investigation for these studies is a corridor of 15-20 km around the alignment. Reference areas have been placed outside the expected impact area, in areas that are comparable to the impact area in terms of physical and chemical characteristics of the habitats. It is, however, also important that the references are situated in conjunction with the impact area, enabling the possibility of making gradient and regression analysis as part of the assessment of impact.

Plankton dynamics are related to the movement of the water masses that continuously import and export pelagic organisms to and from the Fehmarnbelt area. The main purpose of the plankton baseline investigation is therefore to characterise the large scale environmental situation before the construction work and to provide calibration data for ecosystem models used for the baseline description and impact assessment. The scale of the plankton study therefore covers a larger area, including sampling sites in the Great Belt, the Bay of Kiel and the Bay of Mecklenburg.

The extent of the areas of investigation include the relevant Natura 2000 areas in the investigations and impact assessments (see Chapter 2.4) In some of the SPAs (EU bird protection areas) additional sampling has been carried out in order to support the bird studies.

7.4.2. Marine Plankton

Baseline investigations

As for water quality, the plankton baseline investigation shall analyse seasonal and inter-annual variations and historical trends using a combination of extensive measurements and statistical and dynamic modelling. The plankton variables include: fluorescence, primary pro-

duction, chlorophyll, phytoplankton abundance, diversity and biomass, and zooplankton diversity, abundance, diversity and biomass (including jellyfish).

The baseline assessment will be based on the following investigations:

- A targeted monitoring programme comprising 2-years monthly ship borne measurements at about 12 offshore and 10 nearshore stations as well as sensor measurements at 3 fixed offshore stations (Figure 7.5)
- Statistical analyses of long-term time series from earlier Danish and German routine monitoring and targeted surveys (BSH, ICES and the Danish Nature & Environment Portal) and the dedicated monitoring
- Dynamic modelling of the historical and present concentrations of chlorophyll of the greater Fehmarnbelt area using the earlier described dual 3D hydrographic-ecological model complex and inputs from the statistical analyses.

The applied investigation methods are described further in Appendix B.

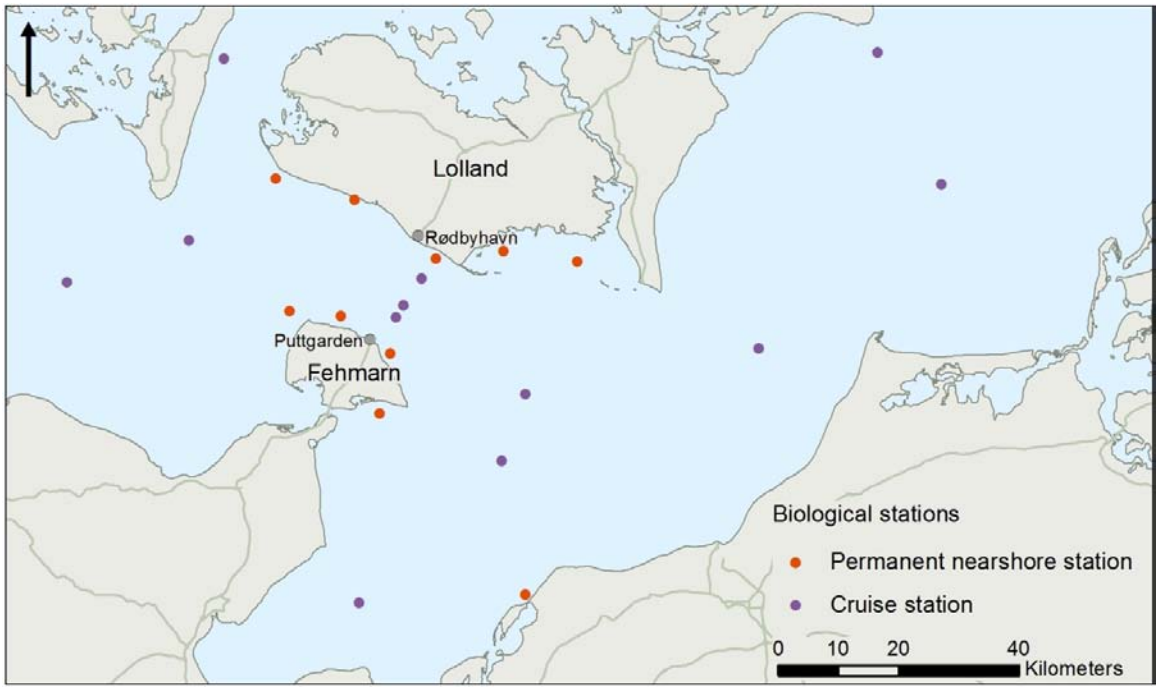


Figure 7.5 **Positions of the in-situ-monitoring-stations used for registration of biological conditions in the water**

Potential impacts

Plankton populations are generally not considered sensitive to disturbances from marine construction activities because of their short generation times and the large exchange of water with adjacent areas. However, theoretically potential impacts may include:

- Changes in phytoplankton production – with subsequent effects on zooplankton – as a consequence of alteration of light and nutrient conditions caused by sediment spill
- Risk of burial of copepod resting eggs – with potential implications for recruitment – as a consequence of settlement of spilled sediment
- Alteration of the pelagic productivity and food webs due to changes of local hydrodynamic conditions (i.e. mixing of water) with potential influence on e.g. occurrence of algal blooms
- Locally higher abundances of juvenile jellyfish (polyp stage) abundances due to the introduction of additional solid substrate like bridge piers and increasing the risk of mass occurrence of adult jellyfish.

Planned assessments

The assessment of impacts on the plankton shall clarify whether sediment spill, introduction of new solid substrate and/or alterations of hydrodynamic conditions will cause notable changes in the plankton communities. The assessment will focus on:

- Impacts on phytoplankton production, diversity, abundance and biomass
- Risks of increases in occurrences of cyanobacterial blooms (blue-green algae)
- Impacts on zooplankton diversity, abundance and biomass
- Risk of effects on resting copepod resting eggs
- Impacts on production of jellyfish
- Impacts on food availability for plankton eating fish.

Overall, the possible impacts of the project scenarios will be assessed using coupled hydrodynamic, sediment and ecosystem modelling in combination with statistical analyses.

7.4.3. Marine Bottom Fauna and Flora

Baseline investigations

The baseline investigation shall determine the spatial distribution of benthic habitats in the greater Fehmarnbelt area and document the species composition, biodiversity, abundance and biomasses of the benthic fauna and flora communities.

The baseline investigation will comprise:

- Mapping of benthic habitats within the Fehmarnbelt area and parts of Kiel and Mecklenburg Bight according to the MESH[8] guidelines; and based on well-known classification systems such as EUNIS[9], the Helcom Biotopes and the EU Habitats Directive

- Targeted investigation of benthic macroalgae (seaweed) and flowering plants (such as eelgrass) including composition, abundance, distribution and biomass; analysed once a year for two years along multiple transects in the potential impact area and in reference areas. The investigations will comprise video recording and sampling carried out by divers at depth intervals (Figure 7.6)

- Targeted investigation of benthic fauna – living in and on the seabed including species composition, abundance, distribution and biomass analysed once or twice a year for two years along multiple transects in the predicted impact area and in reference areas. The investigations will comprise video recording and sampling at different depths using grab, frame techniques etc. (Figures 7.6 and 7.7)

- Analyses of historical data on bottom fauna and flora from local monitoring programmes and scientific studies (including the 1999 Feasibility Study)

- Monthly quantitative frame sampling of blue mussel and macroalgae using frame techniques at a limited number of stations to describe the seasonal variation in variables essential to calibration of the ecosystem model.

An important basis for the benthic habitat mapping is the results from the investigations of the morphology of the seabed. Additional side-scan sonar surveys will be carried out. The shallow water zone will be complementarily mapped by aerial photography. Based on the acoustic and all other relevant available data, the habitats on the seabed will be classified. Each distinct area will subsequently be verified by video recording. Based on the results of the investigations a benthic habitat map will be produced. The map is also important to the planned studies of fish, marine mammals and birds as it helps identifying suitable spawning grounds, feeding habitats etc.

The applied investigation methods are described further in Appendix B.

[8] MESH = Mapping European Seabed Habitats (A project funded by EU).

[9] EUNIS = European Nature Information System on species, habitat types and sites (European Environmental Agency, EEA).

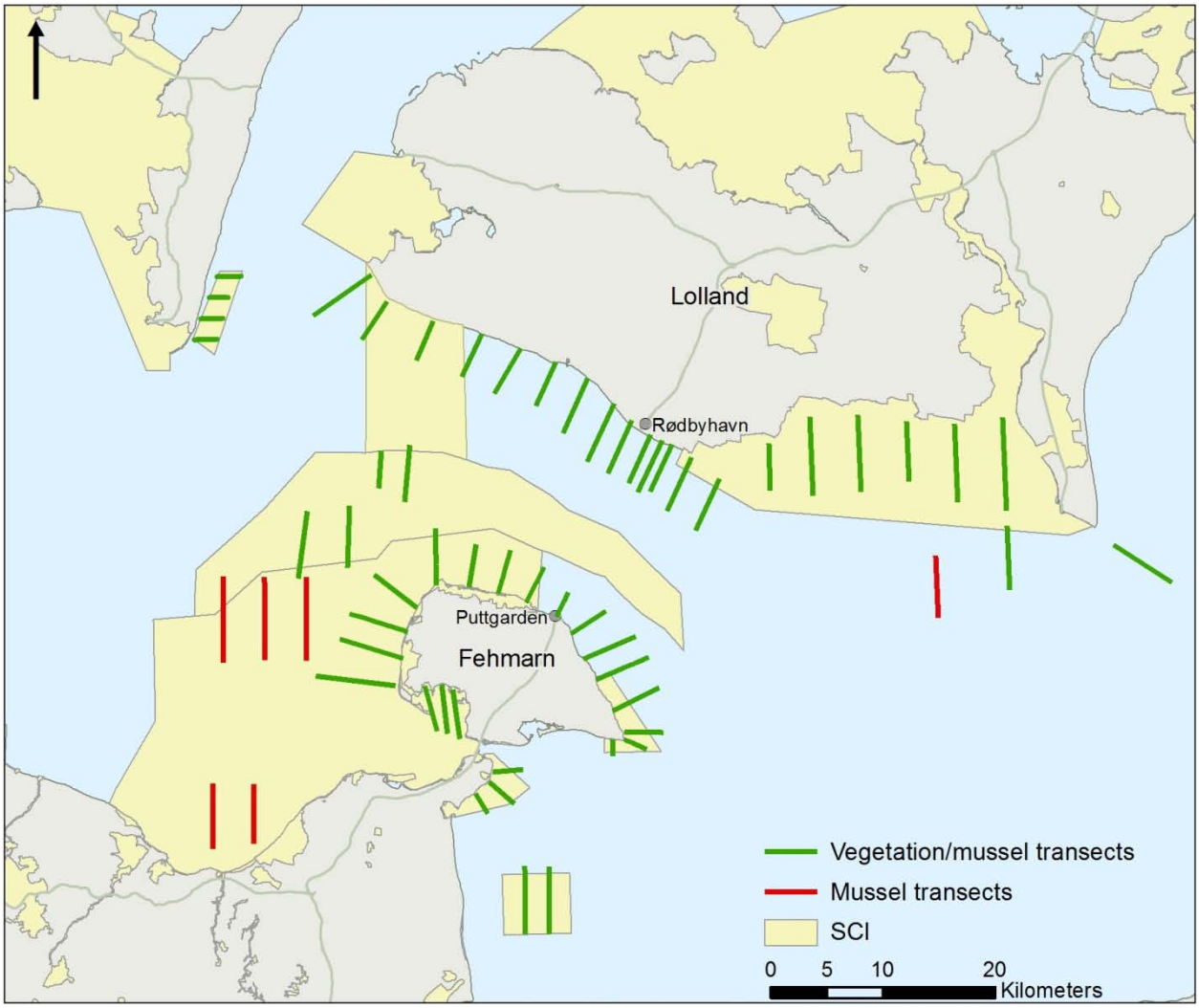


Figure 7.6 **Baseline investigations of benthic vegetation and blue mussels. Green lines indicate vegetation transects. Mussels are investigation at most of these as well. Red lines indicate supplementary mussel transects.**

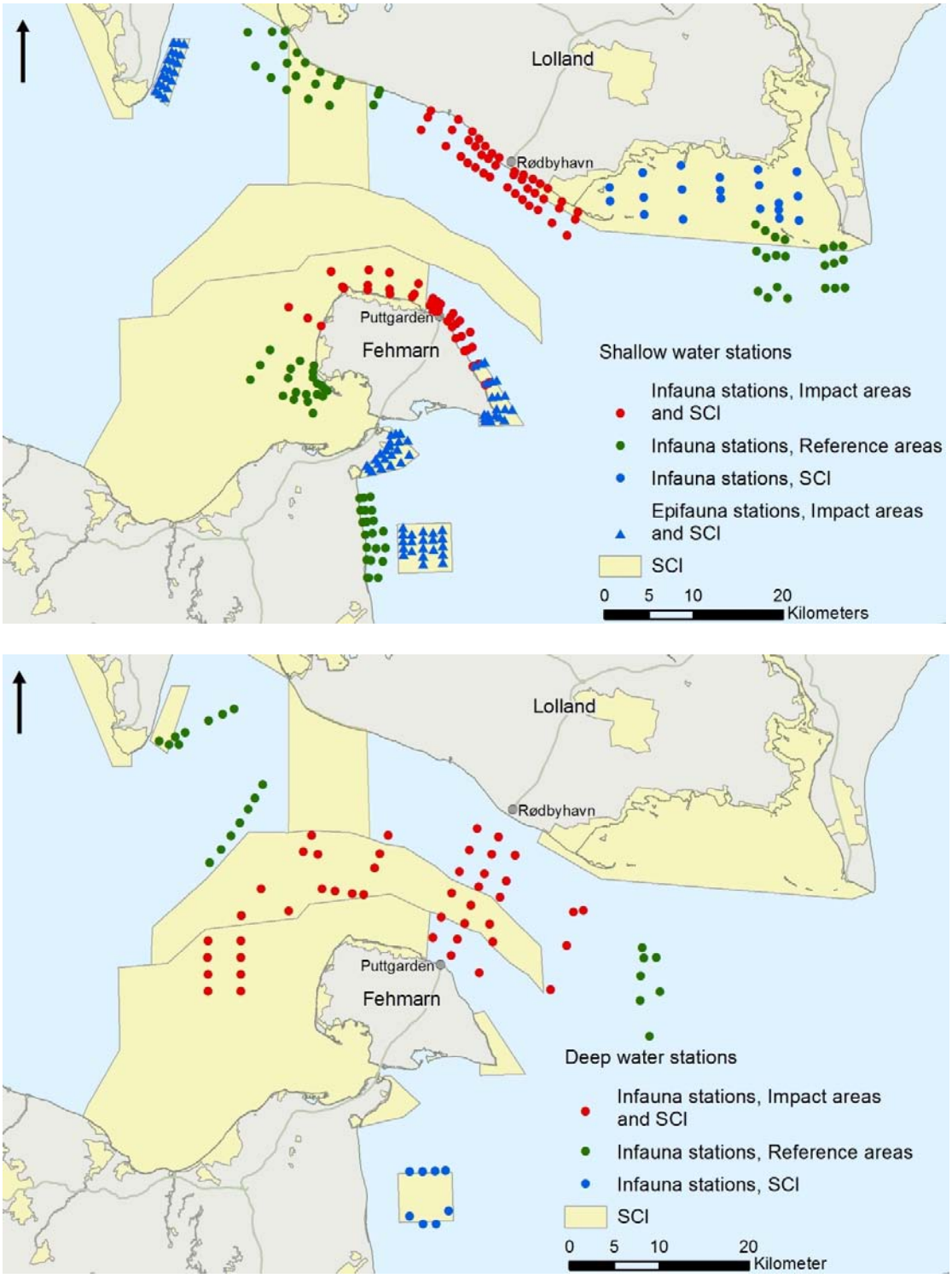


Figure 7.7 **Baseline investigations of marine bottom fauna at shallow water (above) and deep water (below). Colour of sampling stations indicates location: Red: Potential impact area, green: reference area, blue: SCI.**

Potential Impacts

The marine bottom fauna and flora can be vulnerable to impacts from the project. This partly because of the low or absent mobility of the organisms.

Sediment spill due to dredging activities during the construction phase is a short-term pressure from the project as it may cause shading, release of nutrients and smothering of bottom fauna and flora. For instance the blue mussel living on the seabed surface – sometimes in dense mussel beds – is known to tolerate moderate loads of sediment, whereas other bivalves species living buried in the seabed may be more vulnerable (Kiørboe *et al.* 1981; Powilleit *et al.* 2006). Furthermore, the pressure from sediment spill shall be considered in regard to the effect of the reduced light intensity on flowering plants and macro algae (Cabaço *et al.* 2008). Changes in the hydrodynamics may also impact the fauna and flora if current pattern and mixing are altered and may cause derived changes in seabed morphology, light conditions and availability of food (nutrients and plankton).

A direct consequence of the establishment of underwater contructions and dredging on the seabed is that flora and fauna habitats will be lost. The lost habitats will to some extend re-establish on the affected seabed or new habitats will develop on the underwater constructions.

In summary, the potential impacts on bottom fauna and flora are:

- Deterioration and/or loss of fauna and flora organisms and habitats with potential consequences to biodiversity, food availability to higher food chain levels and to oxygen conditions
- Reduced recruitment due to sediment burial due to dredging, which in particular affects juveniles as even thin layer of sediment may interfere with settlement and attachment of spores and larvae on their substrates. Hydrodynamic changes may also affect recruitment
- Reduced biomass and distribution of bottom flora due to shading due to sediment spill as well as hydrodynamic changes. These may affect the availability of food and the suitability of the benthic habitats, e.g. due to increased currents and exposure
- Reduced biomass and distribution of bottom fauna. Sensitivity and recovery potential to sediment spill varies between species; e.g. blue mussels living on banks are rather tolerant to moderate sediment loads while other bivalves living in the sediment are rather sensitive. Hydrodynamic changes may affect food availability for filtering mussels
- Changes in biodiversity
- Changes in the proportion between phytoplankton and bottom flora and between annual (filamentous) and perennial macroalgae.

Planned Assessments

The assessment of impacts on the bottom fauna and flora shall clarify whether physical disturbance, sediment spill, introduction of new solid substrate and/or alterations of hydrodynamic conditions will cause notable changes in the bottom fauna and flora composition. The assessments will include changes in the benthic habitats and in the individual components of the habitats; either caused directly by sediment spill or indirectly through effects on plankton and water quality. The assessment will focus on:

- Alterations of the flora: Biodiversity, vertical and horizontal distribution and biomasses. Regarding sediment spill dose-response relationships will be established based on literature data and field/laboratory experiments. Supplementary, impact prediction models simulating spatial and temporal distribution and abundance of dominant species will be applied. Data from the baseline investigation will be used to develop, refine and calibrate the predictive models. Impacts will be assessed on different scales e.g. populations, communities and habitats. The natural levels of suspended matter and sedimentation will be considered
- Alterations of the fauna: biodiversity, vertical and horizontal distribution and biomasses. Expectable reductions in abundance of selected important species will be quantified by dynamic modelling and/or evaluated on a probability scale – the method depends on the level of available information. The timeline for community recovery following dredging works will be evaluated. Impacts will be assessed on different scales e.g. populations, communities and habitats, and the natural levels of suspended matter and sedimentation will be considered
- Predicting impacts on the mussel population along the Lolland coast as these are important food to diving birds. To quantify the availability of blue mussels and other species such as cockles and soft clams, so-called “carrying capacity” models will be applied; combining dynamic and GIS modelling. The estimated occurrence of blue mussel will build on a shell length resolved population model. The model to be applied will be an adaptation of the MIKE 3D model mentioned under sea water including specific descriptions of the benthic flora and fauna components
- Changes in quantity and distribution of fauna and flora habitats; loss and gain. The baseline benthic habitat maps will be the basis for this assessment. The areas and the associated biomasses of fauna and flora of lost habitats will be estimated. Likewise the gain of biomasses due to colonisation of new solid substrates will be quantified. Effects of these changes on nutrient dynamics, oxygen, plankton grazing and other ecosystem processes will be quantified in model scenarios.

The assessment of impacts on marine fauna and flora is tightly connected to the assessments of hydrography, marine sediment and marine plankton. Further, predicted changes are important inputs to the assessment of fish, marine mammals and birds.

7.4.4. Fish

Baseline investigation and demarcation of the investigation area

The baseline investigation is focused in particular on recording fish migration, fish stocks, fish eggs and fish larvae as well as suitable spawning, nursery and feeding grounds. Most of the investigations are limited to the route corridor and its immediate surroundings as well as reference areas in the vicinity of the project. However, some specific investigations are conducted on a larger scale and extend from the Baltic Sea to the Skagerrak. They involve interregional reference areas in order to assess the potential direct and indirect effects on individual fish species, which either migrate through the Fehmarnbelt or could be affected by hydrographic changes.

Planned investigations and demarcation of the specific investigation areas:

- Analysing historical data:
  Review and summarise historical, published and unpublished studies and fishery data from the Fehmarnbelt and adjacent waters. The data covers all life stages from egg to adult fish and describes the dynamics in time and space of commercially exploited fish stocks (e.g. herring, sprat and cod). It constitutes an important component of the baseline investigations
- Investigating the significance of migratory routes crossing the planned route corridor and the behaviour of important migrating species and their preferred migration routes:
  European eel (*Anguilla anguilla*), herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) are some of the most important migrating fish species in the project area. Areas that may be potentially affected by sedimentation have been identified in the investigation area (Bundgaard et al. 2008). These sedimentation scenarios form the basis for determining the investigation area. The investigation of cod, herring and sprat stocks is being conducted frequently using echo sounding and trawl nets along the project corridor and its surrounding environment (1-4 km, see Figure 7.8). Migratory behaviour, spatial and temporal distribution and the abundance of pelagic fish species will be recorded. Periodic investigations will also be conducted for reference purposes over an area extending 20 km east and 20 km west of the route corridor (Figure 7.8)

  The migratory behaviour of silver eel (adult European eel) will be investigated by catching, marking and releasing eels. The routes for silver eel's spawning migration from the Baltic Sea to the Sargasso Sea lead through Fehmarnbelt and Øresund. Therefore, the investigations are not limited to the project area in the central part of the Fehmarnbelt, but include migration from the Bornholm region too. Silver eels are marked on both the Danish and on the German side of the Fehmarnbelt. The recapture of marked eels covers most of the Danish waters and the most important migratory routes can be surveyed. Some of the marked eels will be transported to the Bornholm region before they are released.

- Characterising fish habitats and fish communities in the route corridor and the surrounding environment
  A network of stations for the investigations has been defined based on the survey of habitat types and sedimentation scenarios mentioned above in section 7.4.3 (Bundgaard et al., 2008). The stations are distributed in such a way that all habitat types are covered representatively. The stations are differentiated with regard to the use of different types of fishing gear e.g. pound nets, gillnets, trawl nets and fyke nets. The mesh size is also varied in order to cover as many fish species and life stages as possible. In addition to analysing the composition of fish communities in the various habitat types, the analysis also allow conclusions to be drawn on the role of the habitats for individual fish species (e.g. spawning, nursery and feeding grounds). The investigation area covers the coastal area from Fastensee in the west to Staberhuk east of Fehmarn and the coastline of Lolland from Kramnitze in the west to the island of Storeager in the east. Western and eastern stations, which are not affected by the construction project, are considered as reference areas. Figure 7.9 shows the location of the stations

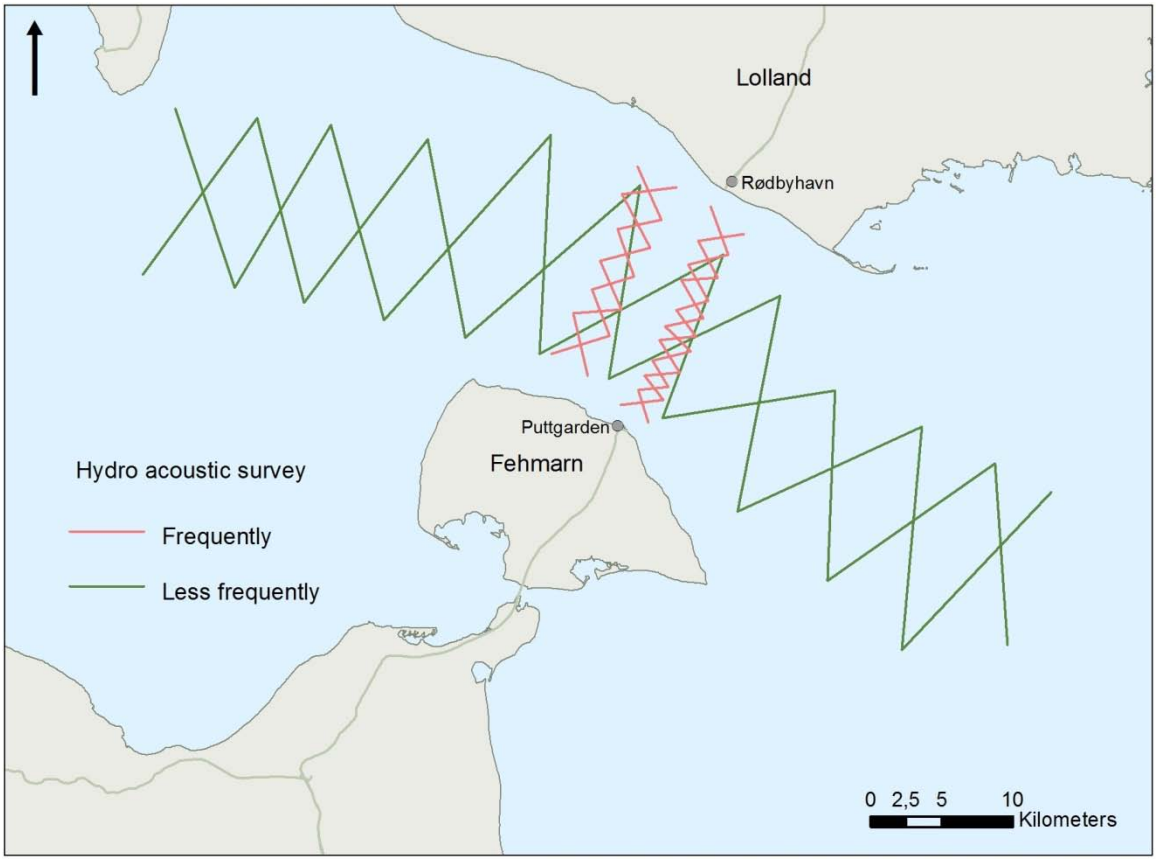


Figure 7.8 **Overview of the transects determined for the hydroacoustic and trawl net investigations to record fish stocks and migratory behaviour. Red lines: Frequent investigations. Green lines: less frequent investigations**

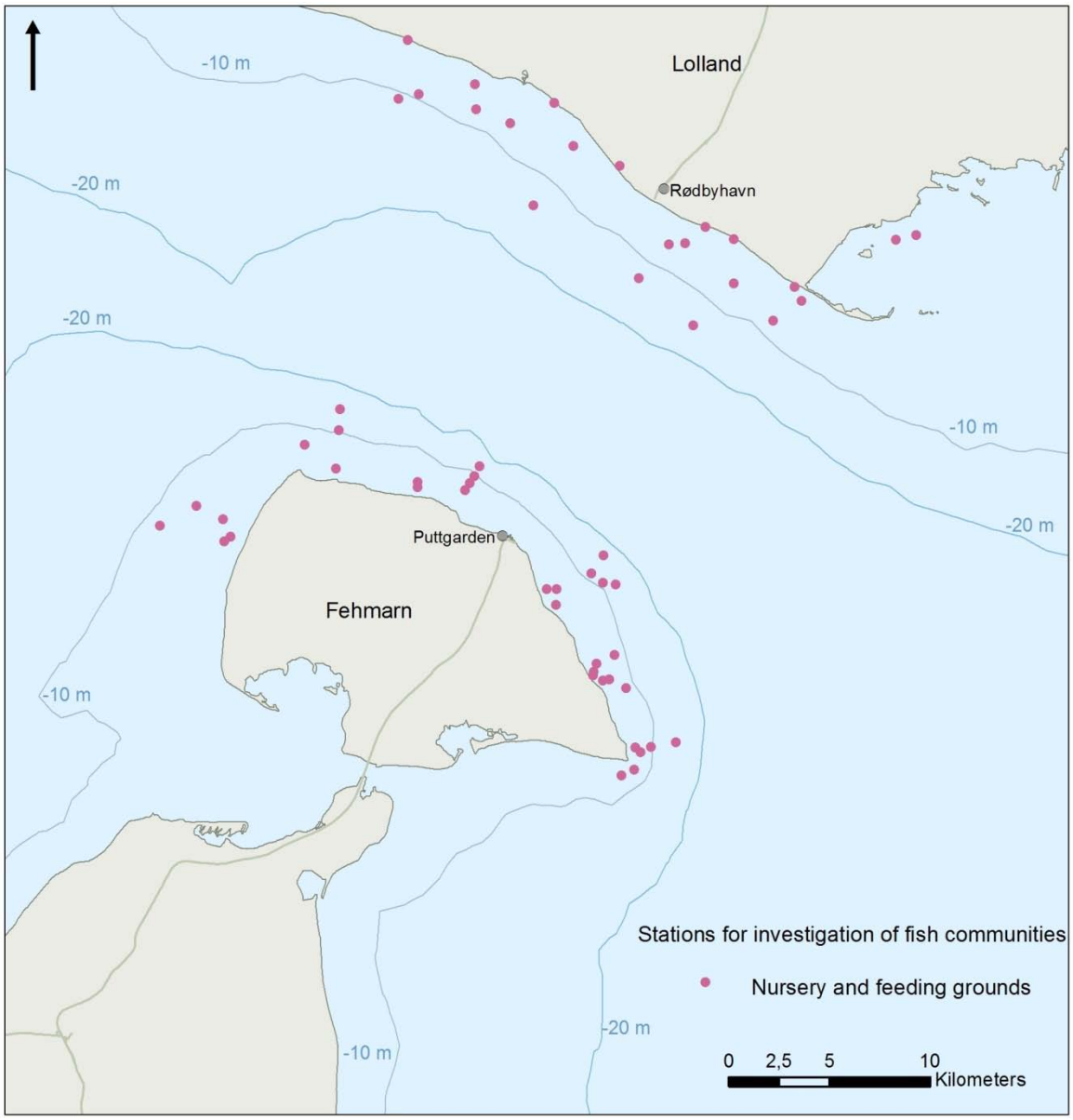


Figure 7.9 **Sampling stations for recording fish communities (different types of fishing gear are used, e.g. gillnets, fyke nets, trawl nets)**

- Characterising fish habitats and fish communities in the route corridor and the surrounding environment
  A network of stations for the investigations has been defined based on the survey of habitat types and sedimentation scenarios mentioned above in section 7.4.3 (Bundgaard et al., 2008). The stations are distributed in such a way that all habitat types are covered representatively. The stations are differentiated with regard to the use of different types of fishing gear e.g. pound nets, gillnets, trawl nets and fyke nets. The

mesh size is also varied in order to cover as many fish species and life stages as possible. In addition to analysing the composition of fish communities in the various habitat types, the analysis also allow conclusions to be drawn on the role of the habitats for individual fish species (e.g. spawning, nursery and feeding grounds). The investigation area covers the coastal area from Fastensee in the west to Staberhuk east of Fehmarn and the coastline of Lolland from Kramnitze in the west to the island of Storeager in the east. Western and eastern stations, which are not affected by the construction project, are considered as reference areas. Figure 7.9 shows the location of the stations

- Fish eggs and larvae
  The extent of the investigations on the occurrence of pelagic fish eggs and larvae is based on current knowledge of the transport of eggs and larvae through the Fehmarnbelt, and the location of spawning grounds (Riber & Raschke, 1999). In addition, reference areas are defined in order to record the present variation of eggs and larvae (i. e. interannual fluctuations or climate-related changes). Samples are taken using bongo nets with a mesh size of 500 µm. The investigation area covers a section measuring 20 km along the coast of Lolland, including Rødsand, and along the northern and eastern coastline of Fehmarn (Figure 7.10). Reference areas outside of the area potentially affected by the construction project are located south-east of Langeland and in Mecklenburg Bay. With the help of hydrodymanic models, the collected data on the occurrence of fish eggs and larvae will be used to draw conclusions about potential spawning grounds and spawning intensity

- Recording herring stocks and investigating recruitment
  The investigations on herring cover (a) estimates of the abundance and biomass of spring-spawning herring in potential spawning grounds in the area around the route corridor and in comparative areas farther away, (b) the mapping of autumn-spawning herring and (c) the inspection of herring larvae stocks. The mapping of herring spawning grounds in the Fehmarnbelt area is based on sedimentation scenarios (Bundgaard et al. 2008). Also included were the descriptions of potential spawning grounds for the spring- and autumn-spawning herring in the investigation area from the feasibility study and other literature (Riber et al. 1999)

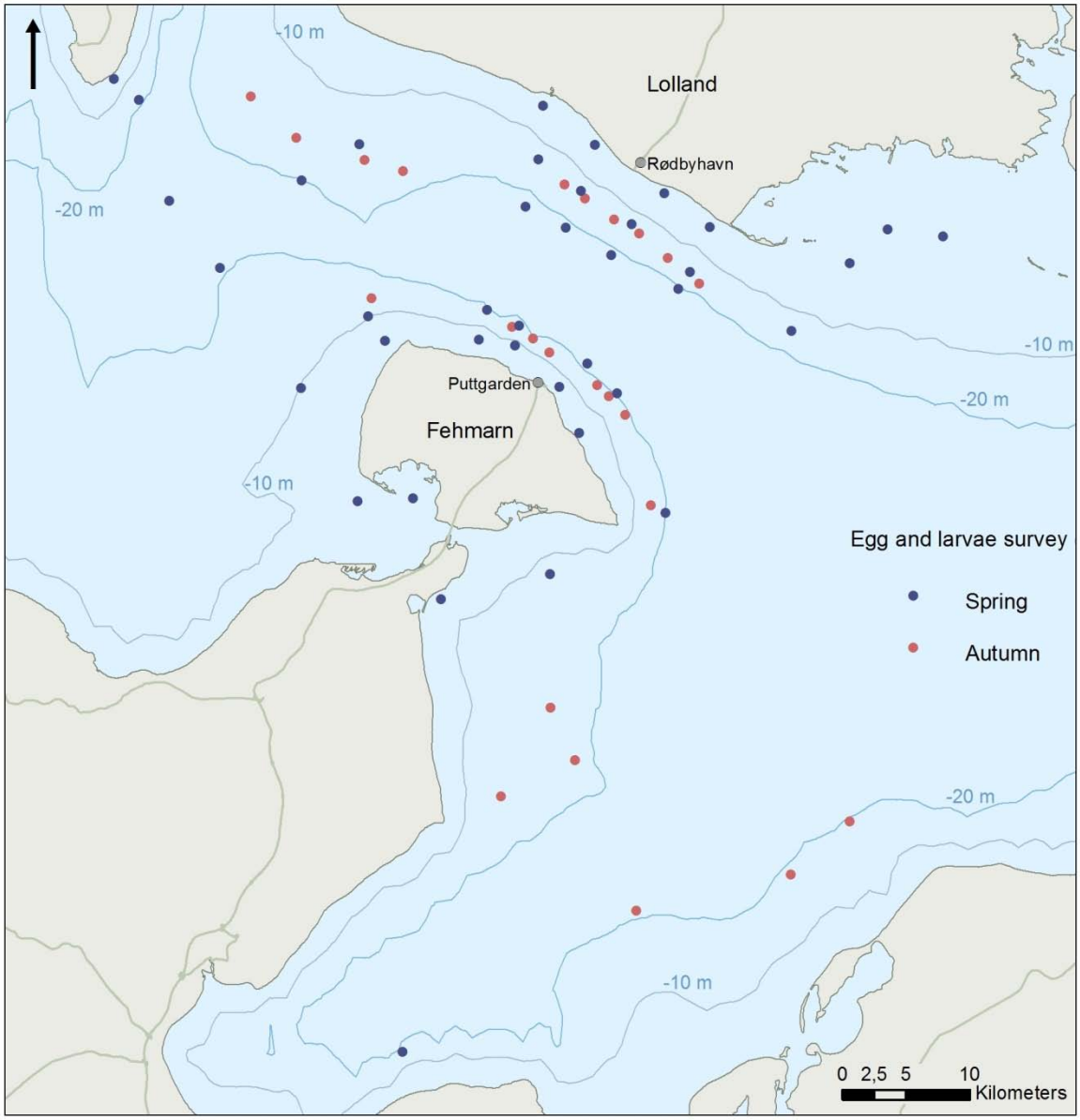


Figure 7.10 **Investigation stations for recording pelagic fish eggs and larvae. Bongo nets are used to catch the fish. Blue dots: Spring investigations: Red dots: Autumn investigations**

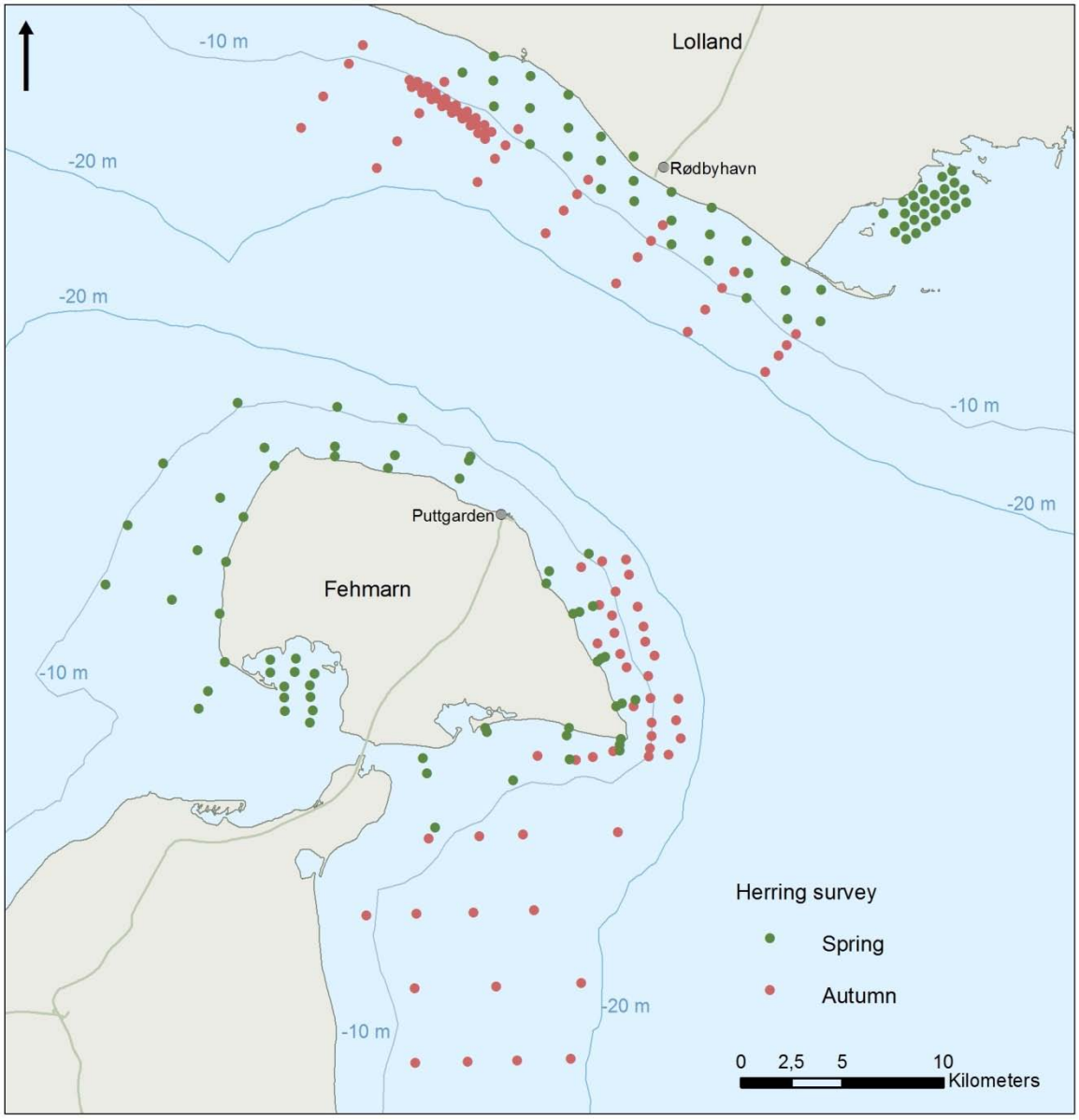


Figure 7.11 **Stations for recording herring stocks. Green dots: Spring investigations. Red dots: Autumn investigations.**

Spawning opportunities for autumn-spawning herring are significantly more restricted in the investigation area than those for spring-spawning herring. This is due to the fact that their spawning grounds in the red algae vegetation are limited to depths of between 10 and 20 m. These spawning habitats can be found only to the southeast of Fehmarn and at a few locations on the coast of Lolland. This was taken into consideration when specifying the investigation design and the siting of stations. Figure 7.11 shows the location of the stations. Underwater video and divers are used to survey the spawn. Gillnets are also used to catch herring. Commonly accepted methods are used

subsequently to assess the maturity of the fish. It is intended to use otolith and DNA techniques to differentiate between the various herring stocks. Data on the spring-spawning herring is provided by ICES (International Council for the Exploration of the Sea) and the national fishery research institutes.

- Assessing stocks of commercially important fish species
  German and Danish fishery institutions conduct annual stock assessments in the Baltic Sea, including the Fehmarnbelt, the Danish Belt Sea, the Kattegat and the Skagerrak. The recorded data is analysed in order to design additional investigations, which expand the spatial and temporal coverage of the stock assessments routinely conducted in the Fehmarnbelt. Two of the additional investigations use demersal trawl nets, targeting fish species living at or near the seabed. The other two investigations use hydroacoustics to determine the stock of pelagic fish and bongo nets for the eggs and larvae

  In order to be able to assess the effects of the planned fixed link on fishery, the existing data is used at local, regional and interregional level. The data for the local area (project and adjacent areas) provides information for assessing the direct effects on the fishery. The regional investigations cover an area extending 80-90 km on either side of the planned fixed link, the data covers the possible relocation of fishery activity to the adjacent sea areas. The data for the interregional sea areas shows the potential impact of the project on fishery in terms of possible changes in the stock structures of commercially important fish species such as herring or cod (spawning success/recruitment, migratory behaviour).

Potential impacts

The main potential impacts on fish species and fish communities are expected in the construction phase due to sediment spill and the resulting increase in water turbidity and sedimentation. The presence of the fixed link may, depending on the selected design of the link also result in potential permanent impacts on the fish communities due to changes in the hydrodynamic regimes and disturbance from noise light and vibrations. Furthermore, new reef communities may develop on underwater structures such as bridge piers.

The potential impacts include:

- Temporal and reversible deterioration of spawning, nursery and feeding grounds due to sedimentation of particles from the sediment spill during construction
- Adverse effects on the survival of eggs and larvae and induced avoidance behaviour due to increased turbidity in the water column. This may potentially affect the spawning migration or migration to nursery and feeding grounds for certain fish species
- Risk of permanently hampered migration of some fish species due to the physical structures as well as operation-related light and noise from a bridge solution

- Permanent and irreversible loss or deterioration of habitats due to physical structures and change of seabed characteristics so that they remain inaccessible or become less suitable for spawning, nursery and feeding
- Permanent effects on the exchange of fish eggs and larvae between Fehmarnbelt and the central Baltic Sea due to hydrodynamic changes in water flow and mixing. This may have consequences for fish communities and species composition in the Fehmarnbelt
- Change of the recruitment of the endangered Baltic cod stock due to changes in exchange of salt water and oxygen to the Baltic.

Planned assessments

The assessment of impacts on fish shall clarify whether dredging and deposition, sediment spill, alterations of hydrodynamic conditions, introduction of new solid substrate as well as noise and light emission will notably affect fish communities; either directly or indirectly through effects on plankton and benthic fauna and flora.

The assessment will focus on:

- Effects on fish migration. The migratory behaviour of herring, sprat, cod and silver eel will be predicted based on dose/response relationships describing avoidance behaviour, and effects on distribution and abundance. The relationships will be established from literature data
- Effects on spawning and availability of spawning grounds. The approach will include habitat suitability mapping combined with predictive dynamic modelling of the different technical link alternatives. An important subject to the modelling will be quantification of possible effects on eggs and larvae recruitment. Laboratory dose-response experiments quantifying the effects of sediment spill on mortality, sensitivity and responsiveness of eggs and larvae of different type of spawners will support the modelling
- Changes in the availability of nursery and feeding grounds with possible consequences to local fish communities. This will be assessed based on key variables such as temperature, depth, sediment grain size and occurrences of bottom flora. As for the spawning grounds habitat suitability modelling will be an important tool
- Effects on the recruitment of Baltic Sea cod. Any changes in the spawning volume will be calculated. This is the volume of water in which the combination of salinity and oxygen allows cods egg to survive. Detailed knowledge on the occurrence and sensitivity of the Baltic cod stock recruitment from the national research institutions will be used in the assessments.In order to back-track fish eggs and larvae to geographical spawning areas, two different model complexes are required. The first model is a temperature dependent growth model and the second is a hydrodynamic model capable of “transporting” egg or larvae backwards in time. The latter model (HD-model) is discussed further in chapter 7.3.2. The individual based models for development of the

fish eggs calculate a temperature dependent development rate for the individual fish eggs. In the model the development rate is expressed as a Daily Fractional Development (DFD) of the time span from spawning to hatching.

The assessment of impacts on fish is tightly connected to the assessments of hydrography, sediment and marine fauna and flora as well as fisheries. Furthermore, the predicted changes in fish communities can be important to the assessment of marine mammals, birds and fisheries.

7.4.5. Marine Mammals

Baseline investigations

The aim of the baseline is to provide detailed information on abundance, distribution and habitat use of harbour porpoise, harbour seal and grey seal in the project area and adjacent waters. Applied methods will follow international standards and comply with the German Standards for Environmental Impact Assessments for Offshore Wind Farms (StUK3) (Bundesamt für Seeschifffahrt und Hydrographie, BSH 2007).

The area of investigation stretches from a line between Kiel and Langeland in the west to a line between Gedser and Dahmeshöved in the east (Figure 7.12). The demarcation of the area of investigation ensures that all Natura 2000 sites designated for the protection of marine mammals in the Fehmarnbelt and adjacent areas are covered. The relatively wide extent to the east and west allows for the registration of possible distribution gradients and focal points of the different mammal species. In addition, the area of investigation covers the maximum area potentially influenced by suspended sediments as identified in earlier investigations. The size of the area also allows for a later separation of non-affected reference areas for the monitoring programme.

The studies will include:

- For harbour porpoises, abundance and distribution will be investigated using monthly large-scale aerial surveys. Aerial line transect surveys will be undertaken following the distance sampling approach (Figure 7.12). The distance to observed harbour porpoises from the transects will be sampled in order to be able to calculate animal densities (number of animals per area unit) utilising the software package DISTANCE (http://www.ruwpa.st-and.ac.uk). The results will be complemented by ship-based observations conducted mainly for seabird counts
- For seals, distribution and abundance data will be derived using regular counts at the existing haul outs
- Habitat usage of harbour porpoises (occurrence in the Fehmarnbelt area and some indications of behaviour) will be investigated using about 20 passive acoustic monitoring devices to be deployed at different distances to the project corridor

- To determine the use and selection of habitat by both harbour porpoises and harbour seals, attempts will be made to tag individuals of both species in order to record their movements via GPS technology and satellite telemetry. Furthermore, the relationship between occurrence of both seals and porpoises with environmental parameters such as temperature and currents will be analysed using established modelling approaches, such as multiple regression analysis. For this purpose the results of the model calculations derived from the hydrological and other biological investigations will be included as a basis. Aerial surveys and passive acoustic monitoring methods have been started in winter 2008
- To investigate interactions with present human activities, ambient noise profiles will be collected with autonomous acoustic recorders in a wider area covering the project area and beyond.

The applied investigation methods are further discussed in Appendix B.

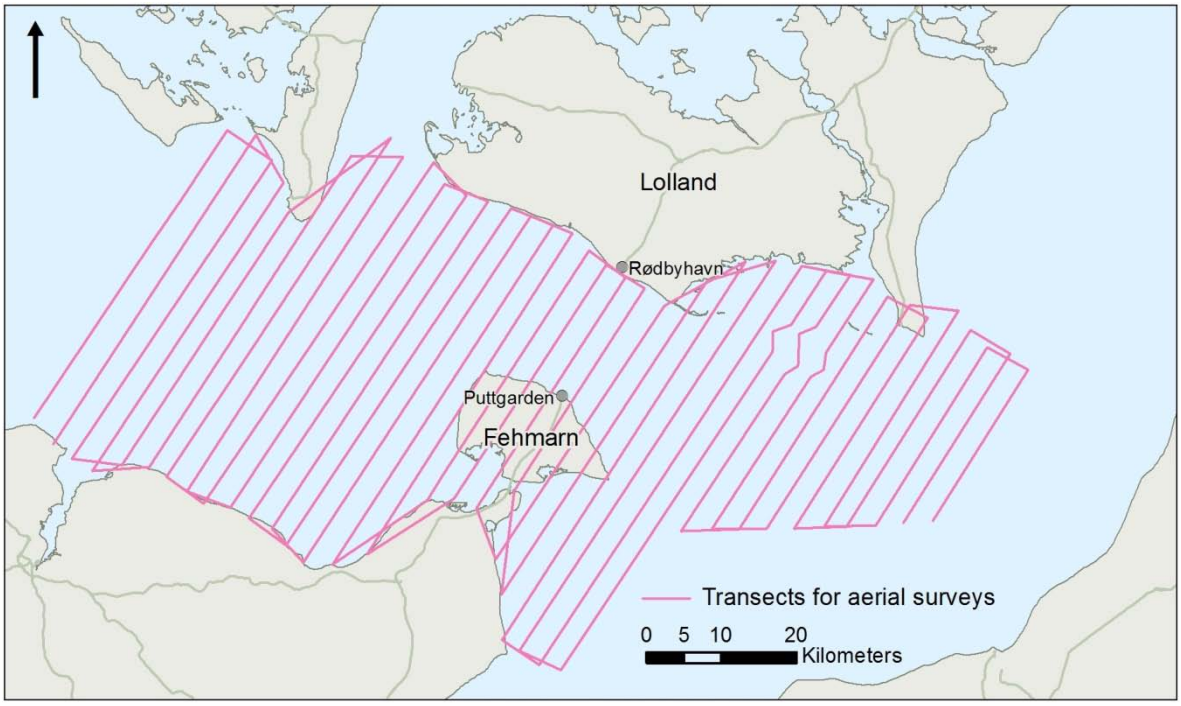


Figure 7.12 Baseline investigation for harbour porpoise and resting birds. The lines represent transects for aerial surveys

Potential impacts

Potential impacts on marine mammals might occur during construction and operation of the fixed link and are derived from both direct and indirect effects. In brief, the potential impacts on marine mammals concern are:

- Disturbance due to underwater noise and vibration during the construction and operation. Noise is emitted from construction ships and dredging. If pile driving is required in case of a bridge, large-scale effects (>10 km) are possible. A bridge solution might concentrate shipping activities in a narrower corridor leading to locally enhanced underwater noise profiles
- Barrier effects may be caused by the physical underwater structures such as bridge piers and ventilation islands. Such effect - if permanent - will affect local habitat utilisation and for porpoises it may also result in effects on a larger scale if movements between the western and eastern Baltic Sea are restricted
- Temporary or permanent changes or even loss of habitats for marine mammals. Changes in hydrography, sediment dynamics, bottom fauna and flora, and fish communities may influence the habitats used by harbour porpoises, harbour seals and grey seals. Furthermore, permanent underwater structures will cause loss of habitats
- Contamination of food sources. Sediment mobilisation during construction activities might lead to a release of previously deposited contaminants into the environment. This could theoretically affect harbour porpoises, harbour seals and grey seals, if the contaminants reach them through the food chain
- Habitat changes leading to new habitats for marine mammals. Underwater structures such as bridge piers will act as artificial reefs which may locally lead to a considerable enrichment in the biomass of bottom fauna and flora. This may attract fish species and in turn marine mammals. Artificial reefs may thus have a positive effect on marine mammals by providing locally enriched food resources.

Planned Assessments

The assessment of impacts on marine mammals shall clarify whether construction activities, alterations of hydrodynamic conditions, physical structures like bridge piers and ventilation islands, and noise will cause notable direct effects. Indirect effects may be derived from changes of marine fauna and flora. The assessment will focus on:

- Alterations of behaviour and distribution caused by noise and vibration from the construction work. Literature information and own measurements of relevant underwater noise sources will be used to assess the noise exposure in the Fehmarnbelt during the construction phase. Models will be developed to describe the underwater noise regime in the Fehmarnbelt area and the received sound pressure levels at different distances from the construction using various transmission loss formulas. Information of noise from relevant construction activities and the ambient noise measurements undertaken

during baseline will be applied for this purpose. Zones of noise influences for audibility, masking, behavioural response and injury will be established using a variety of noise exposure criteria from the literature

- Alterations of behaviour and distribution caused by noise from navigation including analysis of existing noise profiles using baseline measurements. Modelling of changes in noise profiles due to local changes in navigation will be carried out as well as an assessment of zones of noise influences based on received sound pressure levels and various noise exposure criteria from the literature (see above)

- Barrier effects. For porpoises, investigations on behavioural responses at an existing bridge (Great Belt) will be undertaken to assess barrier effects *in situ*. For this purpose a comparative study will be conducted at the Great Belt Bridge, where the harbour porpoise distribution and the behaviour related to the distance to the bridge will be investigated in detail by means of visual and acoustic surveys. The surveys will be supplemented by underwater noise measurements in this area. Furthermore, potential alterations of the migration behaviour derived from the Great Belt Bridge will be investigated by the National Environmental Research Institute (NERI) utilising telemetric data from tagged harbour porpoises

- Alterations of behaviour and distribution due to habitat changes. Predicted changes will be estimated based on the assessments of modification of hydrodynamics and habitats. The assessment is based on the results from the other environmental investigation programmes (hydrodynamics, marine biology, fish). Finally, the impacts on harbour porpoises, harbour seals and grey seals will be estimated using these results and modelling and indications on diet in harbour seals gained during the baseline investigations

- Consequences of contamination of food sources will also be considered if the results from the study of release of substances from sediment spills (see Section 7.2.3) indicate a risk of noticeable contamination of the marine mammal's food sources.

7.5. Soil on Fehmarn and Lolland

Baseline investigations

A comprehensive description of the existing geology, soil texture classes and types of soils, as well as the effect on the natural soils from intensive farming, drainage, sealing, etc., will be prepared for the study areas.

On Fehmarn, the evaluation of the soils will follow the German methodology of the "Framework for population assessment and evaluation – and identification of compensation measures in landscape conservation planning in connection with road construction projects in Schleswig-Holstein"~~,~~ (Landesamt für Straßenbau und Straßenverkehr Schleswig-Holstein, 2004). The

Danish GEUS' classification of soils (soil types and potential yields) will be applied for Lolland (Danmarks Miljøportal, 2009).

Soil maps of the areas and geotechnical investigations carried out during the project, together with information from GEUS' Jupiter database (for Lolland) will be the foundation of the description of soils in the areas. Data on harbour areas, former factory sites as well as disposal sites for contaminated soils will also be included in the investigation in order to consider potential soil pollution (GEUS, 2009).

The importance and sensitivity of soil will be determined based on the following criteria: Importance of the soil for the ecosystem, the degree of naturalness, biotope development potential, natural yield potential, rare soil types and soils of importance to the cultural heritage as well as sensitivity to exposure to contaminants. Existing pressures and effects will also be considered. If necessary, supplementary field investigations will be carried out in order to clarify any uncertainties exposed during the collection and analysis of data.

For Fehmarn, the following existing data will be used:

- Landscape framework plan (Landschaftsrahmenplan), state planning area II (Ministerium für Umwelt, Naturschutz und Landwirtschaft des Landes Schleswig-Holstein, 2003)
- Local landscape plan (Landschaftsplan) for „Stadt Fehmarn“ (Stadt Fehmarn, 2007)
- General map of soils 1: 200.000 (Bundesanstalt für Geowissenschaften und Rohstoffe, 2001)
- Map of objects of geoscientific interest, which have to be protected („Geowissenschaftlich schützenswerte Objekte, GeoSchOb”), 1:250.000 (Geologisches Landesamt Schleswig-Holstein, 1991)
- Geological map of Fehmarn 1:50,000 (Geologisches Landesamt Schleswig-Holstein, 1958)
- Petrografical map of Fehmarn 1:25,000 (Geologisches Landesamt Schleswig-Holstein, 1957)
- Atlas of agriculture and environment of Schleswig-Holstein (http://www.umweltdaten.landsh.de/atlas/; Stand 2009)
- Soil information system of LLUR the Agency of agriculture, environment and rural regions, Schleswig-Holstein (currently under construction)
- Data from the inventory related to the B 207 hinterland road connection (GTU Ingenieurgesellschaft mbH, 2008/2009)
- Data of Femern A/S’ geotechnical information system (the 1999 Feasibility Study etc.)
- Groundwater modelling in the German ramp and approach area.

Data on sites with contaminated soils in the study area on Fehmarn will be acquired from the relevant authorities (The environmental authority in Kreis Ostholstein, Agency of agriculture, environment and rural regions S-H/LLUR). A supplementary examination of existing contamination levels of different heavy metals at selected sites in and around the ramp and approach area (e.g. railway tracks, harbour area) and their possible negative effects on soils (and groundwater) shall be carried out according to the directive of the German Soil Protection Ordinance (Bundesbodenschutzverordnung).

For Lolland, the analysis concerning soils will use the following existing data and information:

- GEUS soil type maps (Danmarks Miljøportal, 2009)
- GEUS soil classification maps (soil quality and fertility) (Danmarks Miljøportal, 2009)
- Data from Region of Sealand (Region Sjælland) on raw materials (Region Sjælland, 2008; Region Sjælland, 2007)
- Data from the "Region of Sealand" (Region Sjælland) on sites with risk of contaminated soils (vidensniveau 1) and sites where contaminated soils are known to exist (vidensniveau 2) (Region Sjælland, 2009)
- Data from the Danish Nature and Environment Portal, including data from the regional plan 2005-2017 (in the former County of Storstrøm) (Storstrøms Amt, 2005)
- Data from the spatial plans of the municipality of Lolland (Lokalplaner) (Rødby Kommune, 2004; Lolland Kommune, 2009)
- Data from the register of contaminated areas of Rail Net Denmark (Banestyrelsen Rådgivning, 2000)
- Information from the GEUS Jupiter database (GEUS 2009).

Information from former geotechnical investigations will be included, such as data from the 1999 feasibility study and a recent survey conducted by Femern Bælt A/S as part of the most recent baseline investigations (2008-2009). This survey includes reflection seismic profiling, MEP (Multi Electrode Potential), TEM (Transient Electromagnetic Measurements) and performance of an additional five borings in the area east of the existing motorway on Lolland.

Potential impacts

Potential impacts of the Fehmarnbelt Fixed Link are the following:

- Degeneration and loss of soils and draining of natural organic soils caused by the project due to physical structures, paving over, excavation and back filling
- Contamination of soils, possible alteration of biochemical processes and impairment of surface or groundwater-affected soils (contamination by emissions from traffic) caused by operation of the Fehmarnbelt Fixed Link.

Planned assessments

The degeneration and loss of soil caused by physical structures and the risk of soil contamination during the construction phase will as far as possible be assessed quantitatively in terms of spatial extent and volume. In addition, the expected contamination from traffic based air emissions will be quantified in time and space.

For Lolland the assessments will also include areas in the urban zone, in which the soil is classified as lightly contaminated (områdeklassificeret) by the Region of Zealand and the municipality of Lolland if such areas are affected by the project.

7.6. Inland Waters on Fehmarn and Lolland

7.6.1. Groundwater

Baseline investigations

The baseline investigation serves to describe the geological and hydro-geological conditions of the areas of investigation on Fehmarn and Lolland (Figure 2.7). For Lolland the description will be based on baseline data procured from the geotechnical borings and studies carried out by the Environment Centre Nykøbing Falster and GEUS (Geological Survey of Denmark and Greenland). For Fehmarn data on soil and hydro-geological parameters will be supplied by the Geological Agency of Schleswig-Holstein and existing publications.

To assess the risk of groundwater contamination, data on contaminated soil and spatial planning, which are collected during the soil baseline investigation, will be used (see section above on soil).

Relevant information regarding drinking water extraction will be gathered from the competent authorities and will include e.g. drinking water interests and aquifers and their vulnerability. Furthermore, waterworks and drinking water boreholes will be identified.

If necessary, further field investigations will be carried out to clarify possible uncertainties identified during collection and analysis of data.

Potential impacts

The project may cause the following impacts on groundwater:

- Risk of sea water intrusion to the groundwater etc. when performing permanent and/or temporary groundwater pumping
- Influences on the groundwater flow field (e.g. barrier effect of tunnel portals)
- Loss or deterioration of areas with special significance for groundwater, possible effects on the groundwater recharge

- Permanent or temporary lowering of the groundwater table
- Demand for consumption of groundwater during construction and operation
- Contamination of groundwater/drinking water resources.

Planned assessments

For Lolland and Fehmarn a geological and numerical groundwater model of the study area will be established. This model will be used to assess changes in groundwater table and potential impacts on the groundwater caused by the establishment of the fixed link (e.g. near a tunnel portal).

The hydro-geological models will be used to simulate permanent and lowering or rising of the groundwater table. Impacts on groundwater resources (quantity) and groundwater quality caused by different project components (tunnel portal, bridge ramp etc.) will also be assessed.

The risk of groundwater contamination due to accidents during the construction and operation phases will be assessed. Furthermore, the effect of an eventually lowering of groundwater table on the dispersion of contamination can be simulated, if relevant. The risk of groundwater contamination caused by traffic during the operation phase is also addressed.

7.6.2. Surface Waters

Baseline investigations

Watercourses (ditches), lakes and ponds and other small water bodies in the study area will be mapped, described and evaluated on the basis of field surveys and a thorough literature review, including their actual and targeted condition. The investigations will focus on the biological importance of the water bodies. Their vulnerability to pollution will be assessed.

In accordance with "Framework for population assessment and evaluation – and identification of compensation measures in landscape conservation planning in connection with road construction projects in Schleswig-Holstein" (Landesamt für Straßenbau und Straßenverkehr Schleswig-Holstein, 2004) the value (importance) and sensitivity of the surface water bodies on Fehmarn will be determined according to two value and sensitivity levels (general value/sensitivity and special value/sensitivity). The following criteria will be applied: Drainage basin of the water bodies, degree of naturalness, rareness in the natural ecosystem, water quality, self-cleaning capacity, stream flow, potential for water retention and the sensitivity to new and existing pressures.

For water areas on Lolland, two formalised indices will be used; namely the DVFI (*Danish* Watercourse Fauna Index, Vejledning fra Miljøstyrelsen nr. 3, 1998) and an index related to the conservation objectives ("Målsætning for vandløb og søer") according to the regional plan (Storstrøms Amt, 2005).

Potential Project impacts

During the construction phase, surface water bodies may be affected by storm water run-off from the construction site and oil spills from construction equipment.

During the operation phase, storm water run-off from road and ramp areas may increase the risk of contamination of surface water bodies. Events of particularly high run-off may cause temporal local flooding.

A temporary or permanent groundwater lowering may also affect the water level of surface water bodies in the ramp and approach areas.

Planned assessments

Based on the design of the ramp and approach facilities, the following impacts on surface waters during the construction and operation phases will be assessed:

- Effect of temporary and permanent groundwater lowering on surface waters
- Effect of alterations in stream flow in water courses due to run-off water from paved over areas
- Deterioration and loss of surface water bodies
- Negative effects of pollutants due to release to the watercourses.

The significance of the different impacts will be presented and the possible alterations of stream flow and naturalness will, as far as possible, be described quantitatively.

7.7. Fauna, Flora and Biodiversity on Fehmarn and Lolland

Baseline investigations

Fauna and flora within the area of investigation will be mapped, described and assessed on the basis of:

- Mapping and field surveys carried out in 2008 and 2009 and supplementary investigations in 2010. Field surveys are scheduled in a way to match with the optimal season or time of the day of important species
- Results of the field surveys/mapping carried out during the 1999 Feasibility Study (Femern Bælt COWI-Lahmeyer, 1999) will be used to identify trends
- A thorough literature and database review - e.g. themes from planning documents and publications and other information from the national authorities, the municipalities, scientific institutions and NGOs

- Input from super-regional or local experts on the occurrence of certain animal and plant species (e.g. insects, amphibians, bats, vascular plants, mosses and lichens (Lolland only) and fungi)
- Ship-based registration of bat migration in context with the radar surveys on bird migration by means of bat detectors as well as fixed installed detectors for permanent surveys (Anabat) on a Scandlines ferry boat.

Extensive field surveys will be conducted within the study areas. The surveys include protected biotopes according to §3 of the Danish Nature Protection Act and §21 Nature Protection Act of Schleswig-Holstein respectively, areas with habitats listed in Annex I of the Habitats Directive, as well as other significant habitats such as forests, hedgerows, water courses and brownfields.

The applied methods applied for mapping of fauna and flora species are listed in Appendix C. The listed species groups have been selected based on their value as indicators and their protection status.

Potential impacts

The potential impacts on present plant and animal species and habitats as well as biodiversity will be assessed – quantitatively to the extent possible. Potential impacts include impacts on breeding, foraging and resting sites for animals and on habitats for plants and fungi during the construction and the operational phases.

The potential impacts related to the ramp and approach areas include:

- Temporary and permanent loss of habitat (e.g. backfilling of ponds affecting amphibians, dragonflies and other organisms, tree felling or removal of buildings affecting bats, paved over areas etc.)
- Barrier effects which may cause fragmentation of habitats and genetic isolation of e.g. populations and meta-populations of mammals, amphibians and reptiles as well as disruption of migration routes between the breeding habitats of amphibians and their other summer and winter habitats
- Potentially increased migration of species between Denmark and Germany due to the possible use of the fixed link by animals (in general as well as by invasive species)
- Changes of nitrogen deposition may result in local changes of eutrophication (unlike cars, ferries do not operate with catalytic converters). The changes of NOx and N deposition and concentrations will be calculated
- Temporary or permanent drainage measures, which change the hydrology and which may thus change the species composition in the area
- Increased mortality of amphibians, reptiles and mammals caused by road or rail traffic

- Direct killing and disturbance of mammals, amphibians, reptiles or insects in the construction phase
- Temporary deterioration of biotopes through noise, vibration, light, dust, etc. during construction phase
- Risk of contamination of natural biotopes in the construction phase through e.g. discharge or spill of harmful substances, storage of surplus soils etc.

Planned assessments

The impacts on fauna, flora including the biodiversity will be assessed based on knowledge obtained from the baseline studies of existing plant and animal populations. The assessments comprise:

- An assessment of the direct loss of registered biotopes and habitats as a consequence of area claims, as well as assessment of the impairment through noise, light and dust emissions. This serves as a basis to stipulate the need for compensation measures. This is part of the Danish environmental impact statement, whereas in Germany, this will be treated separately in the landscape conservation plan
- An assessment of the meta population structure – particularly of amphibians – through GIS-analyses and based on species specific movement ranges in order to describe potential effects on local populations and their possibilities for migration. Identification of the needs for conservation of particular biotopes and landscape elements of ecological importance, and compensation measures (e.g. new ponds, hedgerows etc.)
- Assessment of other interactions and isolation of e.g. mammals and reptiles in interaction with impeding or amplifying effects caused by the project
- An assessment of the potential for regeneration of organisms after loss or deterioration of habitats with special emphasis on protected and red-listed species including temporarily deteriorated areas as well as possible compensation areas
- The extent of deterioration of biotopes affected by temporary or permanent changes of the groundwater table will be quantified by modelling including an evaluation of the sensitivity of the area towards the expected changes. In this context, groundwater close to the surface requires special attention.

Birds are treated in the separate section 7.9 below.

A presentation of the required impact assessments of Natura 2000 sites and strictly protected species is given in the chapters 8 and 9.

7.8. Landscape on Fehmarn and Lolland

Baseline investigations

The landscape and the visual conditions in the areas of investigation on Lolland and Fehmarn (Figure 2.7) will be mapped and described on the basis of field surveys and a literature review (e.g. the 1999 feasibility study, landscape analyses, conservation plans etc.) and assessed through map analysis and visualisations.

One main principle of the landscape analysis is a map analysis focused on geomorphology and topography. A comprehensive description of the natural and cultural landscape as well as of existing disturbances of the landscape features will be prepared. The different assessment approaches for such issues in Germany and Denmark will be accounted for.

Regarding the landscape on Lolland, the so-called landscape character assessment method will be applied as the tool for assessments of the landscapes c.f. “Guidance on the Landscape in the municipality planning” (Vejledning om landskabet i kommuneplanlægningen, Miljøministeriet 2007). The method is GIS facilitated and consists of both desk studies and field surveys. The method identifies so-called landscape character areas.

After the desk study a field survey is applied to adjust the boundaries of the landscape character areas, and a visual and spatial analysis will be carried out. The result is a map with boundaries of each landscape unit. The field survey will be supplemented by a vulnerability study to identify the landscapes that are most sensitive to the establishment of the Fehmarnbelt Fixed Link.

The approach for the Fehmarn area is very similar. The value (importance) and visual sensitivity will be expressed by four category levels to "Framework for population assessment and evaluation – and identification of compensation measures in landscape conservation planning in connection with road construction projects in Schleswig-Holstein", 2004. Criteria for the assessment of the value and visual sensitivity of the different landscape units are naturalness, historical continuity, uniqueness and diversity of the landscape, and the existence of open and visible areas and, finally, the existing disturbances (noise, odours, air pollution, disruptive buildings and technical infrastructure).

Potential impacts

Due to the structure of the landscape on Fehmarn and Lolland, which is predominantly flat and open, the project will – in case of a bridge solution – be a dominant factor, which entails visual impacts on the natural scenery.

Potential impacts on the landscape include, disturbance of the visual perception of the landscape, loss of characteristic landscape elements, fragmentation of characteristic landscape units and disturbance of visual and functional connections (barrier effect) caused by the con-

struction site and the presence of the fixed link. Additional effects on the perception of the landscape may occur due to noise, air pollution and lighting.

Planned assessments

Based on the landscape analysis, evaluation and visualisation, possible conflicts between the project and landscape features and functionalities will be assessed. The assessment will be based on:

- 2D-maps of the delineated landscape units for the quantitative and qualitative description of area loss and loss of landscape structures in the landscape units in question as well as deterioration of visual relations
- A 3D landscape model as a general planning tool for the visualisation
- A number of “photo-match” visualisations, i.e. photo-like images showing the fixed link from the air and from the ground
- Ad hoc visualisations of the project including dynamic models (3D) and photorealistic renderings.

7.9. Bird Life

Baseline investigation

Bird life will be described and depicted cartographically on a local scale, i.e. in the alignment corridor, and on a regional scale. The baseline investigations will focus on the following items:

- Abundance, distribution and trends (from historical data) of birds in the approach and ramp areas and the surroundings on Fehmarn and Lolland, as well as of water birds and seabirds in the Fehmarnbelt area
- Feeding grounds for seabirds and water birds in the sea
- Local flight patterns of land birds, seabirds and water birds
- Migration of land birds, seabirds and water birds.

The investigation will take place in the area bordered by the lines between Kiel and Langeland in the West and between Gedser and Dahmeshöved in the East (Figure 7.12). The extent of this area of investigation ensures that the bordering EU special protection areas (SPAs) and those in the Fehmarnbelt are completely covered. Specifically these are the SPAs in the eastern bay of Kiel and in the Baltic Sea, east of Wagrien, as well as in the Rødsand Lagoon. Significant resting grounds on the western edge (Stoller Grund) and on the eastern edge (Gedser Rev) are included in the investigation area. The relatively wide extent of the investigation area both eastwards and westwards is to enable the investigation of possible gradients in the numbers of different species and to identify particularly high concentrations of birds. Furthermore, the investigation area covers the maximum area, which could possibly be influenced by sus-

pended sediments, as identified in previous model studies. The size of the area allows for the later delineation of unaffected areas for comparison and monitoring.

For the baseline investigation of bird life, the following data will be consulted:

- Data from surveys on land bird breeding numbers in the ramp area
- Data from monthly aerial and ship-based surveys of non-breeding birds along transects
- Data from water bird population density calculations
- Data about bird migration from studies using radar and visual observation as well as acoustic surveys
- Radio, satellite and GPS telemetric data about the foraging patterns and local movements of specific water bird species
- Analysis of ringing data regarding the origins of populations in the Fehmarnbelt
- Other historical data from monitoring and scientific studies which have been carried out in Denmark, Germany and Baltic Sea countries and which contain information necessary for abundance analysis and for ascertaining population trends. Where possible, original data will be used in the analysis.

Overall, the baseline investigation of bird life includes the following:

- Quantitative survey of abundance, distribution and trends of breeding and non-breeding birds in the two approach and ramp areas
- Quantitative survey of abundance, distribution and trends of seabirds and water birds at sea (Figure 7.12)
- Qualitative and quantitative (where possible) survey of water birds' use of feeding grounds
- Survey of the feeding ecology of water birds on the basis of habitat mapping and telemetric and food consumption surveys
- Survey of migratory behaviour of water and land birds with the aid of visual and radar observation as well as night migration study
- Additional evaluation of existing Danish weather radar data.

Data on the quantitative evaluation of abundance, distribution and trends of breeding and non-breeding birds in the approach and ramp area on Fehmarn will be surveyed in line with German regulations for railway and road construction. The mapping of breeding birds will be carried out according to the standards for breeding bird mapping set by Südbeck *et al*. (2005). All seasons will be surveyed as part of the investigation, with a special focus on the breeding season. Important areas for species to be dealt with as a priority (Red List, Annex 1 of the EU

Birds Directive) will be taken into consideration in both countries. On Lolland the survey of breeding birds will be carried out in relevant habitats outside of the cultivated areas.

Data collection for the quantitative evaluation of abundance, distribution and trends of seabirds and water birds at sea will consist of counts carried out using standard visual observation methods, also commonly used in environmental impact assessments for offshore and onshore wind farms and for research studies (according to German regulations, StUK3, BSH 2005). In the area around the Fehmarnbelt, including the alignment corridor and several Natura 2000 sites aerial and ship based surveys will be carried out monthly in 2009 and 2010 along parallel transects with a spacing of three kilometres. In the coastal lagoons Rødsand Lagoon and Orth Bay additional aerial surveys will be carried out to assess the number of herbivorous water birds, in particular swans.

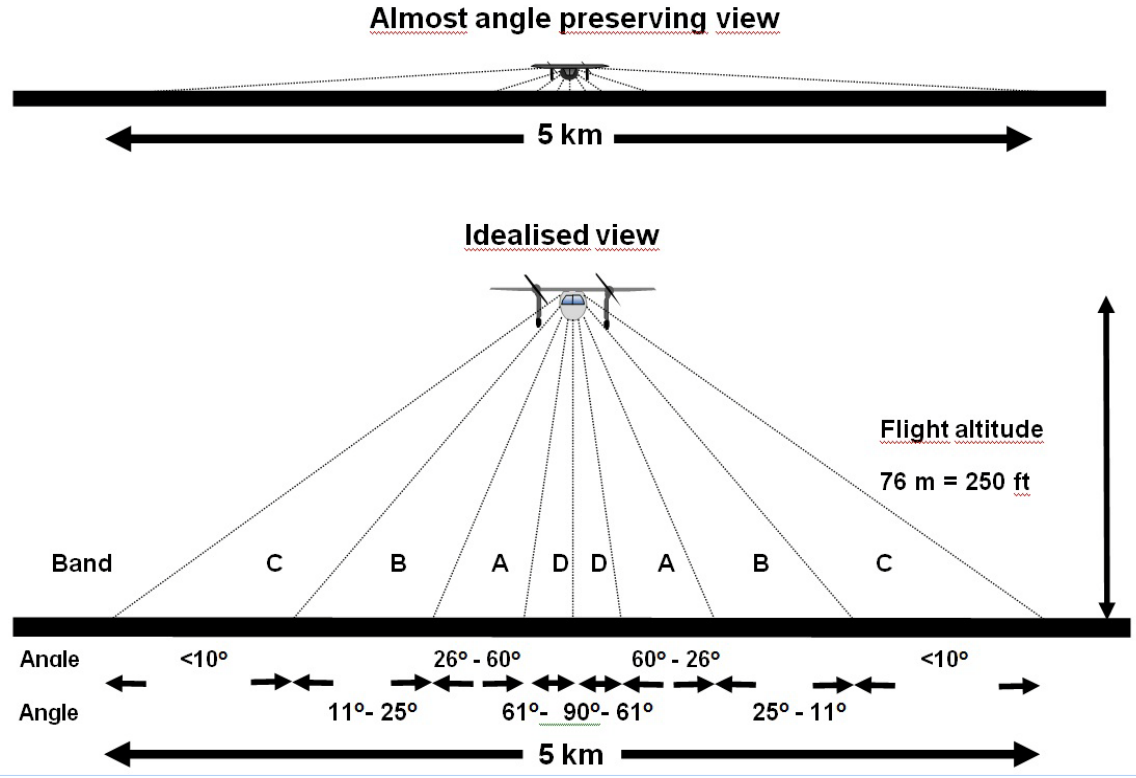


Figure 7.13 Methodology for aerial surveys: division of the transect sections.

The aerial surveys will be carried out according to standard methods (Diederichs *et al*. 2002, Petersen *et al*. 2006) with two-motor airplanes at 250 feet altitude. The airplanes used have 'bubble windows', which enable the observers to look directly down at the birds on the transect. The distance to the birds from the transects will be estimated in defined distance categories in order to generate a subsequent calculation of the density (birds per area unit) with the DISTANCE software (http://www.ruwpa.st-and.ac.uk). This is necessary for the calculation of the detection intervals and calculation of the total population. The surveys will be carried out by three observers and all observations will be recorded with a dictaphone.

The counts from ships will be carried out in the coastal and open waters of the Fehmarnbelt. Methods are applied according to the standards set by the European Seabird-at-Sea Programme. Four observers record birds according to species, behaviour and distance to transect from a raised platform on the ship. The observation platforms are located 7-10 metres above the sea. The ship counts enable the surveying of areas and species close to the coast, which would be harder to survey from an airplane. The calculation of the detection intervals and bird density will be carried out with DISTANCE software (http://www.ruwpa.st-and.ac.uk) as for the aerial observations. This will enable the calculation of total numbers of birds.

The total number of birds in the investigation area and their distribution in various locations, habitats and water depths will be determined with spatial models analysing the visual observations of the transect counts, using geostatistical methods and taking various environmental parameters (water depth, habitats, distance from the coast, hydrographic parameters) into account. Including environmental parameters in the calculation enables greater accuracy and greater spatial resolution of the results and at the same time provides a better basis for the estimation of project related impacts. Established modelling methods and multivariate regression analysis will be used. The analyses are based mainly on data and models from the hydrographic and benthic studies.

For the survey of water birds' use of feeding grounds, two different methods will be combined: Telemetry and food consumption surveys. The investigations concentrate on selected species of seaducks and diving ducks, but plant-eating water birds and fish-eating birds will also be included in the investigation. The telemetric and food consumption will focus on the common eider, the long-tailed duck, the common scoter and the tufted duck. Furthermore, food consumption surveys of swans and fish-eating species such as the cormorant will also be carried out. For the telemetric investigations, radio and GPS transmitters will be attached to seaducks in order to follow their foraging patterns closely and to record their diving activity. The stomach content of dead birds will be analysed for the food consumption survey.

The results of the telemetry investigation and the feeding ecology investigation will be analysed together with the investigation results on the distribution of the relevant species as well as the distribution of the organisms they feed on. The aim is to establish the dependencies of the bird populations on particular types of habitat in the area and thereby to show how they will be affected by changes to these habitats.

The investigation of the migration of seabirds, water birds and terristrial birds will be based on visual observations and radar observations as well as acoustic surveys in the Fehmarnbelt area. Investigations will be carried out in at least two locations on the coast (Lolland and Fehmarn, respectively) and by a ship anchored in the middle of Fehmarnbelt. The investigations will be performed during the migratory months and also during the moulting migration, i.e. from February to November.

To produce data on the numbers, flock size and the flight paths of the different species, visual observation is essential. The visual range is, however, limited to less than 1.5 km from an offshore ship and to less than 5 km from the coast with stronger optical equipment. Observation can thus only be carried out during the day in good visibility. Visual observations will be carried out in approximately 120 days at the two land stations in Rødbyhavn and Puttgarden and in 60 days from a ship. The applied methods follow the specifications set by German regulations, the StUK 3.

For the survey of bird migration at altitudes above the visible area and during the night, images from ships' radars will be assessed. Migratory direction will be surveyed with the help of images from ship surveillance radars with a horizontally turning axis. Altitude distribution and the concentration in the flyway will be surveyed with the help of images from similar radars turning vertically. Conventional ship radar systems with 25 kW power will be used for the investigation. The radar images will be evaluated visually, and individual birds as well as flocks of birds will be identified. Again, the applied methodology follows the specifications set by German regulations, the StUK 3. To avoid radar reflections from waves, the instruments on land will be surrounded by a special fence to shield the lower area. The radar surveys will take place in four locations: Rødby, Puttgarden, a ship in the Fehmarnbelt and at the Westermakelsdorf weather station on the coast of Fehmarn. At the land stations the radar instruments will be constantly in operation, at sea the observations will take place in 60 days during the main migration times.

In Rødbyhavn und Puttgarden a tracking radar with a pencil beam antenna ('Superfledermaus', Bruderer *et al*. 1995) will also be used to directly track flight paths, altitudes and flight patterns of birds and flocks of birds. The tracking radar will enable a more precise survey of particular aspects of bird migration because of its special antenna and better performance, but can only be employed on land. The 'Superfledermaus' (Super Bat) will be in operation continuously from March to November. Its use began in 2009 in Rødby and will continue in 2010 in Puttgarden.

The combination of different methods enables the comparison and calibration of the methods against each other and can thereby reduce or eliminate fundamental problems in the quantification of migration data (Schmaljohan *et al*. 2008).

The investigations of bird migration will include a survey of local movement patterns between resting and feeding grounds. These cannot be examined in isolation from migratory movements over greater distances during the main migration periods. However, investigations will

be carried out outside of the main migration periods, enabling a better survey of local movement patterns.

Information on the large-scale patterns of bird migration will also be collected through the evaluation of available data from various weather radar stations in Denmark, which will supplement the investigations in the Fehmarnbelt. A method for the analysis of bird echoes from the weather radar data available will furthermore be developed by the Danish National Environmental Research Institute (NERI) and the Danish Meteorological Institute (DMI), which will also analyse the data from the five Danish weather radars within a 70 km radius. The aim is to describe the migration dynamics on a large-scale and to identify flyways.

In order to attain as complete a picture as possible of the regional migratory patterns in the Fehmarnbelt, the data will be supplemented by studies of bird migration along the coast of Fehmarn, Lolland and Falster.

The results of the bird migration investigation will be evaluated with regard to species diversity, migratory direction, migratory routes and altitude distribution with reference to meteorological factors. Insofar as species-specific and quantitative data can be collected, an estimate will be made of the bird populations passing over the Fehmarnbelt. Furthermore, their sensitivity towards the construction of vertical structures will be assessed.

Potential impact

The potential negative effects on birds are disturbance during the construction phase, direct effects of the fixed link structures and indirect effects caused by potential changes to their habitats. Barrier effects will occur when birds flying over the Fehmarnbelt or along the coast are hindered in crossing over this area. These effects can be caused by the physical structures themselves or by construction machines or the asociated noise and light emissions and other activities carried out during construction. Another possible effect is spatial displacement, whereby water birds are prevented from using their usual resting and feeding grounds. The consequences of this kind of stress depend on the number of birds in the alignment corridor, the sensitivity of individual species and the ability to adapt to the disturbances over time. Sensitive species groups in the Fehmarnbelt more than likely include diving ducks, grebes, seaducks and auks. The number of non-breeding water birds resting in the actual alignment corridor is, however, generally low.

The most important issues are:

- Changes to the number of water birds, their behaviour and their distribution because of the permanent loss or gain of feeding grounds. Feeding and resting grounds are lost through permanent deterioration or change of the seabed and through the areas claimed for land facilities. On the other hand bridge piers and other new constructions could serve as new habitats (artificial reefs), which would increase the food supply available, such as mussels and fish

- Temporary changes to the use of feeding grounds by water birds because of suspended sediments from dredging would change the suitability of these feeding grounds. Species groups which are more than likely to be particularly sensitive to such changes are swans and bivalve-eating seaducks and diving ducks. Though these effects are probably temporary, they could continue right up until the operational phase
- Permanent changes to the use of feeding grounds by water birds because of possible barrier effects, in particular because of habitat displacement due to the construction of a bridge, in this case the displacement of feeding grounds
- Barrier effects on the migratory movements of water and land birds over short and long distances because of physical constructions, but also because of noise and light emissions
- Risk of collision with bridge constructions: This risk will result from a bridge solution and will probably be strongly influenced by the lighting of a bridge, but also by structural characteristics, such as slip roads, bridge height, cables and cable connections, colour etc.
- Loss and changes to habitats for breeding and non-breeding birds around the ramp and approach areas, as well as disturbance because of construction work and noise and light emissions.

Planned assessments

The planned assessment will mainly cover two main themes. Firstly, the direct consequences of the planned fixed link in the construction and operational phases will be assessed. Secondly the derived consequences of changes to habitats due to effects on the benthic fauna and flora will be analysed and assessed.

Possible changes to the availability of food sources will primarily be assessed on the basis of numerical models of the conditions, the distribution, the amounts and the quality of food organisms combined with data about the food ecology in order to quantify these kinds of changes using spatial-statistical models. The main focus will be on seaducks and diving ducks, whose primary food source is bivalves.

Other important aspects of the planned assessment are:

- Changes to the use of resting and feeding grounds, i.e. the effects of habitat displacement:
  In order to minimise the risk that predictions are confused with natural fluctuations of food sources, an ecosystem aproach has been chosen. The assessment of possible changes to habitats will be based on the data and modelling results of the benthic investigations. Forthermore, predictable effects on the conditions of birds and the effects on the size of the population will be investigated. All existing and available data on the population dynamics of significant species will be consulted for this purpose

- Effect of a bridge on migratory birds:
  This assessment is based on investigations of the reactions of birds and their routes at numerous large bridges, such as the Øresund bridge, the Great Belt bridge (Storebælt), the bridges over the Farøsund (Storstrøm and Farø Bridges) and the bridge over the Kalmarsund. In the studies in winter of 2009/2010 the Fehmarnsund bridge was also included. Investigations at these bridges will be carried out in parallel to the main surveys in the Fehmarnbelt about migration by day and by night. The expected effects on long-distance migratory patterns will be assessed with the aid of a combination of expected behavioural reactions and bench marks for selected migratory bird species and normal migratory routes as well as estimates of changes to energy requirements. Negative effects on short distance migration routes of birds between resting and feeding grounds on Lolland and Fehmarn and along the coast will be investigated as well. For this purpose changes to the distribution and flyway will be analysed as well as changes to the energy requirements of individual species
- Risk of collision in the case of a bridge:
  The risk of collision of particular species groups with bridge structures and the traffic on the bridge will be assessed on the basis of previous studies on other bridges and other vertical structures as well as the results of investigations of species-specific avoidance behaviour. For this purpose data on bridge construction, biological data on the birds, such as wing-span, flight speed and style (gliding or wing-beating) and bench marks regarding abundance and distribution of species will be consulted. The impact of lighting will also be fully assessed.

7.10. Air Quality

Baseline investigations

The baseline regarding air quality will also deal with the present air pollution levels. For estimating the present air quality dispersion modelling of the existing sources will be carried out. This includes in particular all transport related sources including ferries and other important emission sources in the harbour areas or in the vicinity. The method is described in more detail in Section 4.2. In addition, air quality monitoring data from representative sites will be considered to estimate representative background level of air pollution.

Potential impacts

The potential impacts on the ambient air quality caused by air pollution from the construction and the operation of the fixed link include:

- Changed levels of pollutants due to increased road transport in the operation phase
- Changed levels of nitrogen deposition and eutrophication due to increased road transport in the operation phase

- Temporary increased levels of dust and other pollutants due to the construction work.

Planned assessments

The planned impact assessments will include emissions and expected pollution levels at different distances from the planned fixed link. The assessments will be carried out as described in Section 4.2.

7.11. Climate

7.11.1. Global Climate

Baseline investigation

The baseline investigation comprises calculation and assessment of the total greenhouse gas (GHG) emissions from continued ferry operation and associated traffic as defined in the zero scenario (the no-build option). This assessment has already been made in a previous study (COWI & NERI, 2005).

Potential impacts

The establishment of a fixed link across Fehmarnbelt may change the overall emission of greenhouse gasses and thus the manmade contribution to the global climate change. Basically, the emissions of greenhouse gasses directly related to the construction and the road traffic on the link should be investigated. While the construction phase of the fixed link will entail a considerable increase in the emission of CO_2, the picture is more complicated in the operation phase. In principle, the fixed link may cause long term increase of the CO_2 emission due to increasing road and rail traffic. On the other hand a large reduction of the CO_2 emission will be obtained if the ferry services are reduced or discontinued. Finally, the improved, electrified rail connection between Scandinavia and the central Europe may also cause a reduced CO_2 emission from passenger flights.

Planned assessment

The GHG emission will be assessed as described in Section 4.2.

Quantitative estimates of the future GHG emission in the operation phase of a fixed link compared to the zero scenario has already been provided in a previous study (COWI & NERI 2005). These calculations will be supplemented with estimates of the emissions related to the production and construction of the fixed link.

The quantitative emission scenarios related to traffic are based on conventional electrified train service and conventionally fuelled road traffic. The robustness of these scenarios seen in the light of potential future technological developments within the traffic sector will be discussed and evaluated.

7.11.2. Local Meteorological Conditions

Baseline investigation

Baseline information on the local wind climate will be provided by continuous wind measurements at the wind farm Rødsand 2, which is presently under construction about 10 km east of the project corridor. Supplementary data of the regional climate are already available. As the local meteorological conditions are generally determined by the regional climate, no further investigations on Lolland and Fehmarn are considered necessary.

Potential impacts

Any fixed link structure related to the fixed link bridge or tunnel will give rise to changes in the wind climate in the immediate vicinity. These changes will include turbulence and shelter effects, which in turn may cause very local effects on the marine water mixing and flow and cause changes in the living conditions for fauna and flora also on land. The shelter effect may cause a marginal reduction of the wind speed farther away from the fixed link. Theoretically, these changes may influence human beings, flora and fauna as well as the performance of nearby wind turbines.

Planned assessment

The possible shelter effect at different distances from the fixed link under the prevailing wind conditions will be estimated, and the possible implications for nearby wind turbines will be assessed.

7.12. Cultural Heritage

Baseline investigations

The cultural heritage assets and characteristics in the area of investigation (Figure 2.7) will be mapped based on available information supplemented by field studies. Subsequently, potential conflicts will be identified and described.

For Fehmarn, existing information will be gathered from:

- The landscape Framework plan (Landschaftsrahmenplan), planning area II (Ministerium für Umwelt, Naturschutz und Landwirtschaft des Landes Schleswig-Holstein, 2003) and the overall landscape plan of Fehmarn (concerning culture-historical landscape) (Stadt Fehmarn, 2007)
- Data from the Archaeological Department of Schleswig-Holstein (protected archeological monuments, potential monument sites, listed places of finds in the archaeological register (Archäologische Landesaufnahme) (Archäologisches Landesamt Schleswig-Holstein, Stand Januar 2008)

- Data from the State Office for Preservation of Monuments of Schleswig Holstein and also the Kreis Ostholstein (historic buildings) (Kreis Ostholstein, Fachdienst Regionale Planung, Stand 2009).

The investigations will focus on an extended, potential cultural heritage site ("*Verdachts-fläche*") located between Bannesdorf, Marienleuchte and Puttgarden. The scheduled investigation programme on cultural heritage consists of 3 phases: Phase I (prospection), an inventory of existing knowledge of the archive data and an assessment of the relevance of the data in relation to the project (after set-up of the investigation strategy). In phase II, a preliminary field investigation of significant monuments and sites (Sampling) will be carried out. Phase III is - if needed - excavation. This will be considered later and only if sites of archaeological interest will be directly affected by the project when the alignment has been identified. The Archaeological Department of Schleswig-Holstein will carry out this investigation programme.

For Lolland, existing information will be gathered from:

- The local Museum Lolland-Falster (Lolland-Falsters Stiftsmuseum og Lolland Kommune, 2008)
- The Heritage Agency of Denmark (Kulturarvsstyrelsen, 2009 a,c)
- The Regional Plan 2005-2017 (Kreis Storstrøm, 2006)
- The strategy plan and municipal plan for the Municipality of Lolland (Lolland Kommune, 2009; Rødby Kommune, 2004)
- Topographical maps
- The Danish central register on cultural history (Det Kulturhistoriske Centralregister, DKC) The register on Danish protected and preservation-worthy buildings (Register over fredede og bevaringsværdige bygninger, FBB) (Kulturarvsstyrelsen, 2009b).

The investigations will focus on the cultural heritage including valuable cultural landscapes, protected monuments, protected earth and stone dikes, historical road sections, archaeological finds, areas defined as cultural heritage areas, protected and preservation worthy buildings, churches and church surroundings.

The investigation consists of three main phases: 1) mapping of cultural heritage values 2) assessment cultural heritage values and the vulnerability of these, and 3) assessment of the potential impacts and the possible planning of the required mitigation measures.

The investigations will be carried out in cooperation with the Museum of Lolland-Falster in order to draw on local experience and knowledge.

As regards marine archaeology in the alignment corridor, existing information will be gathered from:

- Expert knowledge about the area, most importantly at the Viking Ship Museum in Roskilde and the Archaeological Department of Schleswig-Holstein

- The Danish central register on cultural history (Det Kulturhistoriske Centralregister, DKC) and a comprehensive private register
- Observations from the geophysical investigations carried out in the potential link corridor in 2008 using side scan sonar, multibeam echosounder, sub-bottom profiler and magnetometer.

Supplementary investigations of shipwrecks and other possible archaeological finds will be carried out by The Viking Ship Museum in Roskilde in cooperation with the Archaeological Department of Schleswig-Holstein, and covering both international waters and Danish and German marine territorial waters.

Potential impacts

The Fehmarnbelt Fixed Link will affect the cultural landscape and very likely also the cultural structure and elements in and close to the study area.

Potential impacts on the cultural heritage include:

- Loss of cultural heritage assets above and below the ground or seabed surface due to construction activities or establishment of fixed link structures
- Potential locally increased erosion of the seabed due to fixed link structures, which might expose buried wrecks or other cultural heritage. This will make the items much more susceptible to degradation processes
- Visual disturbance of cultural landscapes and cultural environments potentially caused by the fixed link by crossing earth and stone dikes or cutting through cuts through – or passing close by – protected monuments or historical buildings etc.
- Introduction of new barriers, which cause fragmentation of the landscape and may affect e.g. intact earth and stone dikes
- Disturbance of functional or historical connections (barrier effect) of cultural heritage assets like ancient roads and tracks, small villages etc.
- Disturbance because of vibration.

As far as possible, impacts on cultural heritage should be avoided, since mitigation measures will seldom be able to restore the heritage without losing the authenticity. All locations with finds identified in the baseline investigations, which may possibly be affected by the construction, will be investigated further. Any item or location of archaeological value will be investigated (and excavated if needed) and documented. In case that possible finds are discovered during construction it is a legal obligation to discontinue the activities until the object is sufficiently investigated, documented or eventually excavated.

Planned assessment

Possible conflicts between the project and the cultural heritage, including cultural environs and their functionality, will be assessed. The risk for direct losses of archaeological findings will be assessed. The presentation of the analyses will mainly be qualitative descriptions.

7.13. Material Assets

Baseline investigations

Material assets in the study area will be identified. The investigations will include, *inter alia,* buildings, wind parks, coastal protection (dikes), transport infrastructure like ferry traffic, ferry harbours, marshalling yards, and possible sites for extraction of raw materials.

Information will be gathered from, *inter alia*, the competent Danish and German authorities.

Potential impacts

Material assets like e.g. the wind farms, dikes or the ferry harbours may be affected by the project and their function may be restricted. In relevant cases an examination will establish whether replacement sites for the functions are required and whether such sites are available.

Other material assets like towns, small villages, areas for dwelling and recreation, public institutions (schools, day care centres, administration buildings etc.), roads and railways, high-voltage power lines, natural gas pipelines, Lolland Falster Airport, trade/retail buildings and industry may be affected. The treatment of these issues has already been partly described in other sections like the one about the impacts on human beings, and will also be touched upon in the section about socio-economic effects.

Planned assessment

Possible conflicts between the project and the material assets and their function will be assessed. The presentation of the analyses will mainly be qualitative descriptions.

7.14. Interactions between environmental factors

In accordance with the EU EIA-directive, Article 3 and the German EIA act (UVPG, § 2, subsection 1(2)) and the Danish EIA legislation (Bekendtgørelse nr. 1335 om vurdering af visse offentlige og private anlægs virkning på miljøet (VVM) § 7), the EIA includes the identification, description, and assessment of the direct and indirect effects of a project on human beings (including human health), fauna and flora (including biodiversity), soil, water, air, climate, landscape, material assets and the cultural heritage as well as the interactions between these factors.

”Interactions” pursuant to the EIA-legislation include all possible functional and structural interactions within the individual factors, between the factors and within and between the ecosystems (FGSV, 1997). Considering these interactions, effects are usually added or raised to a power, but in some cases they may be reduced.

One example of an interaction within an environmental factor could be the factor “soil” where mutual independence exists between soil type and the water and air balance of the soil. An example of the interaction between factors is the dependence of the vegetation on the local abiotic conditions. The factor “human beings” has a special position when considering the interaction between the factors because human beings do not directly form part of the biological, geological and chemical cycle of the natural ecosystems. The diverse influence of human beings on the natural ecology and the landscape is mainly assessed by considering the present human impacts on the other factors.

Interactions within the ecosystems mean dependencies and other interactions between all biotic and abiotic factors. The interactions between ecosystems mean interactions between adjacent as well as spatially separated ecosystems. One example of such interactions is the transport of substances. Thus, the consideration of the interactions within and between ecosystems cuts across the individual environmental factors. Identification and description of geographically delimited sub-ecosystems makes it possible to adopt an ecosystem based approach, in which the properties of an area and the impacts of the project are taken into consideration. Subsequently, the individual effect interactions of each sub-ecosystem can be compiled for all environmental factors. These sub-ecosystems can be designated as interaction complexes. These complexes can be classified using the existing vegetation and abiotic characteristics (local conditions) as indicators (FGSV 1997).

The stability of the interaction complexes and their potential for development is decisive for the assessment of these. The stability can be derived from the naturalness and maturity of the complexes as well as their size. The following basic principles can be applied: Complexes with a high degree of naturalness can be assumed to be stable because the human impacts in these cases are relatively small. The maturity can be estimated from the stretch of time during which the complex has developed. In case of a high maturity, complex interactions can develop, which increased the resistance of the system towards changes. Similarly, the stability can be assumed to increase with increasing size because large systems more easily compensate for disturbances.

Based on the assumptions above, interaction complexes in the study areas are listed below. The list is restricted to complexes assumed to be relevant to the environment and environmentally motivated decisions within the framework of the present project (c.f. UVPG, § 6, subsection 1(1)):

- The coastal landscapes on Fehmarn and Lolland: Complex interactions between marine and terrestrial, biotic and abiotic structures as well as land use (recreation, coastal defence etc.)

- Low-lying areas and wetlands on Fehmarn and Lolland: Low-lying areas “Blankenwisch” (potentially “Grüner Brink”) and “Presen” on Fehmarn and wetlands behind the Lolland dike. The complexes include interaction between flora, fauna and land use (human beings) as well as abiotic structures – particularly the water balance (if applicable in the present case also the connections between the groundwater and the sea)
- The marine area: Fundamentally, a diverse array of interactions exists in the Baltic Sea between the hydrographical conditions and the habitat types, the flora and the fauna (e.g. plankton, macro algae and seagrass, foraging and roosting areas of birds, habitats of marine mammals and spawning areas of fish). It will be considered whether the impacts on the interaction complex of the Baltic Sea should be described and analysed further than the planned individual impact assessments concerning e.g. the marine flora and fauna.

7.15. Derived Socio-Economic Impacts

According to Danish legislation, the EIS shall include a description of the potential socio-economic consequences of the possible environmental effects (derived socio-economic impacts). The effects are assessed from a Danish perspective only and are supplementary to the impacts on human beings presented in Section 7.1. These assessments will be provided for the Danish territory only.

In Germany, socio-economic aspects are not included in the EIS. They will, however, be assessed in a separate technical report, which will be included in the plan approval application. The influence on tourism in Germany will be assessed in a separate report.

Baseline investigations

Since the impacts on socio-economic conditions and on human beings are linked closely together, the baseline investigations will be conducted as an integral part of the study of human beings.

The main objective of the baseline investigations is to describe local activities of different population groups and business sectors (such as inhabitants in residential areas close to the project area, agricultural and forestry activities, fishery, tourism and the use of areas for outdoor activities). Furthermore, the general business structure on Lolland will be described in a table.

The main elements of the baseline investigations are:

- Review of results from other components of the EIA and a summary of environmental impacts with consequences to specific population groups or business sectors
- Establishment of GIS maps and registration of addresses in order to estimate the

number of people and the business sectors, that will be influenced positively or negatively by the project, e.g. by noise pollution and barrier effects

- Analysis of statistical data on business activities in important business sectors to establish a summary of the local business activity and the employment in main businesses
- Interviews with important stakeholders such as nature conservation organisations, business organisations and tourist agencies in order to add qualitative information on key issues as regards the positive and negative impacts
- Review of public view points on the existing land use by dialogue through the internet based Femern Bælt Information System (FBIS) to address the key problems or concerns of the local citizens and interest groups concerned with nature and outdoor activities.

Potential impacts

Potential impacts may include:

- Restriction of nature conservation interests, nature tourism and fishery during the construction and operation phases of the project
- Positive and negative effects on property owners, including the agriculture
- Positive and negative impacts on the tourism caused by the enhanced transport infrastructure during operation and the disturbance of the area during construction
- Changed conditions for navigation and aviation activities during construction and, in case of a bridge solution, during the operation of the fixed link
- Change of the local employment in case of a possible closedown of the ferry line and the job creation during the construction and operation of the fixed link.

Planned assessment

The assessment of derived socio-economic impacts is based on three parts: 1) the environmental impacts predicted in other parts of the EIA study, 2) the socio-economic aspects related to changes in land use and 3) the most significant local socio-economic aspects related to the implementation of the infrastructure (discontinued ferry services, easier access, employment etc). Focus will be on the description of how population groups and businesses are influenced by the Fehmarnbelt Fixed Link during both construction and operation.

The descriptions will be mainly qualitative and will be based on specific investigations on selected issues and more general interviews with experts and external stakeholders as well as on a review of existing literature. The target is to describe how present activities and commercial interests will be temporarily or permanently influenced by the project. Specific examples of issues are commercial fisheries, extent and character of tourism and jobs connected to the ferry line.

8. Natura 2000 Assessments

A project can only be approved after the national authorities have ascertained that it will not adversely affect the integrity of the concerned Natura 2000 sites, i.e. Sites of Community Interest, SCIs (under Council Directive 92/43/EEC, Habitats Directive) and Special Protected Areas, SPAs, (under Council Directive 79/409/EEC, Birds Directive). This requires an assessment of the project's implications for the sites in view of the conservation objective(s). The following sections outline the planned approach of those assessments.

Baseline Investigations

Within a preliminary screening those Natura 2000 sites are selected that may be affected by the project. The sites for which impact assessments will have to be carried out will be outlined. In this context the Natura 2000 sites are listed with their conservation objectives and their location in relation to the project and its impact zones.

This approach relates to the network idea of Natura 2000, according to which the coherence between the sites should be preserved. Examples are the deterioration of migration corridors of animal species with large area demands, e.g. fish, bats or birds. This means that even rather remote Natura 2000 sites could be affected. For example it has to be assessed if bird populations from sanctuaries in the North Sea are impacted by the fixed link on their migration routes.

The second step in the assessment is a screening (preliminary assessment) considering the current knowledge about the sites and the potential effects of the project. The screening will identify all critical issues as early as possible and identify sites in which significant adverse effects of the fixed link project on the conservation objectives cannot be excluded. For these Natura 2000-sites a ful Natura 2000 impact assessment is needed.

As an important starting point the existing EU standard data forms of all relevant Natura 2000 sites will be reviewed. In these, the occurrence of relevant species and habitats is described and the conservation objectives and existing threats are listed. More details on the conservation objectives and actual knowledge on the area's protected species and habitats are given in the Danish and German background reports about the Natura 2000 sites. In relevant cases, supplementary data on fauna and flora will be collected in the field.

All Natura 2000 sites in the region around the project area are shown in Figures 8.1 and 8.2. Please note that SCI's and SPA's overlap in several cases.

Potential impacts

According to a preliminary appraisal, seven SCIs and four SPAs may be affected by the project and will be subject to deeper investigation in accordance with the requirements in the Habitats Directive. The potential adverse effects in relation to the conservation objectives of the sites are outlined below (http://www.natura2000-sh.de).

- **SCI DK 006X238 Smålandsfarvandet nord for Lolland, Guldborg Sund, Bøtø Nor og Hyllekrog-Rødsand**: Benthic fauna and flora in the Rødsand area may be affected by increased turbidity of the water (sediment spill) and sedimentation. Possible subsequent effects on the species and habitats for which the site is designated to protect and, finally, risk of nitrogen deposition
- **SCI DK 00VA260 Femern Bælt:** Potential effects on harbour porpoises in the Fehmarnbelt
- **SCI DE 1332-301 Fehmarnbelt**: The fixed link will cross the eastern part of the area. Possible effects on harbour porpoises and sand waves as a consequence of area claims and barrier effects, as well as induced sedimentation and noise during construction phase
- **SCI DE 1532-321 Sundwiesen Fehmarn**: Possible changes of nitrogen deposition
- **SCI DE 1532-391 Küstenstreifen West- und Nordfehmarn**: Possible impairment of amphibian migration routes. Possible changes of nitrogen deposition
- **SCI DE 1533-301 Staberhuk**: Potential impairment of benthic fauna and flora from sediment spill
- **SCI DE 1631-392 Meeresgebiet der östlichen Kieler Bucht:** Possible structural and functional impairment of marine habitats, habitat specific species and the harbour porpoise. In the northern part of the area, benthic fauna and flora may be affected by sediment spill
- **SPA DK 006X087 Maribosøerne:** Possible disturbance of tufted duck populations that utilise Fehmarnbelt as feeding ground during the night
- **SPA DK 006X083 Kyststrækningen v. Hyllekrog-Rødsand:** Possible impacts on bird species that are part of the conservation objectives, e.g. through potential effect on benthic fauna and flora from sediment spill
- **SPA DE 1530-491 Östliche Kieler Bucht:** Possible structural and functional impairment of resting grounds and flyways of birds due to bridge construction. In the northern part of the area, benthic fauna and flora may be affected by sediment spill
- **SPA DE 1633-491 Ostsee östlich Wagrien:** In the northern part of the area, benthic fauna and flora may be affected by sediment spill

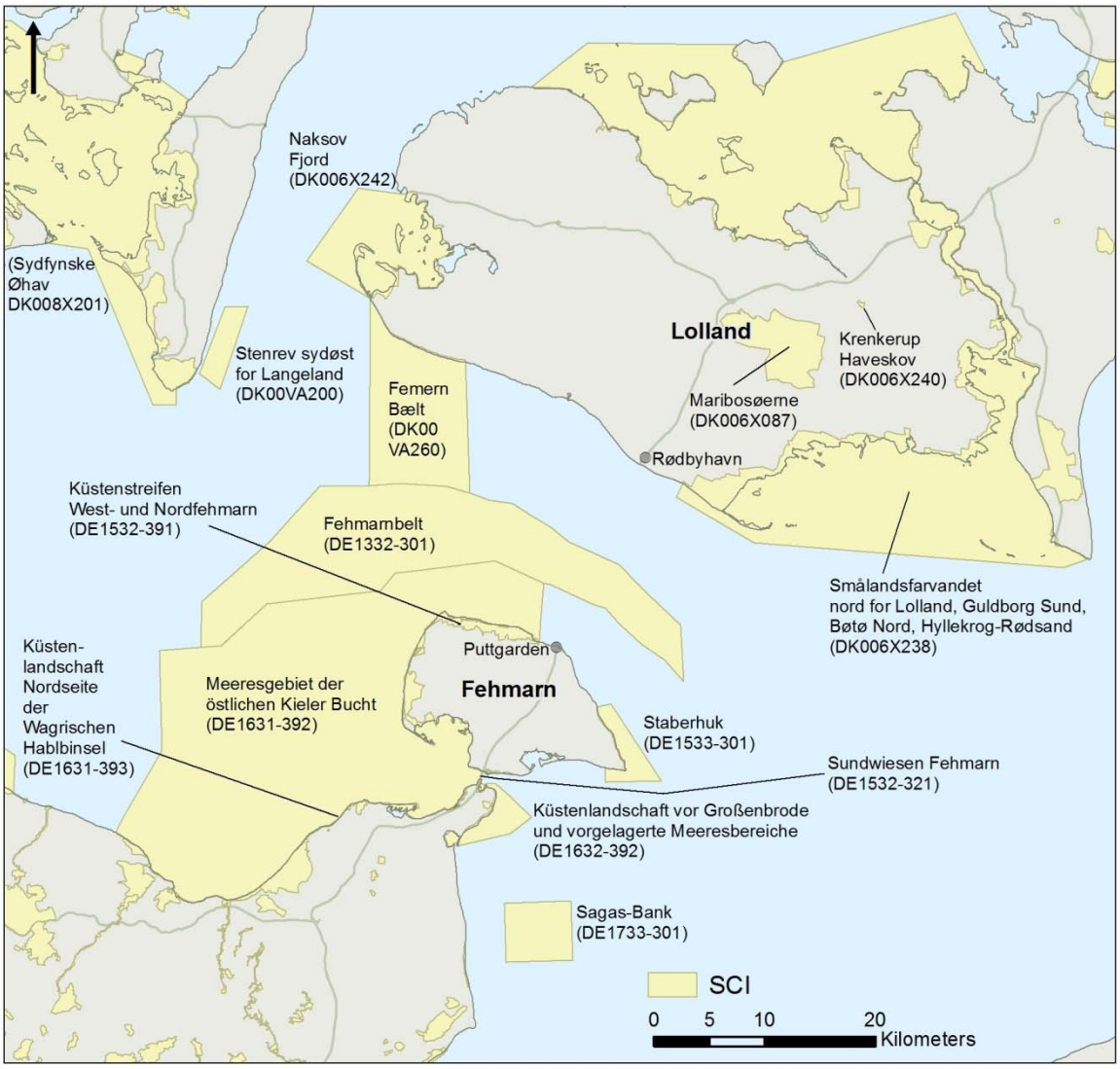


Figure 8.1 German and Danish SCIs in the region around the planned Fehmarnbelt Fixed Link.

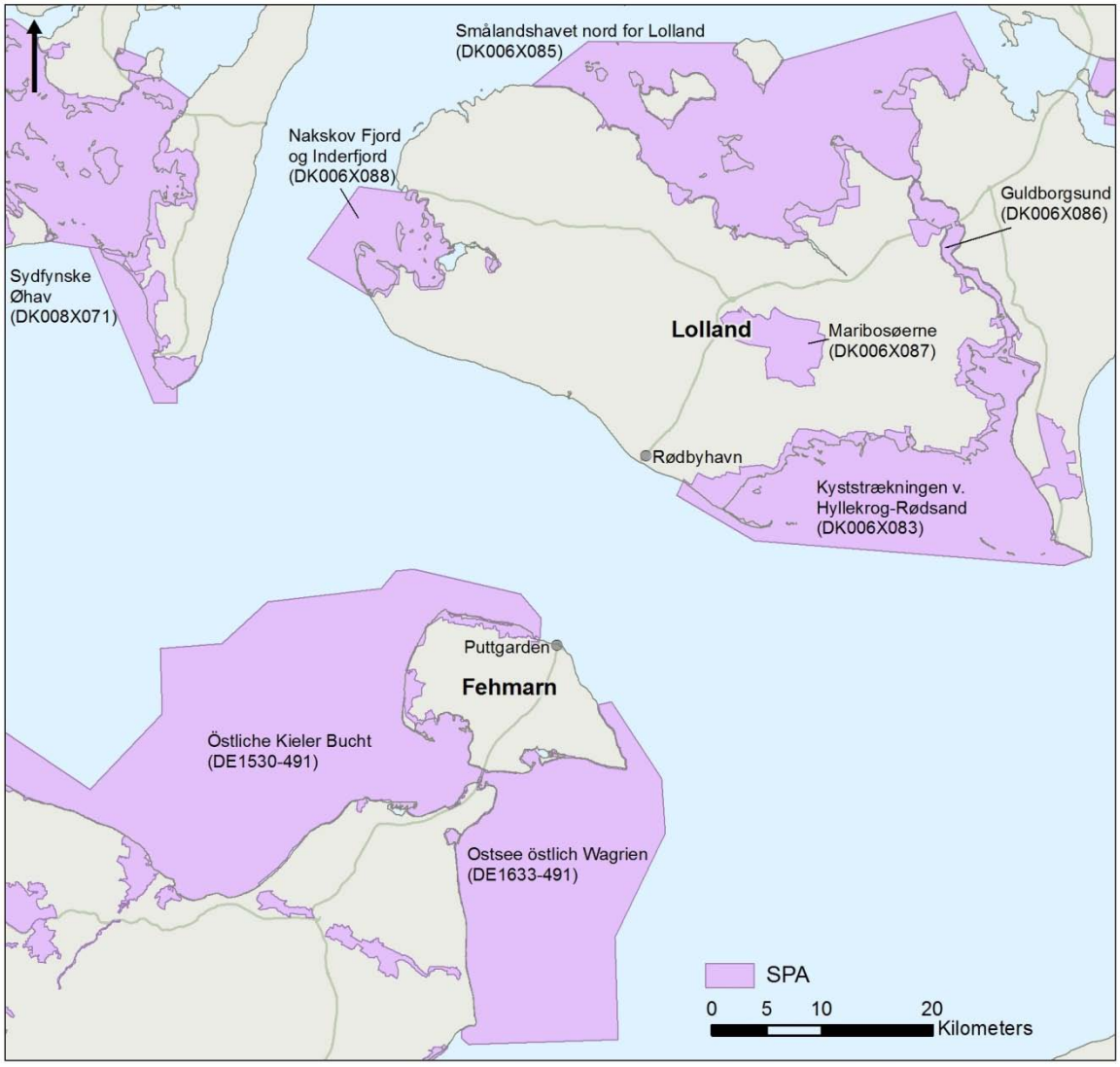


Figure 8.2 German and Danish SPA's in the region around the planned Fehmarnbelt Fixed Link.

The following more distant Natura 2000 sites will be subject to further screening although no significant impacts are expected judged from a preliminary appraisal:

- SCI DK 00VA200 Stenrev sydøst for Langeland
- SCI DE 1632-392 Küstenlandschaft vor Groβenbrode und vorgelagerte Meeresbereiche
- SCI DE 1733-301 Sagas-Bank
- SCI DE 1631-393 Küstenlandschaft Nordseite der Wagrischen Halbinsel
- SPA DK 006X088 Nakskov Fjord og Inderfjord
- SPA DK 006X086 Guldborgsund.

Planned assessments

Following the preliminary appraisal, as the first step of the impact assessments, a screening (initial assessment) will be carried out to identify Natura 2000 sites which may be significantly affected by the project. In accordance with article 6 of the EU Habitats Directive an impact assessment (appropriate assessment) will be carried out for each of these areas.

The assessment will focus on potential adverse effects on the habitats and species that each site is designated to protect. A general conservation objective of each site is to reach or maintain “favourable conservation status” as regards the species and habitats in question. In case of management plans for the Natura 2000 sites are available, it has to be assessed to which extent the measures for preservation, regeneration or development of natural habitat types and species are hampered if the project is realised. At present Denmark conducts a public hearing on the Natura 2000 management plans. Once adopted, they will be handed over to the municipalities for implementation.

The Natura 2000 impact assessments will be conducted in accordance with present legal provisions procedural guidelines prepared by German and Danish authorities and also considering the relevant EU Directives and guidelines issued by the European Commission.

In order to clearly separate and describe the single assessment steps and potential impairments (which are different for every site), the preliminary assessment and impact assessment of each site is documented in separate documents.

9. Impact Assessment regarding Protected Species

9.1. Strictly Protected Species (Annex IV Species)

In accordance with Article 12 of the Habitats Directive species listed in Annex IV of this Directive are subject to strict protection in their natural range. It is prohibited to deliberately kill these species or to deliberately disturb them during critical periods. Furthermore, deterioration or destruction of their breeding sites or resting places is prohibited. These species are often referred to as “Annex IV species”.

The assessments of the impact on Annex IV species are made in accordance with the Federal Nature Conservation Act (BNatSchG,) in Germany and in accordance with the “Habitats order” in Denmark. (Habitbekendtgørelsen, Miljøministeriet (2007b)).

Baseline investigations

The investigations will include all Annex IV species previously found in or close to the potentially impacted area as well as those which according to their general distribution may occur within this area. Existing information on species distribution will be obtained from relevant Danish, German and international sources. For relevant species mapping will be carried out as described in the sections above on fauna and flora.

The purpose of the baseline investigations is to:

- Identify potential habitats of the Annex IV species in question
- Record any occurrence of the species in question
- Assess population sizes, future trends, and significance of the areas for this populations.

The Annex IV species that may occur within or close to the study area are listed in Table 9.1.

Potential impacts

The potential impacts on strictly protected species lie within the array of potential impacts already described in the sections on fauna and flora in Chapter 7.

Planned assessments

In Germany (Schleswig-Holstein), the impact assessment regarding strictly protected species is conducted within the framework of the landscape conservation plan following the procedure established in a guideline (Guideline of Agency of road construction and traffic S-H, June 2008). According to this guideline, an individual protection assessment is made for each species and reporting is done through separate reports outside the EIS. However, a summary of a preliminary assessment regarding protected species will be presented in the EIS.

Table 9.1 Annex IV species, which may be present within or close to the study areas on land or at the sea.

Annex IV species	Germany	Denmark
Bats	All species	11 species are known from Lolland: *Myotis brandtii*, *Myotis dasycneme*, *Myotis daubentonii, Myotis nattereri, Pipistrellus nathusii, Pipistrellus pygmaeus, Nyctalus noctula, Eptesicus serotinus, Vespertilio murinus, Barbastella barbastellus* and *Plecotus auritus*
Amphibians	Possible species in the investigation area include: great crested newt (*Triturus cristatus),* common spadefoot *(Pelobates fuscus),* European green toad *(Bufo viridis),* natterjack toad *(Bufo calamita),* and moor frog *(Rana arvalis)*	Possible species in the investigation area include: Great crested newt (*Triturus cristatus),* common spadefoot *(Pelobates fuscus),* European green toad *(Bufo viridis),* natterjack toad *(Bufo calamita),* moor frog *(Rana arvalis)* and agile frog *(Rana dalmatina)*
Reptiles: Sand lizard *Lacerta agilis*	Sand lizard is probably not present in the study area	No known occurrences of sand lizard on Lolland. However, possible footprints have recently been found at Hyllekrog, only a few km from the study area.
Terrestrial mammals: common dormouse (*Muscardinus avellanarius*)	Common dormouse may be present in the vegetation along roads (primarily nests in November/December dependent on the fall of leaves)	No known occurrences on Lolland. The nearest known population is more than 100 km away
Dragonflies	No known occurrences of Annex IV dragonflies	No known occurrences of annex IV dragonflies
Wood dwelling beetles: great capricorn beetle (*Cerambyx cerdo*) and hermit beetle (*Osmoderma eremita*)	Could be in individual trees, but probably there is no occurrence in the study area	No known occurrences and no potential habitats within the study area. Hermit beetle does, however, occur on Lolland, while great capricorn beetle is absent from Denmark.
Lepidoptera: willowherb hawkmoths (*Proserpinus proserpina*)	May occur in appropriate habitats along the already existing road	The species has been recorded within the study area on Lolland
Marine mammals: harbour porpoise (*Phocoena phocoena)*	Is found throughout the Fehmarnbelt	Is found throughout the Fehmarnbelt

In Denmark, the assessment regarding Annex IV species will be carried out in accordance with the Guidance document to the Danish “Habitats Order”, and Handbook on animal species in appendix IV of the Habitats Directive (European Commission, 1992). The assessment will be reported together with the Natura 2000 impact assessment.

Furthermore, information in “Guidance document on the strict protection of animal species of Community interest under the Habitats Directive 92/437EEC” issued by the European Commission will be considered.

As part of the impact assessment, Annex IV species, which could be affected by the planned project are identified. The vulnerability of the local populations to impacts from the project will be assessed in the light of present threats. The magnitude of the impact will be assessed. The objective is to examine whether significant effects will occur c.f. Article 12 in the Habitats Directive.

In the case of relevant impacts on the protected species, mitigation or compensation measures will be required. This is also valid in case of destruction of the habitats of the species. Compensation measures are also called measures of “Continuous Ecological Function (CEF)” and have to be established before construction is initiated. If CEF measures are not possible and a violation of Article 12 is inevitable, a formal permit for derogation from these provisions will be required.

9.2. Strictly Protected Bird Species and other Protected and Threatened Species

In accordance with the “Guidelines for Bird Protection” in Schleswig-Holstein, the potential impact on certain additional protected species, which are strictly protected in Schleswig-Holstein, will be assessed and reported individually similar to the Annex IV species. This includes the birds on Annex 1 of the EU Birds Directive and all European breeding birds in general. In practice common birds will have to be assessed in habitat groups, but birds listed as “endangered” in the red list of Schleswig-Holstein will be assessed individually. Some further species protected nationally according to German law will also be included, if relevant. These may include the spider *Arctosa cinerea* and the lung lichen *Lobaria pulmonaria*.

On the Danish side, additional Danish red list species and species protected according to Danish law will be treated as described above in the chapters on fauna and flora.

10. References

10.1. Laws and regulations

EU-Directives:

European Commission (1979). Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds.

European Commission (1985). Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment.

European Commission (1992). Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of fauna and flora.

European Commission (1997). Council Directive 97/11/EC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment.

European Commission (2000). Managing Natura 2000 sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC.

European Commission (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

European Commission (2001). Methodological guidance on the provisions of Article 6 (3) and (4) of the Habitats Directive 92/43/EEC.

European Commission (2007). Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC. Clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the Commission.

European Commission (2008). Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

European Commission (2008). Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (Text with EEA relevance).

Laws, orders, regulations etc. in Denmark:

Miljø og Energiministeriet (1999): Bekendtgørelse nr. 126 af 4. marts 1999 om miljømæssig vurdering af råstofindvinding på havbunden (VVM) med ændringer ifølge bekendtgørelse nr. 1454 af 11. december 2007.

Klima- og Energiministeriet (2000): Bekendtgørelse nr. 815 af 28. august 2000 om vurdering af virkninger på miljøet (VVM) af elproduktionsanlæg på havet.

Klima- og Energiministeriet (2000): Bekendtgørelse nr. 884 af 21. september 2000 om miljømæssig vurdering (VVM) af projekter til indvinding af kulbrinter og til etablering af rørledninger på dansk søterritorium og kontinentalsokkelområde.

Transportministeriet (2001): Vejledning nr. 163 af 17. september 2001 om udlægning af telekabler og visse rørledninger på søterritoriet.

Transportministeriet (2005): Bekendtgørelse nr. 809 af 22. august 2005 om miljømæssig vurdering af visse anlæg og foranstaltninger på søterritoriet (VVM).

Miljøministeriet (2006): Bekendtgørelse nr. 1335 af 6.december 2006 om vurdering af visse offentlige og private anlægs virkning på miljøet (VVM) i medfør af lov om planlægning.

Miljøministeriet (2007a): Bekendtgørelse nr. 137 af 10. februar 2007 om mål- og grænseværdier for luftens indhold af visse forurenende stoffer.

Miljøministeriet (2007b): Bekendtgørelse nr. 408 af 1. maj 2007 om udpegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter.

Transportministeriet (2008): Bekendtgørelse nr. 874 af 2. september 2008 om administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter for så vidt angår anlæg og udvidelse af havne og kystbeskyttelsesforanstaltninger samt etablering og udvidelse af visse anlæg på søterritoriet.

Laws, orders, regulations etc. in Germany (federal and state legislation):

Bundesnaturschutzgesetz (BNatSchG): Gesetz über Naturschutz und Landschaftspflege in der Fassung der Bekanntmachung vom 29.07.2009, in Kraft getreten am 1.3.2010; BGBL. I S. 2545.

Landesnaturschutzgesetz (LNatSchG): Gesetz zum Schutz der Natur in Schleswig Holstein vom 26. Februar 2010.

Allgemeine Verwaltungsvorschrift zum Schutz gegen Baulärm (AVV Baulärm): Geräuschemissionen – vom 19. August 1970 (Beil. zum BAnz. Nr. 160).

Verkehrslärmschutzverordnung vom 12. Juni 1990: Sechzehnte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (16. BImSchV) in der Fassung vom 19. September 2006.

Verordnung über Immissionswerte für Schadstoffe in der Luft: Zweiundzwanzigste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (22. BImSchV) in der Fassung der Bekanntmachung vom 4. Juni 2007 (BGBl. I S. 1006).

Verordnung über elektromagnetische Felder: Sechsundzwanzigste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (26. BImSchV) in der Fassung der Bekanntmachung vom 16. Dezember 1996 (BGBl. I S. 1966).

Gesetz über die Umweltverträglichkeitsprüfung: UVPG in der Fassung der Bekanntmachung vom 24.2.2010; BGBl. Nr. 7 vom 26.2.2010 S. 94).

Länderausschuss für Immissionsschutz (2000): Licht-Richtlinie LAI. Hinweise zur Messung und Beurteilung von Lichtimmissionen, 10. Mai 2000.

Richtlinien für den Lärmschutz an Straßen (RLS-90): Ausgabe von 1990 auf der Grundlage der 16. Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes.

Richtlinie zur Berechnung der Schallimmissionen von Schienenwegen (SCHALL 03): Ausgabe 1990, bekannt gemacht im Amtblatt der Deutschen Bundesbahn Nr. 14 vom 4. April 1990.

Technische Anleitung zum Schutz gegen Lärm: Sechste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz vom 26. August 1998 (GMBl. Nr. 26 vom 28.08.1998 S. 503).

Verein Deutscher Ingenieure: VDI 3790: Umweltmeteorologie - Emissionen von Gasen, Gerüchen und Stäuben aus diffusen Quellen - Lagerung, Umschlag und Transport von Schüttgütern; Blatt 1 (2005), Blatt 2 (2000); Blatt 3 (2008, Entwurf).

DIN 18005-1 (2002-2007): Schallschutz im Städtebau. Teil 1: Grundlagen und Hinweise für die Planung.

DIN 18005-1 (1987 – 2005): Beiblatt 1: Berechnungsverfahren; Schalltechnische Orientierungswerte für die städtebauliche Planung.

10.2. Consulted plans, maps and sources:

Denmark

Banestyrelsen Rådgivning (2000): Supplerende miljøundersøgelse ved maskindepotet på Rødby Færgehavn.

Danmarks Miljøportal(2009): Arealinformationssystemet, GEUS jordartskort 1:200.000.

Det Kulturhistoriske Centralregister (2009): http://www.dkconline.dk.

DMU (2007): Håndbog om dyrearter på habitatdirektivets bilag IV - til brug i administration og planlægning (Handbuch über Tierarten in Anhang IV der FFH-Richtlinie – zur Verwendung in Verwaltung und Planung). Fachbericht Nr. 635.

GEUS (2009): Jupiter - Danmarks hydrologiske og geologiske database: http://www.geus.dk/geuspage-dk.htm?http://www.geus.dk/jupiter/index-dk.htm

Kreis Storstrøm (2006): Raumplanung 2005-2017.

Kulturarvsstyrelsen (2009a): http://www.kulturarv.dk/.

Kulturarvsstyrelsen (2009b): Kulturarvsstyrelsens database over fredede og bevaringsværdige bygninger (FBB): http://www.kulturarv.dk/fbb/index.htm.

Kulturarvsstyrelsen (2009c): Kulturarvsstyrelsens database Regin. http://regin.kulturarv.dk/regin/index.do;jsessionid=DB2925023568C84C56A4 D1F14F760CB3

Lolland Kommune (2009): Draft version of the new Municipal Plan to be published in 2010.

Lolland-Falsters Stiftsmuseum og Lolland Kommune (2008): Landsbykataloget. http://www.lolland.dk/Bo_på_Lolland/Mulighedernes_Land/Viden_om_Lolland/Kulturmiljøer_som_ressource.aspx.

Miljøministeriet (2009): http://www.vandognatur.dk

Miljøministeriet, By- og Landskabsstyrelsen, Ekstern høringsudgave (2008): Vejledning til bekendtgørelse nr. 408 af 1. maj 2007 om udpegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter (Dänisches Umweltministerium, Städtebau- und Landschaftsamt: Leitfaden zur Verordnung Nr. 408 vom 1. Mai 2007 über die Ausweisung und die Verwaltung von internationalen Naturschutzgebieten sowie den Schutz bestimmter Arten).

Miljøministeriet (2007): Vejledning om landskabet i kommuneplanlægningen

Miljøstyrelsen (1998): Vejledning fra Miljøstyrelsen Nr. 5. Biologisk bedømmelse af vandløbskvalitet.

Miljøstyrelsens vejledning (2001): nr 2. Luftvejledningen. Begrænsning af luftforurening fra virksomheder.

Region Sjælland (2007): Hvidbog for Råstofplanlægning I Region Sjælland.

Region Sjælland (2008): Råstofplan 2008 for Region Sjælland.

Region Sjælland (2009): http://webkort.regionsjaelland.dk/

Rødby Kommune (2004): Kommuneplan for Rødby Kommune 1998-2009.

Visit Denmark (2009): http://www.visitdenmark.com/danmark/dadk/menu/turist/danmark.htm.

Visit Lolland-Falster (2009): http://www.visitlollandfalster.com/danmark/da-dk/menu/turist/lolland-falster.htm

Germany

Archäologisches Landesamt Schleswig-Holstein (2008): Archäologische Landesaufnahme (Heilgenhafen – Puttgarden), Stand Januar 2008.

Bundesanstalt für Geowissenschaften und Rohstoffe (Hrsg.) (2001): Bodenübersichtskarte, Maßstab 1: 200.000, CC 2326 LÜBECK.

Geologisches Landesamt Schleswig-Holstein (1991): Karte „Geowissenschaftlich schützenswerte Objekte (GeoSchOb)“, Maßstab 1:250.000

Kreis Ostholstein, Fachdienst Regionale Planung (Stand 2009): Denkmälerkartei des Kreises Ostholstein.

Ministerium für Umwelt, Naturschutz und Landwirtschaft des Landes Schleswig-Holstein (2003): Landschaftsrahmenplan für den Planungsraum 2, Kiel 2003.

Stadt Fehmarn (2007): Landschaftsplan Stadt Fehmarn.

Stadt Fehmarn (2009): Flächennutzungsplanung der Stadt Fehmarn (Stand 02/2009).

Stadt Fehmarn (2009): Bebauungspläne Fehmarn, URL: http://www.b-planpool.de, Stand 2009.

10.3. Literature

BACC Author Team (2008): Assessment of Climate Change for the Baltic Sea Basin. Springer-Verlag. Berlin and Heidelberg; Germany.

Bruderer, B., T. Steuri, M. Baumgartner (1995): Short-range high-precision surveillance of nocturnal migration and tracking of single target. Israel Journal of Zoology, Vol 41, p. 207-220.

Bundesamt für Seeschifffahrt und Hydrographie (2003): Merkblatt zum Aufbau und Gliederung einer UVS (Basisuntersuchung) zur Errichtung eines Offshore-Windparks in der AWZ.

Bundesamt für Seeschifffahrt und Hydrographie (2007): Standard-Untersuchungen der Auswirkungen von Offshore-Windenergieanlagen auf die Meeresumwelt (StUK 3).

Bundesministerium für Verkehr, Bau und Stadtentwicklung, Hrsg. (2007): Leitfaden zur Umweltverträglichkeitsprüfung an Bundeswasserstraßen.

Bundesministerium für Verkehr, Bau und Stadtentwicklung (2008): Richtlinien für die Erstellung von Umweltverträglichkeitsstudien im Straßenbau (RUVS) Stand Entwurf 2008).

Bundesministerium für Verkehr, Bau und Stadtentwicklung (2008): Entwicklung von Methoden zur Umsetzung der Anforderungen aus dem UVPG und dem BNatSchG auf der Ebene der Linienfindung (Richtlinien UVS) sowie Entwicklung von Darstellungsformen für Umweltverträglichkeitsstudien (Musterkarten UVS); Gutachten F+E Projekt Nr. 02.0236/2003/LR im Auftrag des BMVBS, Stand 2008.

Bundesministerium für Verkehr, Bau und Stadtentwicklung und dänisches Ministerium für Transport und Energie (2006): Eine feste Fehmarnbeltquerung und die Umwelt. Umweltkonsultationsbericht.

Burchard, H., Bolding K. (2002): GETM - A General Estuarine Transport Model; Scientific Documentation. Ispra: Inst. f. Environment and Sustainability. 157 S. (Report European Comm.; EUR 20253 EN).

Burchard, H., Janssen, F., Bolding, K., Umlauf, L., Rennau, H. (2009): Model simulations of dense bottom currents in the Western Baltic Sea. Continental Shelf Research 29(1), p. 205-220.

Cabaço, S., Santos, R. & Duarte, D.-M. (2008): The impact of sediment burial and erosion on seagrasses: A review. Estuarien, Coastal and Shelf Science 79, p. 354-366.

COWI-Lahmeyer (1996): Coastal morphology data collection and review. Activity 5.2.4.

COWI-Lahmeyer (1998a): Baseline Investigations Fehmarn Belt. Feasibility Study Coast-to-Coast Investigations. Investigation of Environmental Impact. Surface Sediments Baseline Investigations. Technical Note, Phase 2, 123 pp.

COWI-Lahmeyer (1998b): Coastal morphology. Baseline investigation and impact assessment. Techinical Note. Phase 2.

COWI-Lahmeyer (1998c): Fehmarn Belt Feasibility Study. Coast-to-Coast Investigations. Investigation of Environmental Impact. Hydraulic Modelling. Technical Note, Phase 2.

COWI-Lahmeyer (1998d): Fehmarn Belt Feasibility Study. Coast-to-Coast Investigations. Investigation of Environmental Impact. Modelling of Sediment Dispersal. Technical Note, Phase 2.

COWI-Lahmeyer (1998e): Fehmarn Belt Feasibility Study, Coast-to-coast Investigations, Investigation of Environmental Impact, Birds and Marine Mammals. Technical Report, Phase 2.

COWI-Lahmeyer Joint Venture (1999): Fehmarnbelt Feasability Study. Coast-to-Coast investigations. Investigation of Environmental Impact. Phase 2 Report.

COWI & NERI (2005): Fixed Link across the Fehmarn Belt – Effect on Emissions to Air. (Die Feste Querung über den Fehmarnbelt – Auswirkungen auf Emissionen in die Luft. Dänische Ministerium für Transport und Energie und Bundesministerium für Verkehr, Bau und Stadtentwicklung, Bericht Nr. P-60907).

Diederichs, A., Nehls, G., Petersen, I. K. (2002): Flugzeugzählungen zur großflächigen Erfassung von Seevögeln und marinen Säugern als Grundlage für Umweltverträglichkeitsstudien im Offshorebereich. Seevögel 23 (2): S. 38-46.

Durinck, J., Skov, H., Jensen, F. P.,& Pihl, S. (1994): Important marine areas for wintering birds in the Baltic Sea. EU DG XI research contract no. 2242/90-09-01, Ornis Consult report 1994,110 pp.

Düring, I. Lohmeyer, A. (2004): Modellierung nicht motorbedingter PM10-Emissionen von Straßen; Kommission zur Reinhaltung der Luft, Expertenforum Staub und Staubinhaltsstoffe, 10./11. November 2004, VDI, Düsseldorf.

Edelvang, K., Kaas, H., Erichsen, Chr., Alvarez-Berastegui, D., Bundgaard, K., and Jørgensen P.-V. (2004): Numerical modelling of phytoplankton biomass in coastal waters. Journal of Marine Systems 57 (2005) p. 13– 29.

Eisenbahn-Bundesamt (2005): Umwelt-Leitfaden zur eisenbahnrechtlichen Planfeststellung und Plangenehmigung sowie für Magnetschwebebahnen.

Eichhorn, J.: Mikroskaliges Klima- und Ausbreitungsmodell. (MISKAM). Arbeitsgruppe Stadtklima, Institut für Physik der Atmosphäre, Johannes Gutenberg-Universität, Mainz.

European Commission (2002): ENTEC. Quantification of emissions from ships associated with ship movements between ports in the European Community, Final Report, July 2002, Entec UK Limited.

Feistel, R., Nausch, G. and Wasmund, N.: State and evolution of the Baltic Sea 1952-2005. A detailed 50-Year survey of meteorology and climate, physics, chemistry, biology, and marine environment. John Wiley & Sons, Inc., Hoboken, New Jersey, 703 pp.

FEHY (Fehmarnbelt Hydrography) and DMI (Danish Meteorological Institute) (2009): Climate Change and the Fehmarnbelt Fixed Link. Report on the Workshop on Climate Scenarios 13 and 14 May 2009. Technical report. Doc no. E1TR0020.

Femern Baelt (2010a): Beschreibung möglicher Baustellen – Puttgarden – Rødbyhavn. Illustrationen zu Größe, Grundriss und Anforderungen.

Fiedler, H. (2000): Seitensichtssonarmosaik des Rippelfeldes nördlich Fehmarn Messfahrt mit MzB(k) “Breitgrund”. Forschungsanstalt der Bundeswehr für Wasserschall-und Geophysik, Technischer Bericht TB 2000-15.

Forschungsgesellschaft für Straßen- und Verkehrswesen (2001): Merkblatt zur Umweltverträglichkeitsstudie in der Straßenplanung MUVS (2001).

Forschungsgesellschaft Straßen und Verkehrswesen (1997): „Die Berücksichtigung von Wechselwirkungen in Umweltverträglichkeitsstudien zu Bundesfernstraßen“.

Fürhaupter, K., Wilken, H., Meyer, T. (2008): WRRL-Makrophytenmonitoring in den äußeren Küstengewässern Schleswig-Holsteins. MariLim, Abschlussbericht für das LANU-SH, Flintbek. (unveröffent.)

Garthe, S., Ullrich, N., Weichler, T., Dierschke, V., Kubetzki, U., Kotzerka, J., Krüger, T., Sonntag, N. & Helbig, A.J. (2003): See- und Wasservögel der deutschen Ostsee - Verbreitung, Gefährdung und Schutz. Bundesamt für Naturschutz, Bonn.

Guisan, A., Thuiller, W. (2005): Predicting species distribution: Offering more than simple habitat models. Ecology Letters 8, p. 993-1009.

Intergovernmental Panel on Climate Change (IPCC) (2007) (Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis,K.B. Averyt, M. Tignor and H.L. Miller (eds.)): Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC; Cambridge University Press, Cambridge, United Kingdom and New York, USA.

Kahlert, J., Hüppop, K., Hüppop, O. (2005): Construction of a fixed link across Fehmarnbelt: Preliminary risk assessment on birds. Commissioned by The Danish Ministry of Transport and Energy, and the German Federal Ministry of Transport, Building and Housing. NERI, DK. 86 p.

Kiørboe T, Møhlenberg F & O Nøhr (1981): Effect of suspended bottom material on growth and energetics in Mytilus edulis. Marine Biology 61: p. 283-288.

Koop, B. (2004): Vogelzug über Schleswig-Holstein - Der Fehmarn-Belt - ein 'bottle neck' im europäischen Vogelzugsystem. Ornithologische Arbeitsgemeinschaft für Schleswig-Holstein und Hamburg, e.V.

Leipe, T., Harff, J., Meyer, M., Hille, S., Pollehme, F., Schneider, R., Kowalski N., Brügmann L. (2008): Sedimentary records of environmental changes and anthropogenic impacts during the past decades. P. 395-440. In: Feistel, R., Nausch, G. and Wasmund, N. (eds.). State and evolution of the Baltic Sea 1952-2005. A detailed 50-Year survey of meteorology and climate, physics, chemistry, biology, and marine environment. John Wiley & Sons, Inc., Hoboken, New Jersey, 703 pp.

DHI (2009a): MIKE 21 & MIKE 3 Flow model FM. Sand Transport Module. Scientific Documentation. Published by MIKE by DHI.

DHI (2009b): MIKE 21 & MIKE 3 Flow model FM. Mud Transport Module. Scientific Documentation. Published by MIKE by DHI.

DHI (2009c): MIKE 21 & MIKE 3 Flow model FM. Hydrodynamic and Transport Module. Scientific Documentation. Published by MIKE by DHI.

Neumann, T. and G. Schernewski (2008): Eutrophication in the Baltic Sea and shifts in nitrogen fixation analyzed with a 3D ecosystem model. J. mar. syst. 74: p. 592-602.

Niemann S.L.; Jensen H.J.; Zyserman J.A.; Brøker I.; Baek S.;(2006): Morphological modeling of a Danish tidal inlet. Proceeding Int. Conf. On coastal Eng. Liverpool.

Novak, Bernhard and Björck, Svante (2002): Late Pleistocene–early Holocene fluvial facies and depositional processes in the Fehmarn Belt between Germany and Denmark, revealed by high-resolution seismic and lithofacies analysis. Sedimentology 49(3): p. 451-465.

Omstedt, A., Elken, J., Lehmann, A., Piechura, J., (2004): Knowledge of the Baltic Sea physics gained during the BALTEX and related programmes. Progress Oceanography, 63, p. 1-28.

Pacanowski, R.-C., Griffies, S.-M. (2000): MOM 3.0 Manual, Techn. Rep., Geophys. Dyn. Lab., Princeton, USA.

Petersen et al. (2006): Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark. Report request. Commissioned by DONG energy and Vattenfall A/S. National Environmental Research Institute. Ministry of the Environment, Denmark.

Powilleit, Kleine, Leuchs (2006): Impacts of experimental dredged material disposal on a shallow, sublittoral macrofauna community in Mecklenburg Bay (western Baltic Sea). Mar Poll Bull 52:p. 386-396.

Rachor, E., Bönsch, R., Boos, K., Gosselck, F., Grotjahn, M., Günther, C.-P., Gusky, M., Gutow, L., Heiber, W., Jantschik, P., Krieg, H.-J., Krone, R., Nehmer, P., Reichert, K., Reiss, H., Schröder, A., Witt, J., Zettler, M.-L. (2009): Rote Liste der bodenlebenden wirbellosen Meerestiere. (im Druck).

Reissmann, J.H., Burchard, H., Feistel, R., Hagen, E., Lass, H.U., Mohrholz, V., Nausch, G., Umlauf, L., Wieczorek, G., (2009): Vertical mixing in the Baltic Sea and consequences for eutrophication – A review. Progress Oceanography, 82, p. 47-80.

Schmaljohann, H., F. Liechti, E. Bächler, T. Steuri, B. Bruderer (2008): Quantification of bird migration by radar - a detection probability problem. Ibis, 150: p. 342-355.

Siegel, H., Seifert, T., Schernewski, G., Gerth, M., Reissmann, J.-H., Ohde T., Podsetchine, V. (2005): Discharge and transport processes along the German Baltic Sea Coast. Ocean dyn. 55: p. 47-66.

Skov, H., Christensen, K.D., Jacobsen, E.M., Meissner, J. & Durinck, J. (1998): COWI-Lahmeyer (1998e) Fehmarn Belt Feasibility Study, Coast-to-coast Investigations. Investigation on Environmental Impact, Birds and Marine Mammals. Technical Report. Phase 2 Cowi-Lahmeyer/Ministry of Transport, Denmark/Bundesministerium für Verkehr, Germany. 79 pp.

Søgaard, B. & Asferg, T. (red.) (2007): Håndbog om arter på habitatdirektivets bilag IV - til brug i administration og planlægning. Danmarks Miljøundersøgelser, Aarhus Universitet. - Faglig rapport fra DMU nr. 635.

Südbeck, P., Andretzke, H., Fischer, S., Gedeon, K., Schikore, T. Schröder, K. & Sudfeldt, C. (2005): Methodenstandards zur Erfassung der Brutvögel Deutschlands. - Radolfzell, 792 S.

Landesamtes für Straßenbau und Straßenverkehr Schleswig-Holstein (2004): Orientierungsrahmen zur Bestandserfassung, -bewertung und –ermittlung der Kompensationsmassnahmen im Rahmen von landschaftspflegerischer Begleitplanungen für Strassenbauvorhaben. Kiel, 2004.

Landesamtes für Straßenbau und Straßenverkehr Schleswig-Holstein (2009): Beachtung des Artenschutzrechtes bei der Planfeststellung. Kiel, 2009

Tjerry, S., and Fredsøe, J. (2005): Calculation of dune morphology, J. Geophys. Res., 110, F04013; 13 pp.

U.S. Environmental Protection Agency: US EPA. Compilation of air pollutant emission factors, Vol. 1: Stationary point and area sources, Office of Air Quality Planning & Standards

Umweltbundesamt (Hrsg.): AUSTAL2000: Entwicklung eines modellgestützten Beurteilungs-systems für den anlagenbezogenen Immissionsschutz. Umweltforschungsplan: Forschungskennzahl 200 43 256; Ingenieurbüro Janicke, Dunum, im Auftrag des Umweltbundesamtes Berlin.

Umweltbundesamt UBA (2004): Handbuch für Emissionsfaktoren des Straßenverkehrs, CD-ROM Version 2.1, Umweltbundesamt (UBA) Berlin, BUWAL Bern, UBA Wien, erstellt durch INFRAS AG Bern, 28. Februar 2004 (derzeit in Überarbeitung).

Vested, H.J., Justesen, P., Ekebjærg, L.C., (1992): Advection–dispersion modelling in three dimensions. Applied Mathematical Modelling 16, p. 506-519.

Zettler, M.-L., Schiedek, D. Glockzin, M. (2008). Zoobenthos. In: Feistel, R., Nausch, G., Wasmund, N. (eds.) State and Evolution of the Baltic Sea, 1952 – 2005. A Detailed 50-Year Survey of Meteorology and Climate, Physics, Chemistry, Biology, and Marine Environment. John Wiley & Sons, Hoboken: p. 517-54

ANNEX A:

Conservation objectives for Natura 2000 sites

Sites of Community interest (SCIs)

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
SCI DK 006X238 S Smålandsfarvandet north of Lolland, Guldborg Sund, Bøtø Nor and Hyllekrog-Rødsand	Large shallow areas with dense macrophyte vegetation *(Zostera, Ruppia* and *Potemogeton)*. The area is an important resting area for a number of internationally protected birds. Common seal and grey seal are breeding in the area. Saksfjed Inddæmning is reclaimed land. Relatively large areas are species-rich grasslands on acid soils (6230*) and occationally wet meadows on nutrient poor soils (6410 in a non calcareous form). European green toad has been registered in the area in 2003. The area is threatened by drainage which will cause a potential negative impact on bird life.	CONSERVATION OBJECTS: 1014 Narrow-mouthed whorl snail (*Vertigo angustior*) 1084 * Hermit Beetle (*Osmoderma eremita*) 1110 Sandbanks which are slightly covered by sea water all the time 1140 Mudflats and sandflats not covered by seawater at low tide 1150 * Coastal lagoons 1160 Large shallow inlets and bays 1170 Reefs 1308 Barbastelle bat (*Barbastella barbastellus*) 1318 Pond bat (*Myotis dasycneme*) 1210 Annual vegetation of drift lines 1220 Perennial vegetation of stony banks 1310 *Salicornia* and other annuals colonising mud and sand 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) 1364 Grey seal (*Halichoerus grypus*) 1365 Harbour seal (*Phoca vitulina*) 2110 Embryonic shifting dunes 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes') 2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes') 2190 Humid dune slacks 3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp* 3150 Natural eutrophic lakes with *Magnopotamion*- or *Hydrocharition*-type vegetation 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites) 6230 * Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe) 6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils *(Molinion caeruleae)*

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
		6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels 7220 * Petrifying springs with tufa formation (*Cratoneurion*) 7230 Alkaline fens 9110 *Luzulo-Fagetum* beech forests 9130 *Asperulo-Fagetum* beech forests 9150 Medio-European limestone beech forests of the *Cephalanthero-Fagion* 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli* 91E0 * Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)* CONSERVATION OBJECTIVES: In the area the food sources for staging birds and the life in shallow water areas shall be secured by reduced nutrient run off to marine areas. Preservation of the natural coastal dynamics where possible and relevant for obtaining favourable conservation status will also be a priority. The overall objective for the Natura 2000 site is that: - the large marine areas have a good water quality and a diverse flora and fauna that form a sufficient food basis for internationally important numbers of migratory water birds such as Mute Swan, Whooper Swan, Greylag goose and Tufted Duck, for which Denmark has a special responsibility - free landscape formation and coastal dynamics are safeguarded or re-established where it is deemed appropriate from an over all viewpoint for the benefit of a large number of habitat types and species - favourable conservation status is achieved and ensured for the threatened species of the area: Osmoderma eremita, Spotted crake, Sandwich Tern, Little Tern and Short-eared Owl and the threatened habitat types 6230, 6410 and 7230 - the Natura 2000 site's high number of sea and costal dependant birds and harbour seal and grey seal are safeguarded against human disturbance

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
		- the ecological coherence and integrity of the area is safeguarded as a whole in regard to appropriate management and hydrology, low nutrient load and establishment and dispersal conditions for the species. All nature types and species listed as objects shall achieve favourable conservation status within the area
SCI DK 00VA200 Stony reef south-east of Langeland	Boulder reef running parallel to the coast. There is a considerable occurrence of common mussel in the shallow parts of the reef. Macroalgae growth is sparse.	CONSERVATION OBJECTS: 1170 Reefs CONSERVATION OBJECTIVES: No specific conservation objectives has been established yet
SCI DK 00VA260 "Fehmarnbelt" (Danish site)	Core area for Harbour porpoises (*Phocoena phocoena*). An important corridor for whales to the eastern part of the Baltic Sea	CONSERVATION OBJECTS: 1351 Harbour porpoise *(Phocoena phocoena)* CONSERVATION OBJECTIVES: No specific conservation objectives has been established yet
SCI DE 1332-301 Fehmarnbelt (German site)	The area is designated due to reefs and sand bank-like megaripples. The area has a relatively high density of Harbour porpoises *(Phocoena phocoena)* and is considered an important corridor for harbour porpoises to the eastern part of the Baltic Sea. Common seals *(Phoca vitulina)* are regular feeding guests in the SCI.	CONSERVATION OBJECTS: 1110 Sandbanks which are slightly covered by sea water all the time (special case) 1170 Reefs 1351 Harbour porpoise *(Phocoena phocoena)* 1365 Seehund *(Phoca vitulina)* CONSERVATION OBJECTIVES: Preservation and regeneration of the biological diversity and the natural hydro- and morphodynamics of the area as well as the specific ecological functions, especially - as a corridor for the undisturbed exchange of aperiodic inflowing salt water from the North Sea and outflowing brackish water of the Baltic Sea; - as a main migration corridor for marine fauna and flora of the eastern Baltic Sea; Preservation and restoration of a favourable conservation status of the habitat types „Sandbanks which are slightly covered by sea water all the time (1110)" and „Reefs (1170)" with their characteristic and threatened biocoenosises and species. Preservation and restoration of a favourable conservation status of the following species and their habitats: Harbour porpoise (by

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
		ASCOBANS Recovery Plan of Harbour Porpoise in the Central Baltic, among others) and harbour seal.
SCI DE 1532-321 Sundwiesen Fehmarn	The south coast of Fehmarn immediately east of the Fehmarnsund bridge. South-exposed coastline of the Schleswig-Holstein Baltic Sea coast. Depressions with brakish ponds behind several rows of crests and dunes. Dunes consist of primary, secondary and tertiary dunes. Last known location of creeping marshwort (*Apium repens*) in Schleswig-Holstein	CONSERVATION OBJECTS 1150 * Coastal lagoons 1210 Annual vegetation of drift lines 2110 Embryonic shifting dunes 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes') 2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes') 1166 Great crested newt *(Triturus cristatus)* 1614 Creeping marshwort *(Apium repens)* Apart from the natural habitat types in the standard data form the Following were recorded by leguan in 2006: 1160 Large shallow inlets and bays 1220 Perennial vegetation of stony banks 1330 Atlantic salt meadows *(Glauco-Puccinellietalia maritimae)* 2190 Humid dune slacks CONSERVATION OBJECTIVES Preservation of a broad belt outside the dike at the coast of Fehmarnsund with beach, crests and dunes along with natural or close to natural lagoon features, brackish water and freshwater ponds and bogs, non-utilised tall herb fringes, reeds and salt meadows. Furthermore, the sustainable protection and preservation of the rare and threatened plant species Creeping marshwort *(Apium repens)* at its close to natural habitats as well as the protection of its over-all population in the area have to be safeguarded. Preservation and – where required – restoration of a favourable conservation status of the above mentioned habitat types and species.
SCI DE 1532-391 Küstenstreifen West- und Nordfehmarn	Narrow coastal strip along the northwest, west and southwest coast of Fehmarn between the island Warder and Grüner Brink. Beach crests and lagoons with numerous transitions and characteristics. This stretch of coast belongs to the most extensive landscapes in Schleswig-Holstein with the above	CONSERVATION OBJECTS 1140 Mudflats and sandflats not covered by seawater at low tide 1150 * Coastal lagoons 1210 Annual vegetation of drift lines 1220 Perennial vegetation of stony banks 1330 Atlantic salt meadows *(Glauco-Puccinellietalia maritimae)* 2120 Shifting dunes along the shoreline with

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
	features .	Ammophila arenaria ('white dunes') 2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes') 2150 * Atlantic decalcified fixed dunes *(Calluno-Ulicetea)* 2190 Humid dune slacks 1166 Great crested newt *(Triturus cristatus)* 1188 European fire-bellied toad *(Bombina bombina)* Apart from the natural habitat types in the standard data form, the following were recorded by Leguan in 2006: 1160 Large shallow inlets and bays 2110 Annual vegetation of drift lines 2170 Dunes with *Salix repens ssp. argentea (Salicion arenariae)* CONSERVATION OBJECTIVES: Preservation of the storm beach and lagoon landscape, which has been shaped by the natural coastal dynamics because it lies outside the dyke. This includes lagoons, crests and large dune areas along with reeds, grassland areas, salt marshes as well as the populations of European fire-bellied toad and great crested newt. Preservation and – where required – restoration of a favourable conservation status of the above mentioned conservation objects (natural habitat types and species).
SCI DE 1533-301 Staberhuk	Cliff coast on the south-eastern shore of Fehmarn including a coastal forest. Coastal waters up to a depth of 10 m. Part of an internationally important roosting area of seaducks.	CONSERVATION OBJECTS: 1170 Reefs 1210 Annual vegetation of drift lines 1220 Perennial vegetation of stony banks 1230 Vegetated sea cliffs of the Atlantic and Baltic Coasts 9180* *Tilio-Acerion* forests of slopes, screes and ravines 1351 Harbour porpoises (*Phocoena phocoena)* CONSERVATION OBJECTIVES: Preservation of the characteristic biotope complex of a continental-shaped cliff consisting of spring-affected slope forests, shrubs, perennial forb community and nutrient-poor grassland as well as storm-beaches particularly rich in boulders, pebble beaches and reefs of the shallow water areas off the coast outheast of Fehmarn (as a

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
		habitat of harbour porpoise among others). Preservation and – where required – restoration of a favourable conservation status of the above mentioned habitat types and species.
SCI DE 1631-392 Meeresgebiet der östlichen Kieler Bucht	The area covers coastal waters stretching from Hohwacht Bight to the west of Fehmarn and the western part of the Fehmarnbelt and includes the largest reefs and sandbanks at Schleswig-Holsteins' Baltic Sea coast. Due to the building of the railway and road ramp some 40 years ago, accumulation of sand and calming of currents have led to the development of three terrestrial habitat types.	CONSERVATION OBJECTS: 1110 Sandbanks which are slightly covered by sea water all the time 1160 Large shallow inlets and bays 1170 Reefs 1351: Harbour porpoise (*Phocoena phocoena)* Apart from the natural habitat types in the standard data form, the following is recorded in the official list of the LLUR: 1210 Annual vegetation of drift lines 1220 Perennial vegetation of stony banks 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes') CONSERVATION OBJECTIVES: Preservation of the most significant part of the largest shallow water area of the western Baltic Sea around Fehmarn in its non-disturbed, natural, dynamic development. This includes the occurrence of harbour porpoise and the largest Baltic Sea reef area of Schleswig-Holstein, which extends far into the EEZ displaying species-rich and exposed stony reefs. Furthermore, the extreme redistributions and largely exposed sands of the Flügger Sand with diverse Benthal (among others) have to be preserved as a resting ground for sea ducks. Preservation of a favourable conservation status of the above mentioned conservation objects (natural habitat types and species).
SCI DE 1631-393 Küstenlandschaft Nordseite der Wagrischen Halbinsel	Northern coastal strip of mainland Ostholstein including cliff coast at Johannistal, Eichholzniederung, Steinwarder Strand, Graswarder and beach lagoons north of Großenbrode. Varied landscape of the Baltic coast including cliff coasts, beach lagoons and spits. The beach crest areas of Graswarder are of particular high conservation value, because of its unique	CONSERVATION OBJECTS: 1150 * Coastal lagoons 1210 Annual vegetation of drift lines 1220 Perennial vegetation of stony banks 1230 Vegetated sea cliffs of the Atlantic and Baltic Coasts 1310 *Salicornia* and other annuals colonizing mud and sand 1330 Atlantic salt meadows *(Glauco-Puccinellietalia maritimae)* 2110 Embryonic shifting dunes

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
	characteristics in Schleswig-Holstein.	2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes') 2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes') 1188 Fire-bellied toad (*Bombina bombina*) CONSERVATION OBJECTIVES: Preservation of the varied Baltic Sea coastal landscape with the species-rich coastal cliffs near Johannistal, the low lying lagoons with a characteristic succession of the natural habitat types of the Eichholzniederung as well as the storm-beach formation of Graswarder, which is unique in Schleswig-Holstein. Preservation of a favourable conservation status of the above mentioned habitat types and species.
SCI DE 1632-392 Küstenlandschaft vor Großenbrode und vorgelagerte Meeresbereiche	Marine and coastal site that include the Grossenbrode region from the east of the Fehmarsund Bridge to Grossenbrode Lagoon. It is a characteristic part of the east coast of Ostholstein's with diverse and partly natural habitats. It comprises the northernmost location of fen sedge (*Cladium mariscus*) in Schleswig-Holstein.	CONSERVATION OBJECTS: 1150 * Coastal lagoons 1160 Large shallow inlets and bays 1170 Reefs 1210 Annual vegetation of drift lines 1220 Perennial vegetation of stony banks 1230 Vegetated sea cliffs of the Atlantic and Baltic Coasts 1310 *Salicornia* and other annuals colonizing mud and sand 1330 Atlantic salt meadows *(Glauco-Puccinellietalia maritimae)* 2110 Embryonic shifting dunes 2120 Shifting dunes along the shoreline with Ammophila arenaria ('white dunes') 2130 * Fixed coastal dunes with herbaceous vegetation ('grey dunes') 7210 * Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* 1351 Harbour porpoise *(Phocoena phocoena)* CONSERVATION OBJECTIVES: Preservation of a relatively complete coastal ecosystem typical to the Baltic Sea because of its exposed and dynamic nature. The area is characterised by marine shallow water areas, blue mussel beds and reefs, drift lines, crests and lagoons, coastal cliffs with boulder fields off the coast and sandy beaches with dune sections as well as the central

SCI-CODE AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
		remaining areas of a talassogen coastal bog, which is unique in Schleswig-Holstein (though currently dyked-in and drained). The special characteristics of the lagoon at Großenbroderfähre are the submerged macrophyte community with species closely intermingled and consisting of various seagrass and algae species, as well as brackish water reeds, salt marshes and drift line, storm-beach and dune vegetation on a relatively small area. Especially, the natural, exposed and species-rich stone reefs in the area of the Fehmarnsund should be high-lighted Regarding the interaction between the natural habitat types especially the preservation of: - the largely natural hydrophysical and hydrochemical water conditions and processes (habitat types 1160, 1170, 1310, 1330); - the structures and functions typical of the habitats (habit types 1170, 1210, 1220, 1230,1310,1330, 2120, *2130); and - the largely natural morphodynamics of the seabed and its structure as well as that of the shallow water areas and the coasts (1160, 1310, 1330). Preservation and – where required – restoration of favourable conservation status of the above mentioned habitat types and species.
SCI DE 1733-301 Sagas-Bank	Reefs and sandbanks covered by seaweed vegetation, mussel beds and red algal populations. Hosts 115 species of benthic fauna, among these at least 20 red listed species in Germany and 17 algal species (6 red listed). It is an important feeding ground for eider, common scoter and long-tailed duck.	CONSERVATION OBJECTS: 1110 Sandbanks which are slightly covered by sea water all the time 1170 Reefs 1351 Harbour porpoise (*Phocoena phocoena)* CONSERVATION OBJECTIVES: Preservation of these large species-rich shallow water areas with several hills and block fields as well as undisturbed, large-scale seagrass meadows, blue mussel beds and sandbanks. It is also significant for wintering sea ducks in this area. Preservation of a favourable conservation status of the above mentioned habitat types and species.

* Priority Habitats

Special Protection Areas (SPAs)

SPA-ID AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
SPA DK 006X083 Küstenstreifen bei Hyllekrog-Rødsand	Large shallow brackish water area between Lolland and Falster. The area is designated for protection of several bird species that are frequently breeding or staging in the area in such numbers that it has national or international importance.	CONSERVATION OBJECTS: Breeding birds: Bittern, White-tailed Eagle, Marsh Harrier, Avocet, Sandwich Tern, Common Tern, Arctic Tern, Little Tern, Short-eared Owl Staging Birds: Whooper Swam, Smew, Cormorant, Mute Swan, Been Goose, Darkbellied Brent Goose, Common Goldeneye, Coot Several water bird species occur in numbers outside the breeding season exceeding 1 % of European mid-winter population. The site is particularly important to herbivorous species like Mute swan and Coot. CONSERVATION OBJECTIVES: This site is contiguous to SPA DK 006X086, and the conservation objectives of the two sites are listed together in the Natura 2000 plan. The most important objectives in the present context are: The condition and areal extent of habitat for breeding Common Crane, Bittern, white-tailed Eagle, Short-eared Owl, Marsh Harrier, Spotted Crake, Avocet, Corn Crake, Common Tern, Sandwich Tern, Arctic Tern and Little Tern shall be stable or increasing to ensure sufficient breeding and foraging habitats within the area. The condition and areal extent of habitats for staging Common Crane and Smew shall be stable or increasing to ensure sufficient staging and foraging habitats. The conditions and the total area of habitat for the following migrant species shall be stable or increasing so they can support at least the following numbers of staging/ foraging birds: 2,800 Cormorants, 1,450 Whooper Swans, 14,000 Mute Swans, 5,000 Bean Geese, 3,500 Barnacle Geese, 8,600 Greylag Geese, 2,000 Dark-bellied Brent Geese, 9,000 Common Goldeneyes, 34,300 Tufted Ducks, 13,000 Common Pochards, 3,500 Common Mergansers, 5,000 Red-breasted Mergansers and 40,000 Coots

SPA-ID AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
SPA DK 006X0086 Guldborgsund	The area of Guldborgsund is designated due to its importance to breeding and non-breeding birds.	CONSERVATION OBJECTS: Breeding birds: White-tailed Eagle, Marsh Harrier, Staging birds: Whooper Swan, Mute Swan, Tufted Duck, Common Pochard, Common Goldeneye, Goosander Some of the species feed on benthic flora or fauna. Breeding white-tailed sea eagle and brown harrier and its international importance as staging and wintering area for carnivorous and herbivorous water birds. CONSERVATION OBJECTIVES: The most important objectives in the present context are: Please refer to SPA DK-006X083 above. The areas are contiguous to each other and the conserva-tion objectives are common to both.
SPA DK 006X087 Maribo-Seen	Large freshwater lakes situated in the immediate vicinity of the town of Maribo. Important area for breeding, staging and wintering birds, of which tufted ducks regularly feed in Fehmarn Belt (during night).	CONSERVATION OBJECTS: Breeding birds: Bittern, White-tailed eagle, Honey Buzzard, Marsh Harrier, Common Crane, Common Tern Staging birds: Smew, Greylag Goose, Shoveler, Tufted Duck, Common Pochard Occurrence of diurnally roosting tufted ducks exceeding 1% of the European mid-winter population. The area and quality habitats for Common Crane, White-tailed Eagle, Honey Buzzard, Marsh Harrier and Common Tern is stabilised or increased so that there are sufficient breeding and foraging areas available for the species. The area and quality of habitat shall be stable or increasing so that the area can support at least 50 pairs of Bittern. The area and quality of habitat shall be stable or increasing so that there are sufficient staging and foraging sites for Smew within the area. The area and quality of habitat shall be stable or increasing so that they can support at least the following numbers of staging/foraging birds: 13,000 Greylag Gees, 2,200 Shovelers, 20,000 Tufted Ducks and 10,000 Common Pochards

SPA-ID AND NAME	DESCRIPTION	CONSERVATION OBJECTS AND OBJECTIVES
SPA DE 1530-491 Östliche Kieler Bucht	The area covers marine waters stretching from Kiel Bight to the west of Fehmarn and western part of the Fehmarnbelt. Shallow bights with adjacent beach ridges, beach lagoons and lagoons. It's an Internationally important staging and wintering area to sea ducks, important breeding area for beach ad coastal birds.	CONSERVATION OBJECTS: 30 staging and breeding bird species of Annex I. The area is especially important to large concentrations of seaducks feeding on bivalves. CONSERVATION OBJECTIVES: Preservation of the coastal waters exceedingly significant to the international bird migration as an undisturbed (to the degree possible) staging and wintering area for numerous duck species, as a favourable foraging habitat for breeding and staging birds as well as breeding habitat for coastal, meadow and reed birds. In conjunction with the other Baltic Sea sites it is essential as a wintering area for (sea) ducks. Preservation of non-fragmented areas, which are largely free from vertical disturbing structures (e.g. power cables and wind farms). Preservation of a favourable conservation status of the bird species which are mentioned as conservation objects.
SPA DE 1633-491 Ostsee östlich Wagrien	The area is located to the east coast of Ostholstein and includes largest reefs and sandbanks of Schleswig-Holstein's Baltic coast. It is home for 12 species protected under the EU Bird Directive.	CONSERVATION OBJECTS: 12 staging and breeding bird species of Annex I. The area is especially important to large concentrations of seaducks feeding on bivalves. CONSERVATION OBJECTIVES: Preservation of the coastal waters with exceedingly high significance for the international bird migration as a staging and wintering area for tufted ducks, greater scaups, eiders, long-tailed ducks and common scoters. In conjunction with the other Baltic Sea sites it is exceedingly important as a wintering area for Baltic Sea's duck population. Especially in the shallow water areas and the Großenbroder Binnenhafen ten thousands of wintering sea and diving ducks as well as other water bird species are found. In the area of the Lenster Strand the most significant population of little terns of Schleswig-Holstein has to be preserved. Preservation of a favourable conservation status of the bird species which are mentioned as conservation objects.

ANNEX B

Investigation methods in the marine area

SUBJECT	INVESTIGATION METHODS	NUMBER OF VISITS
Hydrodynamics	Dedicated surveys conducted in 2009 and 2010 (2 years) to map seasonal and interannual variation in key hydrographical parameters as salinity, temperature, currents and waves.	
	Continuous data collection for 2 years at 3 main offshore fixed stations with ADCP and CTD sensors at three depths measuring salinity, temperature, and current direction and speed.	
	Laboratory experiments to investigate blocking and mixing effects of various designs of fixed link structures.	
	Survey to investigate the effects on hydrodynamics of the piers at the existing bridge in the Great Belt.	
Water quality	Dedicated surveys conducted in 2009 and 2010 (2 years) to map seasonal and inter-annual variation in key water quality parameters as nutrients and water turbidity/light penetration. 14 offshore and 10 nearshore stations.	
	Continuous data collection at 10 fixed coastal stations measuring water turbidity at one depth (5 nearshore stations along the coast of Fehmarn, 5 nearshore stations along the coast of Lolland).	
	Continuous data collection at 3 offshore fixed stations which measure water turbidity and fluorescence (phytoplankton biomass) at three depths.	
Seabed and coastal morphology	Mapping using side-scan data in Fehmarnbelt and multi-beam sonar survey outside of 6 m water depth and single beam survey inside the 6 m contour.	
Sediment and sedimentation	Sediment samples of the seabed, pollutant survey and fauna and flora investigation for analyses of the structure of the surface sediment.	
	Sampling of sediment samples in the alignment corridor to determine content of toxic substances and nutrient in the depth strata covering the industrialised period. The mapping of pollutants will be supplemented by measurements in mussels collected along the coasts of the planned alignment.	
	In-situ sediment trap measurements. Three to five sites will be investigated with focus on natural sedimentation areas. At each site three traps will be installed in the water column. The precise locations for the sediment traps studies will be based on preliminary modelling of natural sedimentation of the greater Fehmarnbelt area.	

SUBJECT	INVESTIGATION METHODS	NUMBER OF VISITS
	Field experiments on fall velocity and dispersion, for which natural fine grained bottom sediment will be mixed with Fehmarnbelt water and gradually released into the sea in order to mimic the behaviour of a sediment plume. Settling velocities as well as spreading of the plume are measured. Hydrodynamic and sediment transport model parameters will be derived from the experiments.	

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Marine fauna and flora		
Phytoplankton	The *biomass* will be assessed using chlorophyll as a proxy to the biomass. Chlorophyll will be measured according to the HELCOM guidelines.	2 year: 12 offshore and 10 nearshore stations visited monthly;
	Primary production is measured using the ^{14}C method according to the Danish Monitoring guidelines.	2 year: 4-12 stations visited monthly;
	Species composition is analysed at two levels: as algal groups based on HPLC analyses of pigment composition. And based on microscopy analyses in accordance to the HELCOM guidelines.	2 year: 4-12 stations visited monthly; 2 year: 3 stations visited monthly;
Zooplankton: Copepods and meroplankton	Analysis of *composition and abundance*. Sampling using WP2 net; 2 vertical hauls (surface+bottom water). Analysis of Sampling and analysis following HELCOM guidelines.	2 year: 4-12 offshore stations visited monthly;
Zooplankton: Jellyfish	Analysis of *composition, abundance and settling*. Sampling using multinet; 2 horizontal hauls (in surface and bottom layer). Analyses using state-of-art methods	2 year: 4-12 offshore stations visited monthly; settling: 6 stations visited monthly
Bottom fauna and flora		
Macroalgae	Distribution determined from aerial photographs supported by ground truth surveys. Covering the potential impact area and reference areas and relevant Natura 200 areas	1 flight
	Video transects and frame sampling to determine year-to-year variation in distribution and abundance. Covering the potential impact area and reference areas as well as Natura 2000 sites.	2 year: 1 campaign per year; 34 transects;

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Eelgrass	Distribution determined from aerial photographs supported by ground truth surveys. Covering the potential impact area and reference areas. and relevant Natura 200 areas	1 flight
	Video transects and frame sampling to determine seasonal variation in distribution and abundance. Covering the potential impact area and reference areas as well as Natura 2000 sites.	2 year: 1 campaign per year; 8 transects;
Soft bottom fauna	Frame or grab sampling to determine seasonal variation in distribution and abundance. Covering the potential impact area and reference areas.	2 year: 2 campaigns per year; 50 offshore stations and 168 nearshore stations;
Epi-fauna	Frame sampling to determine distribution and abundance in Natura 2000 sites.	2 years, 1 campaign per year, 103 samples
Mussels	Distribution determined from aerial photographs supported by ground truth surveys. Covering the potential impact area and reference areas.	1 flight
	Video transects and frame sampling to determine seasonal variation in distribution and abundance. Covering the potential impact area and reference areas.	2 year: 1campaign per year; about 30 transects;
Fish fauna		
Pelagic fish	Hydroacoustic surveys to identify and to determine the distribution of spawning grounds covering the potential impact area and reference areas. Key species: cod, herring and sprat. Gill net and video transect surveys for the identification of spawning grounds for autumn and spring spawning herring. Covering the potential impact area and reference areas.	2 years: 3 seasonal campaigns per year 1 year: high density spring/autumn campaign: 120 stations and 200 video transects. 1 year specific seasonal campaigns.
Eggs and larvae	Bongo net surveys to determine species composition and spatial distribution. Mapping of spawning areas ~~on~~ based on back tracking of drifting eggs and larvae.	1 year: 6 campaigns in spring, 52 stations 1 year: Campaigns in autumn, 52 stations 1 year: Specific seasonal campaigns

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Demersal fish (bottom dwelling)	Seasonal variation in distribution, abundance and spatial distribution of species in different habitats on basis of surveys using multi mesh gill net, d-trawl/ YOY-trawl, pound net, drop net; covering nursery and feeding areas in the potential impact area and reference areas. Mapping of migration routes of Silver Eel using tagging techniques.	1 year: High spatial density monthly campaigns for mapping, 58 stations 1 year: Specific seasonal campaigns Specific seasonal campaigns in nursery and feeding areas 2 years: 1 campaign during autumn
Marine Mammals		
Harbour porpoise	Investigations on the abundance, distribution and habitat use in the construction area and adjacent waters. Description of underwater noise profiles in the Fehmarnbelt area to assess existing pressures. Methods after international standards and the German Standards for Environmental Impact Assessments for offshore wind farms (StUK3; BSH 2007). Abundance and distribution: Aerial line-transect surveys covering Fehmarnbelt and adjacent waters; 36 transects each 3 km apart; altitude 600 m; calculation of absolute densities after Buckland et al. (2001). ArcGIS maps showing distribution of sightings for each survey. Habitat use: Passive acoustic monitoring using porpoise click detectors (C-PODs) in the impact area and two reference areas. Porpoise presence/absence and indices of acoustic activity (daily frequency, waiting times); data analysed after StUK3 (BSH 2007). Habitat use: Telemetry study; satellite transmitters placed on individual porpoises; data on movements of porpoises in the vicinity of Fehmarnbelt and beyond; assessment of area coverage, potential home ranges, distances travelled per day. Interaction with present human activities: noise assessment: Acoustic monitoring at strategic sites in the Fehmarnbelt area and adjacent waters. Usage of autonomous recording systems (< 20 Hz - 20 kHz); Data analysis: 1/3 octave sound pressure level (in dB re 1µPa) of underwater noise profiles.	2 year; 8 surveys per year from March-Oct. 2 full year campaign; 27 detectors 2009: Up to 10 porpoises approx. 5 caught in pound nets and ca. 5 from active catches. 1 year: Campaign (September 2009 – August 2010); 2 devices monitoring 2 weeks at various sites.

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Harbour seal and grey seal	Investigations on abundance, distribution and habitat use in the construction area and adjacent waters. Investigation into health status of individual seals.	
	Abundance and distribution: Aerial surveys covering known harbour seal haul outs in the Fehmarnbelt and adjacent areas (e.g. Rødsand).	20 aerial surveys (10 per year)
	Habitat use: Telemetry study using GPS phone tags; Analysis of the movements of harbour seals in relation to the intended location of the proposed fixed link	1.5 year study; 12 seals tagged in initial period (March-Nov 2009).
	Health status: Provision of baseline information of the health status of seals before the onset of construction and operation. Collection of faecal samples during tagging and screening for cortisol in the lab. Investigation of body condition using morphometric variables; collection of blood samples for further tests.	Ad hoc during tagging in 2009.
Birds		
Non-breeding birds at sea	Investigation of abundance, distribution and habitat use in the project areas and nearby waters. Methods in accordance with international standards and the German Standard for the Assessment of Impact of Offshore Wind Farms on the Marine Environment (StUK3; BSH 2007).	
	Distribution and abundance: Aerial surveys along transects in the Fehmarnbelt and nearby waters, 36 transects with intervals of 3 km, altitude 250 feet, calculation of absolute density with DISTANCE software (http://www.ruwpa.st-and.ac.uk) as an integral part of the spatial model.	2 years: 12 counts per year
	Distribution and abundance: Ship-based surveys along transects in the Fehmarnbelt and nearby waters, calculation of detection intervals and densities (birds per area unit) with DISTANCE software (http://www.ruwpa.st-and.ac.uk) as an integral part of the spatial model.	2 years: 10 counts per year
	Habitat use: Telemetric investigations with satellite, GPS and radio transmitters; transmitters on individual seaducks (common eiders, long-tailed ducks, common scoters, tufted ducks); data on activities and movements of seaducks near the Fehmarnbelt and nearby waters, assessment of the use of space, potential areas for intervention.	2 years
	Food ecology: Examination of localised net catches or dead water birds, examination of swans' and cormorants' droppings or pellets.	2 years

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Migratory birds	Investigation of bird migration during the day using visual observation at three locations: Rødbyhavn, Puttgarden and a ship in the Fehmarnbelt, collection of data for comparison at Hyllekrog, survey of species diversity, migration intensity, flight altitudes and directions. Investigation of bird migration during the day and at night with ship radars; three horizontally orientated instruments (radius < 6 km) in Rødbyhavn, Puttgarden and on the ship; four vertically orientated instruments (radius 1.5 km) in Rødbyhavn, Puttgarden, on the ship and in Westermakelsdorf. Measurement of migratory concentration and altitudes. Investigation of bird migration during the day and at night with tracking radar, survey of migratory concentrations, species groups, flight altitude, direction and speed.	2 years: 120 days per year from the land stations, 85 days per year from the ship 2 years: On land continuously from February to November, 85 days from the ship 2 years: 2009 Rødbyhavn, 2010 Puttgarden, March to November
	Investigation of bird migration during the day and at night using acoustic surveys, recording of migrating bird calls with microphones.	2 years: On land continuously from February to November, 85 days from the ship
	Assessment of reactions of seabirds and water birds to existing bridge structures. Studies on collision risk. Visual observation and measurement of reactions with range finders in Kalmarsund, Øresund, the Great Belt and Farø Sund. In 2010 additional radar surveys in Øresund and the Great Belt. Investigation of day and night migration.	2 years
Breeding birds on land	Survey of breeding bird numbers according to the standards for breeding bird mapping set by Südbeck et al. (2005). On Fehmarn covering the whole area around the hinterland infrastructure, on Lolland focusing on the special structural features of the landscape outside of the agricultural areas.	2009

ANNEX C

Investigation Methods for Flora and Fauna in the Approach and Ramp Areas on land

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Fungi	In Germany, a literature review regarding the occurrence of fungi will be carried out. In Denmark, suitable habitats will be investigated for occurrence of fungi.	DK: 3
Flora		
Biotope types	In Germany, biotope types in the entire study area will be mapped during summer. All legally protected biotopes (§25 LNatSchG) will be photographed. A polygone with attributes in GIS (size, biotope type, protection status) is assigned to each biotope type. A short description of each biotope type concerning use, dominant vegetation and characteristic structures will be added. In Denmark, areas/biotope types within the study area with biologically high values will be identified and mapped. Each site will be given a unique ID number and for each area a data sheets will be filled in with basic data, including a general description of the area and its ecological condition and function, species lists for plants, selected insect groups (dragonflies, damselflies, grasshoppers, butterflies, burnets), amphibians, reptiles and mammals, as well as an estimation of the suitability as potential breeding habitat for amphibians. The habitat structures of importance to flora and fauna (e.g. dispersal corridors such as hedgerows or earth- and-stone dikes) will be mapped and present barriers will be identified. Other areas within the study of lower biological value (e.g. cultivated fields) will be mapped, but not described in detail. Each area /biotope type is given a value based on its biological and ecological values. A valuation of the natural value of relevant sites on a five-graded scale (very high, high, medium, low and very low) will be done in connection with the field work. Parameters taken into account in the valuation include: presence of rare species (annex IV species, red listed species, other rare species including yellow listed species in DK (species of national responsibility), the ecological connectivity with other sites (i.e. degree of isolation), the current human pressures on the site (e.g. from nutrients, nearby barriers, draining etc.) and the “naturalness” and rareness of the site type within the area. The valuation is carried out in the field and validated afterwards. The valuation can be changed, if e.g. more visits to a given site have been made, and new natural values have been mapped. The valuation is not the result of calculation is an expert assessment made on the basis of the mentioned parameters. A subjective assessment of the general potential of the given site is included in the valuation.	1

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Plants on the Red List	Within the study area, plants on the Red List will be specifically investigated in May/June and July/August. This is a standard in Germany . In Denmark, the occurrence of yellow listed species (species of national responsibility) will also be investigated. Data will serve to adjust the value of biotope types up or down and to assess whether rare and endangered species can potentially be affected. The results will be recorded by GPS (not every single plant, but important spots and stands) with information concerning species number or coverage in square metre as well as a valuation of the occurrence.	2
Fauna		
Dragonflies and damselflies	All suitable ponds within the study area will be investigated. Suitable ponds are identyfied based on an assessment, which takes into account the level of eutrophication, the shading of the water surface and the potential for hosting many and/or rare species. There are no known occurrences of dragonfly species of Annex IV neither in the German nor in the Danish study area. If suitable habitats are found, the species will however be searched for.	5
Grasshoppers	Mapping along transects in important and suitable habitats (e.g. road dams, along the Lolland dike and railroad areas) within the study area in May, July, and August	3
Butterflies	Mapping along transects in important and suitable habitats within the study area (e.g. road dams, along the Lolland dike and railroad areas) in April, May, June, August and September	5
	In Denmark, a literature review regarding the occurrence of moths will be carried out.	
	Willowherb hawkmoth (*Proserpinus proserpina*, Annex IV). Mapping in important and suitable habitats within the study area (railroad areas).	3
Seaside spider (*Arctosa cinerea*) (Strictly protected species)	Mapping in important beach habitats within the study area. Only relevant in Germany as the species is not under legal protection in Denmark.	1
Reptiles	Mapping along transects in important and suitable habitats within the study area (e.g. road dams, dikes and railroad areas) in March/April, August and September.	3
	Sand lizard (*Lacerta agilis* Annex IV). Mapping in habitats which are suitable for sand lizard like dry grasslands or other habitats with sandy soil. The species will be investigated within the general mapping of reptiles mentioned above.	3

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Ground beetles	Mapping in important and suitable habitats within the study area. 5 traps per site, 3 capture series.	3
Wood dwelling beetles	Cerambyx longicorn (*Cerambyx cerdo, Annex IV*) and hermit beetle *(Osmoderma eremite,* Annex IV). Investigation of old trees as potential habitats in the study area. Only relevant in Germany as no potential habitats exist in the Danish study area.	1
Amphibians (several annex IV species)	All ponds within the study area will be investigated at least once. During this first visit it will be assessed, how suitable the pond is for amphibians The suitable ponds will be revisited in periods suited for the relevant species. Suitability of ponds is an expert assessment, based on the occurrence of fish, feeding of ducks, level of eutrophication, steepness of the banks and shading of the water surface. Where relevant, funnel traps for catching newts will be used in Germany. In Denmark newts will be searched for with flashlight at night in April/May and with nets in the beginning of July to look for larvae. Suitable ponds will be visited 3 times during daytime and 1 time during nighttime.	4
Bats (all are annex IV species)	Overview mapping of the whole study area to identify structures which can be used as flight corridors, e.g. hedgerows, forest edges and tree lined streams or foraging habitats like tree lined lakes, park like landscapes with trees, fens, wetlands etc.	1
	Investigations with bat detector of the potential flight corridors and foraging habitats, which are found during the overview mapping. Every site is visited for 1-2.5 hours when conditions are good (relatively warm, light wind and no or little rain) in the period June-September. The most suitable bat sites are investigated by a bat expert with bat detector, while the less suitable sites - including flight corridors, where bats only occasionally pass - are investigated by means of unmanned bat detectors and automatic recording. Bats are found and determined to species by means of both the visual, behavioural clues and their sounds registered by means of a bat detector. The detector uses time expansion and is connected to a digital recorder. If the species cannot be determined in the field, the sounds are analysed later in a computer using the programme "Batsound". Mapping of trees potentially suitable as resting- and roosting sites (i.e. trees with loose bark, lianas, and cavities) and identification of buildings (e.g. houses, bridges), which will be demolished during construction. The mapping is made partly based on aerial photographs and maps and partly in the field using GPS. All suitable resting- and roosting areas, potentially affected by the project, will be investigates with regard to the occurrence of bats. Not least the potential roosting sites. The investigations will be carried out in July.	3

SPECIES/BIOLOGICAL GROUP	INVESTIGATION METHODS	NUMBER OF VISITS
Medium and large sized mammals	No separate investigations will be carried out. Instead data from hunting authorities, hunters, forest authorities, registrations of road kills and information from additional experts will be evaluated.	
Small mammals	Common dormouse (*Muscardinus avellanarius*, Annex IV). Nests will be looked for in suitable habitats like hedges or blackberry stands. Only relevant in Germany as the species does not occur on Lolland.	1
Terrestrial birds	Please refer to Annex B	